Journal of Problem Based Learning in Higher Education

VOL 14 • 1

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Journal of Problem Based Learning in Higher Education
VOL 14, No. 1 (2026)

Issue Editors
Patrik Kjærsdam Telléus, Bettina Dahl Søndergaard, Nikolaj Stegeager, Vibeke Andersson, Jette Egelund Holgaard & John Vergel

Editorial Team
Patrik Kjærsdam Telléus (Editor-in-Chief)
Bettina Dahl Søndergaard (Case editor)
John Vergel (Editor of Spanish Section)
Vibeke Andersson
Jette Egelund Holgaard
Line Bune Juhl

Copyright
The authors of the original articles retain copyright © 2026



Journal of Problem Based Learning in Higher Education is published by Aalborg University Open Publishing under a CC BY license:
http://creativecommons.org/licenses/by/4.0/

ISSN
2246-0918

Published by
Aalborg University Open Publishing
Kroghstræde 1-3
DK 9220 Aalborg Øst
aauopen@aau.dk

Further information about JPBLHE:
https://journals.aau.dk/index.php/pbl

Table of contents

Editorial

Editorial I-III
Bettina Dahl Søndergaard, Patrik Kjærsdam Telléus

Invited Author

Problem-Oriented Teaching and Learning at Roskilde University 1-21
Martin Niss, Mogens Allan Niss

Research Papers

Equipping Students for Wicked Problems: The Potential of Problem-based, Challenge-based and Transdisciplinary Learning to Encourage Contextual, Constructive, Collaborative and Self-regulated Learning 22-37
Diana Dolmans, Boukje Compen, Hans Savelberg

EIPA-PBL: An Embedded, Real-Time Approach to Individualised Performance Assessment in Problem-Based Learning Tutorials - A pilot Instrument-Development Study 38-64
Colin Greengrass

PBL Teachers' Perceptions of Education and Learning Based on Educational Background 65-89
Nicolaj Riise Clausen, Mia Thyrre Sørensen, Niels Erik Ruan Lyngdorf

Graduate Students' Perceptions of the Project-Based Learning (PJBL) Model: A Phenomenological Study in the Context of Puerto Rico 90-112
Isabel Delgado Quiñones, Emil Santos De Jesús

The Effectiveness of Problem-Based Learning in Enhancing Learners' English Language Skills: Meta-Analysis and Systematic Review 113-140
Alemayehu Assefa, Mebratu Mulatu Bachore, Tagesse Daniel

Project-Based Learning to Promote EFL Students' Self-oriented and Collaborative Skills Within Education for Sustainable Development 141-162
Ridho Praja Dinata, Utami Widiati, Efa Silfia, Mutia Hasymi, Mala Rovikasari, Trishna Nanda Barianti

Conflict Resolution in Project-Based Learning: A Mediation Approach 163-188
Safia Bendjebar, Yacine Lafifi, Sevinç Gülseçen, Zohra Mehenaoiu, Aymen Boukeskes

"What is in it for me": Student Perspectives on Interdisciplinary Learning Activities 189-210
Kirsten Jæger, Jette Egelund Holgaard, Mia Thyrre Sørensen, Maria Hvid Stenalt, Thomas Ryberg, Katrine Lohmann Bjerg

Implementing Hybrid Problem-based Learning in an ESP Context: Dentistry Students' Perceptions and Challenges 211-241
Burçak Yılmaz Yakışık

Cases of PBL in Practice

Making the Classroom Inevitable: The Role of Dialogic Learning in Problem-Based Learning Environments 242-254
Joachim Wiewiura

Establishing a Learning Community to Support Master's Thesis Writing Students in a Problem-Based Learning Context 255-265
Martin B. Østergaard

Integrating the Curriculum for Respiratory Scientists: Evaluating the Impact of Online Problem-Based Learning Integrating Pulmonary Pathophysiology with Pulmonary Function Testing Interpretation 266-280
Alison White

Experiences of the Introduction of Project-Based Learning at Széchenyi István University 281-297
Eszter Sós, Katalin Deé-Kovács, Szabolcs Kiss, Zsolt Kovács, Éva Happ

Design of a PBL-based Immersive Content Production Curriculum 298-312
Gum Young Kim

Sección en Español | Spanish Section

Project-Based Learning for Sustainable Design in a Heat Transfer Course 313-332
Juan Sandoval Herrera

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, 2026 – Page I-III

Editorial

Twenty-second Issue of the Journal of Problem Based Learning in Higher Education

Bettina Dahl Søndergaard * | Aalborg University, Denmark
Patrik Kjærsdam Telléus | Aalborg University, Denmark

Welcome to Issue 1, volume 14 of the *Journal of Problem Based Learning in Higher Education*. We are very proud of this issue containing an insightful discussion of the nature of problem-based teaching and learning by our invited authors Mogens Allan Niss and Martin Niss, also father and son. Martin and Mogens are both from our Danish PBL sister university, Roskilde University, and are well known figures in the PBL community. The issue also includes nine research papers, five Cases of PBL in practice, and our very first paper for the Spanish section. The submissions come from around the world: Algeria, Australia, Bahrain, Colombia, Denmark, Ethiopia, Hungary, Indonesia, The Netherlands, Puerto Rico, Republic of Korea, and Turkey. When we started this journal 14 years ago, we intended it to become an international journal, which indeed it has. We want to thank all the authors for contributing to making JPBLHE an international home for PBL research in higher education.

As mentioned, this is our 14th volume. Our first volume was published in August 2013. In the old days in Denmark, most children attended school for only seven years, leaving in the year they turned 14. The end of schooling also coincided with being confirmed in the national Lutheran church. Both occurrences jointly marked the transition from childhood to adulthood, with the expectation of the child leaving his/her parents' home and finding a job and life of his/her own. Things are naturally and fortunately different now, but let us use the story to ask ourselves, if we have now, as of a 14th volume, reached adulthood?

* Corresponding author:
Bettina Dahl Søndergaard, Email: bdahls@plan.aau.dk

We are experiencing a growing interest in our journal, more authors submit their work to us and our citation ranking is rising as the papers get cited, so we are growing up. To some extent, however, we are still living with our mother, Aalborg University. We are fully funded by the university, and the editorial board members get credited in our local system of work distribution. This has the advantage that we can be a Diamond Open Access journal where publishing is completely free for both authors and readers. At the same time, we have noticed that it is now becoming increasingly expensive for both authors and readers to access other journals. We find it essential to remain a Diamond Open Access journal to both create possibilities for everyone to publish their research, and for everyone to read it. It is problematic when researchers cannot publish their research if they cannot afford the Article Processing Charges. They do not receive the credit for this research, and it is also a problem for the world if we do not get to know about this research either if it is not published or if we cannot afford to read it. Hence, sometimes it is not so bad to live at home with one's mother.

But times are also changing. As everywhere, we are also discussing AI – a lot. How will this affect research and publication? During this year, we have therefore added some requirements concerning AI to our submission guide. And as all editors these days, we are discussing what is good practice when it comes to AI, and what should count as not. Most likely our current requirements concerning AI will be revised before the next ordinary issue and probably revised again after that. Changes happen so fast. Regardless, we want to remain a journal that publishes quality research done by humans. Stay tuned for updates on our journal website for AI requirement and policy.

This year has seen some changes in the editorial team. Associate professor and long-time member Nikolaj Stegeager has left us to take on the responsibility of being director of Institute for Advanced Study in PBL. We thank Nikolaj for his valuable work and his deliberative voice over the years. Joining in his place, in the early autumn we welcomed associate professor Line Bune Juhl to the editorial team. For next year we expect to see further changes, since the workload of the editorial team has multiplied over the last couple of years. No doubt, amongst other causes, a result of the introduction of AI to the scientific community.

Finally, we would like to thank all the reviewers who have donated their time and wisdom to help to improve the papers and cases of PBL in practice in this issue:

Leila Ali

Eva Bendix Petersen

Antonella Lotti
Lykke Brogaard Bertel
Milena Alcocer Tocora
Tetiana Horokhivska
Henrik Vardinghus-Nielsen
Julie Marie Isager
Franklin Cuenca Soto
Mads Peter Klindt
Niels Erik Ruan Lyngdorf
Muh. Fitrah
Lin Henriksen
Giajenthiran Velmurugan
Ron Ulseth
Lidan He
Svend Hauekrog Christiansen
Natalia Buitrago Ricaurte
Ikhfi Imaniah
Frederik Voetmann Christiansen
Justin Whitney
Camilla Rams Rathleff
Amando Pimentel Sigun

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, 2026 – Page 1-21
doi.org/10.54337/ojs.jpblhe.v14i1.11677

Problem-Oriented Teaching and Learning at Roskilde University

Martin Niss * | Roskilde University, Denmark
Mogens Allan Niss | Roskilde University, Denmark

Abstract

Drawing on a historical account of the development of problem-oriented project studies at Roskilde University (Denmark), this article analyses the key concepts underpinning this educational tradition as well as the positions and frameworks advanced by its proponents. Focusing on problems and how they originate in such studies, it distinguishes between problems of practice, which concern challenges that arise in areas of practice and require resolution, and intellectual problems, which arise from efforts to understand phenomena and processes through scientific or scholarly inquiry. The problem-oriented tradition at Roskilde University has tended to privilege problems of practice, while neglecting intellectual problems. We argue that this is a highly problematic tendency because intellectual problems have significant formative value for learners. Hence, we advocate for a more pluralistic understanding of what constitutes a legitimate problem in project work. The argument is illustrated through authentic examples of discipline-related intellectual problems from science and mathematics education at Roskilde University.

Keywords: Problem-orientation; problem types; discipline-related intellectual problems; Roskilde University

* Corresponding author:
Martin Niss, Email: maniss@ruc.dk

Received 5 August 2026 | Accepted 26 October 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

Introduction

Taking its point of departure in a historical account of the development of problem-oriented project studies at Roskilde University (Denmark), this article aims at providing an analysis of the key concepts of this notion as well as of the different positions and frameworks promoted by protagonists in this development. Furthermore, we plead for adopting a pluralistic view of the kinds of problems that deserve "civil rights" in project-oriented project work.
In September 1972 Roskilde University Centre (RUC) opened its doors for its very first cohort of students. As a marked example of "paving the road while driving on it", only two-year so-called *basic education programmes* were in place when the students arrived. Three such programmes were established, in the humanities, in the natural sciences, and in the social sciences. MAN (Mogens Allan Niss) was a member of the founding staff for (the natural) science programme(s) from the very beginning, as well as for the subsequent mathematics programme. MN (Martin Niss) led the bachelor's programme in science from 2020-2027, and before that the physics programme 2014-2019.

It was part of the initial planning scheme that a number of three-year further education programmes were to be designed and implemented during the first two years such that the students could move on to 3 (or 1½) year studies right after having completed one of the basic programmes. This would result in degree programmes of a total of either 5 (master level) or 3½ (a kind of bachelor level) years. This was the reason why the institution was named "university centre" rather than just "university", since the term "university" was reserved for institutions that offered only master's and PhD-level programmes, even though RUC was a research institution from the very beginning. In 2008, it changed its name to Roskilde University in order to better reflect its actual status. As the acronym RUC had been an established "trademark", well known to the public, for 36 years, it was decided to keep this acronym, although the literal referent of "C" no longer existed. It should be mentioned that in 1999 all Danish universities were subjected to the so-called Bologna model, which instigated a sequential 3 (bachelor)/+2 = 5 (master)/+3 = 8 (PhD) system as the standard structure. This implied that RUC no longer would have its own special structure. So, keeping "Centre" in its name would simply be misleading.

One trait was common to all three basic programmes. They were all centred around *problem-oriented project work* carried out by small groups of students. In the humanities and social science programmes such work was in fact the only study activity on the agenda during the first handful of years. In contrast, the natural science programme included an even split of 50% project work and 50% course work already from the start. Although typically innovative in content

and form, the courses were designed, led, carried out, and assessed by the academic staff, as was – and is – usual.

As problem-oriented project (group) work formed the centrepiece of the three programmes, we need to pay closer attention to what this is. The concept is an amalgam of three rather different, in fact conceptually independent, kinds of components. As the name suggests, project work is a particular *way of working*, whereas problem-orientation is a *content category* focusing on the investigation of a (set of) problem(s). *Project work* – the first component – is undertaken in order to obtain some kind of product meant to fulfil certain goals or requirements. It can be conducted by a single person or by a group – the second component – of individuals, in university contexts consisting of students supervised by an academic staff/faculty member. At RUC, in the early years and in most subsequent periods, groups typically were small *project groups* composed of 3-7 students. Project groups are meant to carry out and take full responsibility for all the decisions, actions, and activities involved in undertaking the project work within the overall framework laid down in study programmes and regulations (see, e.g., Blomhøj & Kjeldsen (2008) and Niss (M.) (2025)). Dependent on its purpose, a piece of project work can generally be of a very diverse nature and have a highly diverse kind of content. In *problem-oriented* project work, however, the key purpose is to deal with a problem, or a set of problems, with the ultimate goal of "solving" it (or them). Hence, the content of the project work in this case consists of everything involved in dealing with the problem(s) towards achieving the goal.

Project work can deal with lots of things other than problems. For example, it can focus on training participants to effectively perform certain tasks or procedures. And, depending on their nature, problems can be investigated and solved in several other ways than by means of project group work, e.g. by seeking extant answers or solutions in relevant literature. Hence, the content component and the way-of-working component are indeed different and independent.

Problem-oriented project work (POPW) and problem-based learning

The key term in problem-oriented project work (POPW) is "problem", which is also the key term in what has become known as "problem-based learning" (PBL). Hence, an in-depth compare-and-contrast analysis of POPW and PBL must have an investigation of the very concept of problem as a core ingredient. Below we shall offer a first attempt at such an analysis.

Before doing so, however, it is worthwhile to attend to the issue of why POPW, respectively PBL, were introduced into tertiary education in the first place. POPW was first introduced in the late 60's and early 70's at some German, British and Danish universities and colleges (Cornwall & Schmithals, 1977) for a variety of different reasons. One such reason (Andersen & Kjeldsen, 2015a) was to bridge the gap between tertiary academic education and the post-college professional world of work - a gap which was sometimes named the "practice shock" - by preparing students for types of work characteristic of different sorts of academic workplaces. Another reason was to have students experience some degree of "authenticity and relevance for learning" of their studies, as regards both the objects and the subjects of study and the ways these objects and subjects could be treated in investigative processes (Andersen & Kjeldsen, 2015a, Habbal et al. 2024). A third reason was that by letting students take responsibility for their own work, they would experience motivation, ownership, and agency in their studies rather than being passive recipients of top-down knowledge transmission (Illeris 1974). A fourth reason (Simonsen & Ulriksen, 1999, Ulriksen, 1997, Christensen, 2007) was to place students in situations that required long-term collaborative work with peers and thus expose them to and prepare them for the challenges and intricacies of such work and to the different roles it calls for.

As is well known, tertiary academic education takes a multitude of different forms and purposes. Some are devoted to the study of scientific and scholarly academic disciplines and subjects in their own right – e.g. mathematics, physics, social science, economics, philosophy, linguistics, history, or geography, to name just a few. Others are studies that prepare for well-defined professions, such as, for example, medical doctor, engineer, teacher, lawyer, pharmacists, or architect. Especially with the latter sort of studies, students often experienced a gap between, on one the hand, the foundation subjects and, on the other hand, the professions-oriented subjects included in their study programmes. In some cases, the gap between these two kinds of subjects was seen, by students, as so large that the foundation subjects appeared to be irrelevant, without any obvious bearing on the "real" (i.e., profession-oriented) material that initially recruited the students to the programmes. Hence, this gap might end up rendering the studies demotivating for some students. PBL was introduced, above all, in order to counteract the consequences of this gap. To some – but a much minor – extent this was also the case with POPW.

Above, we mentioned "foundation subjects". We should also mention "service subjects". Foundation and service subjects are included in a study programme in order to provide a conceptual, theoretical and methodological foundation for the essential parts of the programme, like, e.g., mathematics for physics studies or engineering programmes, chemistry for medical studies, and statistics for

social studies and economics. Service subjects may also be meant to facilitate dealing with these essential parts of a programme, like foreign languages – say Latin - for programmes in history, literature or philosophy. Thus, foundation or service subjects are secondary subjects in relation to the primary subjects that constitute the core of a study programme. This does certainly not imply that foundation or service subjects are unimportant, quite the contrary. For example, one cannot study physics, engineering, actuarial science or economics without being well versed in mathematics, or study medicine or pharmacy without a strong background in chemistry. Despite their importance, foundation and service subjects may often be felt by students as a detour from the route of essence. One of the reasons for proposing POPW or PBL as an educational framework for academic studies was – and is – to create a platform that allows for a demonstration of the role and importance of foundation and service subjects for the study of this essence.

What is a "problem" and how do problems originate?

The term "problem" has several different meanings, and problems come in a multitude of different sorts, shapes and forms, and have a variety of different origins. Basically, a problem is a phenomenon, condition, process or issue that is "nagging", "hurting", "biting", or "itching" in one way or the other and hence provides a *challenge* for individuals, groups, communities or societies. Any problem can be stated in terms of a set of interrelated questions: What is the problematic entity we're talking about? Why is it a problem? To whom is it a problem? What does it mean to handle, or eventually solve, the problem? And how can the problem be dealt with so as to achieve a satisfactory outcome?

There is neither an end to what may constitute a problem, nor to whom a problem is a problem. In academia, there are fundamentally two classes of problems. *Intellectual problems* are problems where there is something which somebody wants to *understand* by involving scientific and/or scholarly methods to help generate well-founded understanding of and insight into this "something". If such a problem has not yet been dealt with satisfactorily or exhaustively by relevant communities, we typically call it a research problem, but lots of problems can be of an intellectual nature without being research problems. This is the case, for instance, with hosts of problems that students encounter within academic studies. *Problems of practice* are problems that are *troubling* or *challenging* to the life or work of people, professions, communities, organisations or societies, problems that need to be removed, overcome, reduced, or counteracted by way of effective decisions or actions of some sort.

Such problems are relevant to academia to the extent academia has something important to offer to those who struggle with them.[1]

Intellectual problems and problems of practice differ in terms of their purpose and orientation, but they certainly need not represent disjoint categories as far as content is concerned. Thus, any profession-oriented academic programme attempts to handle (some) problems of practice by converting them into intellectual problems, solving these, and eventually generating solutions to the initiating problems of practice. Conversely, discipline-oriented academic programmes oftentimes consider intellectual problems, and possible answers to them, that end up having a bearing on problems of practice.

In discussions and analyses, one often gets the impression that the type of problems people have in mind for POPW and PBL are predominantly problems of practice. Particular kinds of such problems consist of so-called *social* or *societal* problems, a.k.a. problems of social or societal *relevance*, or even *real-world problems*. Although these notions are generally ill-defined (what is, e.g., "the real world"?), such problems typically refer to themes, issues or topics that are on the agenda of politico-societal national or international discourses in a certain era. Examples include problems related to: economy; environment; climate; energy; food supply; demography; migration; social conflicts; culture(s); politics and policies; public governance; structure and organisation of society; centres of power; the functioning of legal and judicial systems; education; technology in a broad sense; safety and security; defense and warfare; infra-structure; transport; information and communication structures and systems; public health; allocation of resources; industry, business, and finance; media; and international relations, to mention just a few.

---

[1] Adolphsen (1999) makes a distinction similar to, but narrower than, the distinction between problems of practice and intellectual problems. Adolphsen was affiliated to Aalborg University, which is a hub for problem-based learning in Denmark. According to Adolphsen "Practical or real problems arise from contradictions or perplexing choices between what we want and what we can do. […] Practical problems can be solved without us knowing why they are solved." (Adolphsen, 1999, p. 253). Theoretical problems "are perplexing contradictions or choices between what we know and how things are (or seem to be), or they can be contradictions between two competing theories. A theoretical problem is formulated ignorance — something which our (or my) current theories cannot explain." (Adolphsen, 1999, p. 253). While practical problems are quite like problems of practice, it is clear that theoretical problems with their requirement of being contradictions within a theory or choices between competing theories belong in the category of intellectual problems, but the latter category is broader and includes problems that are not theory-induced.

Throughout history, topics such as these have always been essential to any society, because they shape the structure, organisation and function of society and people's lives therein. But the actual ways in which they are configured and manifest themselves depend on the specific point in time when they are on the agenda as well as on their geographical distribution. This means that they typically have a marked presence in media discourses, which is probably a major reason why they are considered socially or societally relevant. All these themes and topics give rise to specific problems in different contexts and locations, at different levels and on different scales. The predominant ones are ultimately problems of practice, because they have a direct impact on society and call for actions to be designed, planned, and taken. However, they also include intellectual problems focusing on the understanding of structures, processes and mechanisms, especially in contexts where it is acknowledged that the solution of pertinent problems of practice require in-depth understanding of their nature.

It is no surprise that social and societal problems receive considerable attention within POPW and PBL as they are easily visible and recognisable and easily acknowledged as socially and societally relevant.

In contrast, intellectual problems tend to receive much less attention within POPW and PBL, probably because they are more hidden, less recognisable, oftentimes less accessible, and appear to be lacking relevance to large segments of society. We argue that this is highly problematic because intellectual problems have great educational value, oftentimes more so than problems of practice. Firstly, intellectual problems call for consciousness about the need to pose and specify a problem in such a way that it can be subjected to disciplined enquiry (Dewey, 1938; Cronbach & Suppes, 1969) leading to evidence-based conclusions, where "evidence" is relative to the domain at issue. This, in turn, involves the need for a high level of analytical and methodological clarity and understanding. Furthermore, it activates the need to address and reflect on what knowledge and evidence are – and are not – in different domains, and how knowledge can be obtained and substantiated. Ultimately, intellectual problems help us distinguish between claims that can be trusted and claims that cannot. Thus, working on intellectual problems has a significant formative value for learners.

As there is no end to the kinds of problems that can be subjected to treatment in POPW (and to a lesser extent also in PBL), one question naturally arises: What criteria can be invoked to create or select problems that are suitable for POPW? Of course, a multitude of rather different criteria can come into play. It would take us too far to provide a systematic account of such criteria. (See Olsen & Pedersen, 2008, for some such criteria.) Instead, we focus on one significant

criterion, which is pertinent to POPW, namely *exemplarity*. As regards PBL, see also Dahl et al. (2003).

According to the notion of exemplarity, the relevance of a problem-oriented project is not solely determined by the stand-alone relevance of the problem investigated but also by the insights and learning generated by undertaking the project (see, e.g., Christiansen (2001) and Blomhøj & Kjeldsen (2009)). More specifically, if the insights and the learning generated are (likely to be), of a somewhat general nature, i.e. representative of a larger class of important insights and learning going beyond the singular project at issue, this project serves as an *exemplar* for this larger class of learning and insights. A project may be representative in several different respects, e.g., concerning the (potential) generalisability of the questions posed, the objects studied, the findings obtained, or the methods employed. The extent to which a singular project may serve as an exemplar in this sense is not only a criterion for what problem-oriented projects one might choose to undertake but also a potential criterion of quality of the resulting project. Engaging in analyses and discussions of the potential for a given project to become an exemplar in one or several respects is a key element in determining the pros and cons of undertaking that particular project.

Prevalent conceptions of problem-orientation at RUC

We now turn to how the conceptions of problem-orientation have evolved since the founding years of Roskilde University. For many years since its establishment, the prevalent understanding of problem-orientation in significant quarters of the university was shaped by Knud Illeris's three-part framework for student project work (Andersen & Kjeldsen, 2015b). According to this framework, the problems studied should be relevant to the students themselves, to their educational programme, and to society. Personal relevance was intended to foster motivation and engagement, educational relevance to ensure students' qualifications, and societal relevance to orient the work towards extant social issues (Illeris 1981, Ulriksen 1997).

Here, we focus on the societal/social relevance criterion as this was the one subject to the strongest debate at RUC. Illeris stressed that the problem "should be situated within a broader—and ultimately always societal—context." (Illeris 1981, p. 100, our translation). He and others maintained that this should apply not only to the social sciences, but also to the humanities and the natural sciences, while others—as discussed by Servant (2016)— strongly objected to such a one-size-fits-all approach. As we shall see below, faculty members

affiliated with the natural sciences were particularly resistant to attempts to impose this part of the framework, or similar ideas, on "their" programme.

Olesen and Andersen (2015) provide a recent, articulate update of Illeris' point of view. They note that modern academia is characterised by centrifugal forces rather than the centripetal forces of earlier times. Furthermore,

> "Strangely, the nuclear physics paradox implied that it was precisely when science pursued science itself that it became of value to society – be it in the form of weapons or power-production –and this is still a valid argument. This example shows the extremely ambiguous and political nature of societal impact. The critical quest for truth can, on the other hand, hardly find itself an object that is not in itself interwoven with this context. The fact that the qualms of conscience experienced by theoretical physicists during the 1940s with respect to nuclear technology had such great metaphorical impact is probably because they, dramatically, showed the final profanation of pure, truth-seeking science – without any real possibility of being able to set the social and political agenda themselves." (Olesen & Andersen, 2015, p. 269)

This led Olesen and Andersen to conclude that

> "Today, the challenge is to provide a space where students can practise handling more profane versions of the relation between academic knowledge and practical competence. This relation is mediated by the students' situation and subjective engagement." (Olesen & Andersen, 2015, p. 269).

In this situation,

> "[the] argument for project studies is to create an institutional hybrid space which enables the (re-)engagement of these centrifugal forces, with the clear understanding that they will not be harmonious. 'Problem-oriented project studies' is an alternative way of opening universities to society and at the same time preserving basic academic qualities of independence, criticism and truth-seeking." (Olesen & Andersen, 2015, p. 269)

Olesen and Andersen summarise their ideas in a depiction of the study environment as a hybrid space as in Figure 1. Here, 'social challenges' is their update of Illeris' 'societal issues', the 'academic traditions' corresponds to the educational criterion, while students' 'social experience' is similar to Illeris' 'student relevance'.

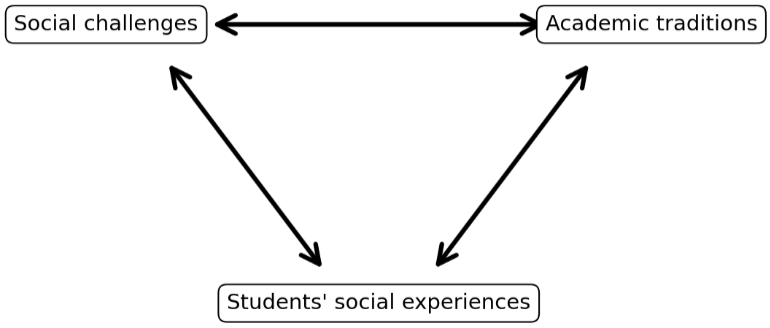


Figure 1. The study environment as a hybrid space (Olsen & Andreasen, 2015).

Olesen and Andersen clearly prioritise problems of practice within the 'intellectual/practice' distinction as they emphasise the development of students' "practical competence," as well as a need for "letting in a criterion of practical relevance." (Olesen & Andersen, 2015, p. 270) Furthermore, in their view "'Non-academic' discussions of functional and political relevance play a significant role in project work, not least through the attempts to trace the interrelation between practical epistemological issues and the theoretical and methodological questions related to traditional academic work." (Olesen & Andersen, 2015, p. 270) Their view thus implies that purely intellectual problems, and in particular discipline-related intellectual problems, should have at most a marginal position in problem-oriented work.

Over time, a shift occurred at RUC away from an emphasis on societal problems towards what is termed "real-world" problems. While all societal problems can be perceived as real-world problems such problems/issues are rarely explicitly defined. The typical usage of the term appears to align with Ulriksen's definition, according to which a real-world problem "must be something that actually occurs and occurs outside the sphere of academic study" (Ulriksen, 1999, p. 22, our translation). An example could be: "Why is it the tomato sauce that burns your mouth when eating a hot pizza?" This problem can hardly be considered a societal problem as it concerns an everyday phenomenon affecting individual experience rather than a broader social issue with consequences for the community. Nor is it within the sphere of academic study (but it can be translated into an academic problem). No matter the precise definition, the category 'real-world problems' must be broader than 'societal problems' as the former type of problems includes the latter as a proper subset.

Thus, "real-worldliness" has emerged as a prevalent criterion at RUC. For example, this is the case with the description of the principle of problem-orientation in branding material used by the university during the last decade: "The projects at RUC are oriented towards understanding and solving real world issues through the use of theory and scientific methods." (RUC, 2026a)

Moreover, RUC's so-called framework documents on interdisciplinarity stress real-world problems as the basis of problem-orientation (RUC, 2026b).

While Ulriksen's definition is neutral in regard to the intellectual/practice distinction, others (e.g., Knudsen, 2009) often understand the term 'real-world problem' to involve a concrete issue or challenge to somebody and thus eventually becomes a problem of practice.

Now, a multitude of intellectual problems reside within, or relate to, scientific or scholarly academic disciplines. Since the dawn of civilisation, such disciplines and their development have constituted the key categories by means of which humankind has conceptualised, understood, and dealt with the world. Such problems are posed, specified and handled with reference to the conceptual, theoretical and methodological frameworks that govern the discipline(s) under consideration and constitute their accomplishments. Ulriksen's definition rules out such discipline-related intellectual problems such as they occur within the sphere of academic study.

However, dealing with discipline-related intellectual problems allows learners to go into depth with the edifice of the discipline at issue and ultimately come to grips with essentials and fundamentals of that discipline. This is the reason why large parts of academic study programmes traditionally, in the past, have been centred around scientific and scholarly disciplines. However, in recent decades one can detect a growing trend, in tertiary institutions, to replace discipline-centred programmes by composite study programmes taking the shape of packages mixing different kinds of elements and being oriented towards preparing students for more or less specific professions or classes of professions. Composing such programmes is a rather flexible undertaking, as mixed programmes can easily be changed in response to changing demands and trends in society. While there may certainly be very good reasons to establish such mixed packages, this should not be taken to imply that there is then no longer any need for maintaining and developing discipline-centred study programmes in academia. In fact, dismantling such programmes would be a disastrous break-away from the accumulated, structured, and stored insights generated by centuries – sometimes millennia – of discipline-centred research and education.

Alternative conceptions of problem-orientation at RUC

Right from the beginning, alternative conceptions to Illeris's framework and its derivatives existed at RUC – in particular within the natural sciences – and thus in parallel with the prevailing conceptions of problem-orientation as involving

social/societal problems. Here, a divide emerged between two positions. One advocated that natural science programmes should provide students with in-depth knowledge and skills concerning the natural sciences as an end in itself, and that the acquisition and application of these require systematic and progressive exposure. The other position held that any such programme should instead focus on societally relevant problems; accordingly, the natural science elements should be limited to providing only sufficient understanding to allow for the engagement with these problems, and that such understanding could and should be developed in an *ad hoc* manner as needs arise in working on the problem. Many members of the natural science faculty at RUC defended the former position, in opposition to groupings who wanted engagement with societally relevant problems to serve as the central – if not the only – organising principle for all programmes. The former position argued that if serious natural science qualifications were indeed desirable, then an educational focus exclusively on societal problems would be insufficient for preparing students in the fundamental disciplines of natural science.

For instance, Gustaw Kerszman (1977) wrote about projects inspired by current political debates:

> "Such projects do not as a rule force the students to learn 'hard' science, to plan and perform experiments, to interpret their result, to test hypothesis, to use the tools of mathematics […] The students often move only on the surface of natural science and its technological applications. The projects drift almost naturally towards dilettante journalism." (Kerszman, 1977, p. 147)

In line with this view, since the late 1970's, and still today, the basic studies in natural science are organised around projects with problem formulations leading to the involvement of the natural sciences as such, see below.

Initially, following the establishment of RUC, the basic studies in the humanities — like those in the social sciences — largely focused on societal problems. Over time, however, a tension similar to that concerning the natural sciences emerged, and by 2015 Andersen & Kjeldsen could write:

> "The criterion of *social relevance* – one of the main original arguments in favour of problem-orientation – has been reinterpreted, because it has been difficult to relate some subjects in some academic cultures directly to this criterion. The social relevance criterion, in particular in the natural sciences and humanities, has gradually moved to an interpretation where the connection between the problems and the outside world passes through the problems of the academic disciplines rather than the other way round." (Andersen & Kjeldsen, 2015b, p. 24)

The argument in favour of not focusing solely on problems of social relevance is not that societally relevant problems involving the humanities and the natural sciences cannot be found. In fact, there are hosts of such problems amenable to academic treatment. The argument is rather that there are crucial aspects of the humanities and the natural sciences that will not be covered if students are only studying such problems.

The conception of problem-orientation in recent times

Against this background, in recent times, a more pluralistic view has emerged at RUC, at least judged from the official framework document on the pedagogical profile of the university, which has an inclusive view on suitable problems: they should be so-called "knowledge issues", often, but not necessarily, based on problems of practice from the real world. In general, this document uses a wide interpretation of "suitable problems":

> "Project work at Roskilde University is problem-oriented. It is aimed at identifying, illuminating, understanding, explaining and solving problems that may arise theoretically or from society and/or the environment. A problem can be defined in many ways and can take on various forms within different academic fields. Similarly, it is possible to work with problems in various ways, for example with varying emphasis on qualitative or quantitative approaches, inductive or deductive approaches, and with combinations of these approaches." (RUC, 2026c)

While problems of practice readily fit within this pluralistic framework, it also accommodates intellectual problems, including discipline-specific ones, as they arise in theoretical form.

We have already noted that this pluralism permeates the bachelor programme in natural science. It also permeates the master-level programmes. In the next section, authentic examples of projects within mathematics and physics are presented. A cursory look at some of the projects being done in the humanities in recent years at RUC tells a similar story of pluralism where students can pursue problems that are focused on understanding rather than on counteracting obstacles occurring in practice. Moreover, two researchers affiliated with the humanities at RUC, Feldt and Pedersen (2021), advocate that the problems of student inquiry in the humanities should be academic problems, i.e. problems of the academic field, connected to the academic literature etc. Such problems are very close to what we have termed intellectual problems. Hence, the view taken by Feldt and Pedersen can be seen as a further testimony of the growing pluralism in recent times.

Discipline-related intellectual problems

Against the background established above, we find it worthwhile to pay particular attention to discipline-related intellectual problems, some of which may, indeed, as already mentioned, have a significant bearing on problems of practice as well, even though they do not have to. As our backgrounds are in science and science education in general, and physics and mathematics education in particular (see also Niss (M.A.), 2001), we want to point out that there are fundamentally three kinds of intellectual problems relating to mathematics and physics – and most probably to any discipline in natural science - namely problems posed *within* the discipline, problems posed *about* the discipline, and problems dealt with *by means of* the discipline being applied outside its own domain. Problems posed within a discipline address issues that are *internal* to the discipline, ranging from singular questions of a concrete nature, over questions pertaining to the methods and techniques of the discipline and to the results it produces, to questions related to its theoretical constructs and the interrelations amongst these. Problems posed about the discipline address the nature, state and role of the discipline *as a discipline*, including its foundation, structural characteristics, general methodologies, origin, history, and philosophy, as well as its relationships with other disciplines. Finally, issues that deal with the application of a discipline to problems that are *external* to its own domain, be these problems of a scientific, scholarly or practical nature, constitute the third kind of problem. It is important to realise that problems dealt with *by means of* an academic discipline need not be intellectual problems, even though they certainly can be. However, it should also be emphasised that problems concerning the application of mathematics or physics to another scientific discipline, say biology or economics, which are not intellectual problems within mathematics or physics, may well be intellectual problems within that other discipline. The issue of exemplarity of problem-oriented projects related to an academic discipline then particularly focuses on the extent to which the project is an exemplar with regard to problems *within*, *about* or *by means of* that discipline.

We now present some intellectual problems which have actually been made subject of investigation by problem-oriented projects conducted by students at Roskilde University during the last several decades. There are several hundred examples of such projects. To keep things simple, we have chosen to present just six projects, three related to mathematics and three to physics.

We begin by considering three mathematics projects selected to illustrate the three kinds of intellectual problems introduced above.

The project *"On the strategies used to attack unsolved mathematical problems – a case study of the Collatz Conjecture"* was carried out by four mathematics students in 2015. The initiating problem statement reads as follows (original in English):

> "Given that the Collatz Conjecture is hard, what approaches have been used to attack related, but potentially easier problems? In what way can these derived problems help mathematicians settle the conjecture?" (p. 2)

The Collatz Conjecture (posed in 1938) is a problem in elementary number theory asking whether a certain process of repeated halving of the even natural numbers that arise in the process will always result in the number 1 (the conjecture). The problem is easy to understand, and no counterexample has ever been found. However, so far, despite a multitude of different attempts and approaches, no universal proof has been found either, which is what makes the problem challenging from a mathematical point of view.

This clearly is an intellectual problem posed *within* mathematics as a discipline. The four mathematics students reported their work in a 47-page project report. (Zoet, et al, 2015)

The project *"Pathological examples – on the impact of weird mathematical "fish" on the development of mathematics"* (our translation from Danish) was carried out by five mathematics students in 1993. The problem statement reads as follows (our translation from Danish):

> "What kinds of impact did [selected] pathological examples have on the development of mathematics? Why did these examples have an impact, i.e. what properties of the examples made them significant?" (our translation) (p. 3)

By "pathological examples", the project group understood a well-known collection of notorious mathematical entities with counter-intuitive and unexpected properties, typically resulting from rather complex or surprising constructions.

The problem stated deals with aspects of the development of mathematics as a science and hence is an intellectual problem *about* mathematics. The students reported their work in a 90-page project report (Dræby, et al., 1993).

The project *"The Radon transform and its application to CT-scanning"* was carried out by four mathematics students in 1993. The problem statement reads as follows (our translation from Danish):

> "How is the Radon Transform applied in relation to CT-scanning and what model assumptions lie behind this application?" (p. 8)

This project deals with the construction and use of a medical scanning device created *by means of* mathematics, in this case the so-called Radon Transform introduced by Johann Radon in 1917. The Radon Transform, which was introduced for purely mathematical purposes, takes its point of departure in a so-called real mathematical function f defined on a 3D-domain. The integrals of this function along all planes determine a new function F – the RT - defined on the set of all planes. Radon proved that given F, f can be completely retrieved. Thus, this is an example of a mathematical entity put to use in a domain (medical diagnostics) that is *external* to mathematics itself. Albeit not an intellectual problem within mathematics (Radon had already solved the mathematical problem at issue), the problem investigated – linking Computerised Tomography with the Radon transform - was in fact an intellectual problem within medical diagnostics. The students reported their work in an 89-page report (Christiansen et al., 1993).

The project *"A Study of the Role of Solvents and Chain Length in Anomalous Swelling in Phospholipid Bilayer"* is an experimental project performed by four physics students. They studied so-called anomalous swelling of bilayers of a certain type of molecules called lipids. Such bilayers are made of two layers of lipids that in water arrange themselves, such that their water-loving heads face outward, and their water-repelling tails face inward. Anomalous swelling is a surprising "extra swelling" of the layers that happens under specific conditions (like temperature changes), which cannot be explained by normal thermal expansion alone. A model developed at DTU was proposed to account for this phenomenon.

The project studied the following questions (slightly rephrased for clarity):

> Do the explanations proposed in the literature regarding the importance of salt and chain length for the anomalous swelling agree with the results we obtain when the two parameters are varied simultaneously? Do we obtain results that further support the prevalent model or contradict it? What information do our results provide about the interlamellar forces in the system? (p. 3, our translation)

The students reported their conclusions in a 129-page report (Niss et al, 2001).

This project concerns a model-based explanation of an already identified phenomenon in physics, namely anomalous swelling, and the extent to which this explanation agrees with some novel experiments performed by the project group. With its focus on matters internal to physics, it is clearly a *within* project.

While the phenomenon of "anomalous swelling" may have practical applications, with the actual scope, the project is about understanding and explaining the phenomenon without regard to the practical consequences. Thus, the problem investigated is an intellectual one.

The project *Study on the Simultaneous Discovery of the Conservation of Energy, and in particular on the Works of Mayer, Colding, Joule and Helmholtz* (our translation) was carried out by three physics students in 1992. The problem statement reads

> "On the basis of an interpretation of Mayers, Colding's, Joules' and Helmholtz's respective formulations of a general principle of the conservation of energy in one form or another, it is examined what agreement there exists between the four formulations and what prerequisites each scientist had for putting them forward." (p. 3, our translation)

In this project, the students took a historical approach and read and compared the original work on conservation of energy of the four scientists mentioned in the problem statement. Furthermore, they studied what particular knowledge enabled the scientists to put forward the conservation principle. Thus, the project sheds light on how principles may emerge in physics. The project report contains 92 pages. (Arleth et al, 1992)

This is clearly an intellectual problem *about* physics as a discipline.

Five science students carried out the project *Determination of the Rolling Resistance of Rubber Balls on a Rotating Plane* in 2015. The project studied methods for reducing rolling resistance, an important factor in lowering fuel consumption and reducing fossil fuel use. Determining rolling resistance, which causes energy loss to heat and leads to vehicle deceleration, requires simple and reliable measurement techniques. In this work, the problem statement reads

> "Can a rolling resistance coefficient be determined through experiments with a rubber ball on a rotating, hard surface, and is the method we use to determine the magnitude of the rolling resistance coefficient appropriate?" (p. 12, our translation)

Thus, this project focuses on bringing the experimental methods of physics to bear on this problem motivated by the real-world problem of reducing fuel consumption through reduced rolling resistance. Hence, it is clearly an intellectual problem in physics addressing a problem of practice by *means of* physics. The project report consisted of 95 pages (Gylling et al., 2015).

The six examples just presented show how very different intellectual problems within, about and by means of mathematics and physics have been dealt with in discipline-specific problem-oriented project work that possesses all the crucial properties characteristic of POPW. These projects gave rise to essential academic learning for the students involved. Moreover, two of the three projects also demonstrate how problems, which are intellectual from an academic perspective, can have a highly significant impact on problems of practice outside an academic context.

Concluding remarks

Given that POPW and PBL have been around and gained momentum in tertiary education for nearly sixty years, it is worth acknowledging that no overarching conceptual framework to encompass all the key aspects of POPW and PBL has been universally agreed upon. On the contrary, different – if not competing – conceptualisations and associated frameworks exist. These frameworks differ, for instance, in their emphasis on problems of practice versus intellectual problems, on socially/society relevant issues versus issues with a broader focus, on professions- versus discipline-oriented study programmes, and on skills-focused versus competence-focused study programmes.

It seems that these differences sometimes represent antagonistic positions trying to dominate "the marketplace", in some cases even to the point where certain positions exert what might be called *hegemonic reductionism* over other positions. One component in this reductionism is a single position's insistence on knowing what happens in, and is important across, all academic domains, typically leading to *coerced harmonisation* of the structure and organisation of markedly different study programmes, without paying due respect to the need for substantive knowledge of the nature and characteristics of different academic domains, a knowledge which only scholars and scientists within the respective domains possess.

We find this state-of-affairs markedly problematic and harmful to the quality of academic programmes. In line with this view, we argue that dealing with discipline-oriented intellectual problems is very important and relevant, also for problem-oriented project work within, about, and by means of academic disciplines. Our position is certainly not that such projects should be the only ones dealt with in POPW, just that they should have "civil rights" within the entire spectrum of academic programmes centred around such work. We sincerely hope that such an inclusive view may be underway at Roskilde University.

References

Adolphsen, J. (1999). Why 'why' and why not 'what' or 'how'? In H. S. Olesen, & J. H. Jensen (Eds), *Project studies: A late modern university reform* (pp. 253-256). Roskilde Universitetsforlag.

Andersen, A. S., & Kjeldsen, T. H. (2015a). Theoretical foundations of PPL at Roskilde University. In A. S. Andersen & S. B. Heilesen (Eds). *The Roskilde model: Problem-oriented learning and project work*, (pp. 3-16). Springer. https://doi.org/10.1007/978-3-319-09716-9_1

Andersen, A. S., & Kjeldsen, T. H. (2015b). A critical review of the key concepts in PPL. In A. S. Andersen & S. B. Heilesen (Eds). *The Roskilde model: Problem-oriented learning and project work*, (pp. 17-35). Springer. https://doi.org/10.1007/978-3-319-09716-9_2

Arleth, L., Dybkjær, G. I., & Østergård, M. T. (1992). *Undersøgelse om energiens bevarelse og i særdeleshed om de af Mayer, Colding, Joule og Helmholz udførte arbejder*. Roskilde Universitetscenter, Tekster fra IMFUFA, 232.

Blomhøj, M., & Kjeldsen, T. H. (2009). Project organised science studies at university level: exemplarity and interdisciplinarity. *ZDM Mathematics Education, 41*, 183–198 (2009). https://doi.org/10.1007/s11858-008-0102-3

Christiansen, F. V. (2001). Projektarbejde i naturvidenskabelige grundfag (in Danish). *Papers from DCN, 12* (2nd ed.). Dansk Center for Naturvidenskabsdidaktik.

Christiansen, T. G., Hansen, N. S., & Iversen. C. (1993). *Radontransformationen og dens anvendelse i CT-scanning*. Roskilde Universitetscenter, Tekster fra IMFUFA, 244.

Christensen, G. (2017). The didactics of group work: Between means and aims in theory and practice. In A. Qvortrup & M. Wiberg (Eds.), *Dealing with conceptualisations of learning: Learning between means and aims in theory and practice* (pp. 81-90). SensePublishers. https://doi.org/10.1007/978-94-6351-029-5_7

Cornwall, M., & Schmithals, F. (1977). *Project-orientation in higher education: proceedings of the seminar 'Project-orientation in higher education for science and science-based professions', Bremen, 23-26 March 1976.* Brighton Polytechnic.

Cronbach, L. J., & Suppes, P. (1969). *Research for tomorrow's schools: Disciplined inquiry for education.* Macmillan.

Dahl, B., Hüttel, H., Rasmussen, J. G., & Rasmussen, M. G. (2023). Contextualisation in university level problem-based learning. *For the Learning of Mathematics*, *43*(3), 27-31.

Dewey, J. (1938). *Logic: The theory of inquiry*. Henry Holt & Company.

Dræby, C., Hansen, J. S., Johansen, R. U., Maibom, P., & Nielsen, J. K. (1993). *Patologiske eksempler. Om sære matematiske fisks betydning for den*

matematiske udvikling. Roskilde Universitetscenter, Tekster fra IMFUFA, 240.

Feldt, J. E., & Petersen, E. B. (2021). Inquiry-based learning in the Humanities: Moving from topics to problems using "the Humanities Imagination". *Arts and Humanities in Higher Education*, *20*(2), 155-171. https://doi.org/10.1177/1474022220910368

Gylling, A. R., Lillevang, L. B., Nielsen, A. T., Petersen, M. S., & Thorsboe, M. L. (2015). *Determination of the rolling resistance of rubber balls on a rotating plane*. Roskilde University. Retrieved July 1, 2026, from kb.dk.

Habbal, F., Kolmos, A., Hadgraft, R. G., Holgaard, J. E., & Reda, K. (2024). *Reshaping engineering education: Addressing complex human challenges*. Springer Nature. https://doi.org/10.1007/978-981-99-5873-3

Illeris, K. (1974). *Problemorientering og deltagerstyring: Oplæg til en alternativ didaktik*. Munksgaard.

Illeris, K. (1981). *Modkvalificeringens pædagogik: Problemorientering, deltagerstyring og eksemplarisk indlæring*. Unge pædagoger.

Kerszmann, G. (1977). What is a project? In M. Cornwall & F. Schmithals (Eds.) *Project-orientation in higher education: proceedings of the seminar 'Project-orientation in higher education for science and science-based professions', Bremen, 23-26 March 1976*. Brighton Polytechnic.

Knudsen, S. (2009). Har du et problem? En undersøgelse af universitetsstuderendes forståelse, anvendelse og kommunikation af problemorienterede vidensproblemer. *Dansk Universitetspædagogisk Tidsskrift*, *4*(7), 49-57. https://doi.org/10.7146/dut.v4i7.5597

Niss, K., Skimminge, A., Thormann E., & Timmermann, S. (2001) *En undersøgelse af solvents og kæde-længdes betydning for anomal swelling i phospholipiddobbeltlag*. Roskilde Universitetscenter, Tekster fra IMFUFA, 397.

Niss, M. (2025). Active and agentic: Participant-directed inquiry in an introductory science programme. In Svabo, C., Shanks, M., Zhou, C., Carleton, T. (Eds), *Creative pragmatics for active learning in STEM education*. Contributions from Science Education Research, vol 14. Springer, Cham. (pp. 79-87) https://doi.org/10.1007/978-3-031-78720-1_4

Niss, M. A. (2001). University mathematics based on problem-oriented student projects: 25 years of experience with the Roskilde model. In D. Holton (Ed.), *The teaching and learning of mathematics at university level. An ICMI study*. New ICMI Study Series, volume 7, (pp. 153-165). Kluwer Academic Publishers. https://doi.org/10.1007/0-306-47231-7_14

Olesen, H. S., & Andersen, A. S. (2015). The Roskilde model and the challenges for universities in the future. In A. S. Andersen & S. B. Heilesen (Eds). *The Roskilde model: Problem-oriented learning and project work*, (pp. 263-280). Roskilde Universitetsforlag. https://doi.org/10.1007/978-3-319-09716-9_17

Olsen, P. B., & Pedersen, K. (2008). *Problem-oriented project work* (2nd ed.). Roskilde Universitetsforlag.

RUC (2026a). Problem-oriented project learning. Retrieved June 22, 2026 from https://ruc.dk/en/problemoriented-project-learning-pedagogical-model-roskilde-university.

RUC (2026b). *Interdisciplinarity at Roskilde University*. Retrieved June 22, 2026 from https://libguides.ruc.dk/ppl-english/foundationaldocuments

RUC (2026c). *Pedagogical profile at Roskilde University*. Retrieved June 22, 2026 from https://libguides.ruc.dk/ppl-english/foundationaldocuments (accessed 22.6.2026)

Simonsen, B., & Ulriksen, L. (1999). *Universitetsstudier i krise*. Roskilde Universitetsforlag.

Ulriksen, L. (1997). *Projektpædagogik – hvorfor det?* Erhvervs- og uddannelsesgruppen, Roskilde Universitetscenter.

Zoet, A., Følsgaard, J. M., Pedersen, R. K., & Freiman, K. E. D. (2015). *On the strategies used to attack unsolved mathematical problems – a case study of the Collatz Conjecture*. Roskilde University. Retrieved June 25, 2026, from kb.dk.

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 22-37
doi.org/10.54337/ojs.jpblhe.v14i1.10581

Equipping Students for Wicked Problems

The Potential of Problem-based, Challenge-based and Transdisciplinary Learning to Encourage Contextual, Constructive, Collaborative and Self-regulated Learning

Diana Dolmans * | Maastricht University, Netherlands
Boukje Compen | Maastricht University, Netherlands
Hans Savelberg | Maastricht University, Netherlands

Abstract

The world is facing many wicked problems, including climate change, political polarisation, scarcity of natural resources and inequal access to quality health care and education. Education has an important role to play by equipping students with the competencies needed to navigate an unpredictable future with these systemically interwoven challenges. Next to problem-based learning, challenge-based education and transdisciplinary learning are educational approaches increasingly being implemented to better prepare students. In this theoretical paper, we demonstrate how the design principles of contextual, constructive, collaborative and self-regulated learning (CCCS) inform the student-centered approaches of problem-based learning, challenge-based education and transdisciplinary learning and prepare students to better understand wicked problems. We refer to scientific evidence behind the CCCS

* Corresponding author:
Diana Dolmans, Email: d.dolmans@maastrichtuniversity.nl

Received 18 July 2025 | Accepted 13 March 2026 | Available online in Early View 13 May 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

principles and make a plea on how to bridge these with the three approaches to teaching. Nevertheless, we acknowledge that success of a particular approach in one context does not guarantee success elsewhere. What works best is dependent on many variables, including the intended outcomes, the particular target group of students, the assessment formats and teachers' experiences with these approaches.

Keywords: Problem-based learning; challenge-based learning; transdisciplinary learning

Introduction

The world is facing major challenges, including climate change, political polarisation, scarcity of natural resources and inequal access to quality health care and education (e.g. Tassone et al., 2018; UN DESA, 2024). These challenges could be identified as 'wicked problems', as they have a variety of characteristics; i.e. these problems are difficult to define and hard to solve because stakeholders have conflicting values on what the problem is and how it can solved, and because these problems are often interconnected with other problems (Rittel & Webber, 1973; Lönngren & van Poeck, 2020). The diversity of values of perspectives of actors involved, make wicked problems challenging to understand, make it difficult to find better solutions and to forecast outcomes.

Education is tasked with the responsibility of equipping students with the competencies needed to navigate their demanding role in an unpredictable future (Veltman et al., 2019; Head & Alford, 2015). Students should learn to embrace challenges and learn that uncertainties are inherent to wicked problems. Furthermore, they should be willing to learn from failures and to take responsibility. However, earlier studies focusing on the higher education setting have shown that not all teaching approaches, for instance lecture-based education, are suitable to develop such competencies among students (O'Neill & Short, 2023). Therefore, we need to critically reflect on the teaching approaches adopted by higher education institutions and assess their potential to equip students to better understand wicked problems (Bowman et al., 2024; Van Rijnsoever et al., 2023).

In this theoretical paper, we argue that student-centred approaches to teaching align with the social-constructivist paradigm (i.e. the idea that knowledge is constructed by and between people, gained through dialogue and interactions with others), as opposed to a positivist paradigm (i.e. where knowledge is

considered absolute, objective, and generalisable) (Jonassen, 1991; Tangney, 2014).

Problem-based learning is an example of a student-centred teaching approach fitting well within the social-constructivist paradigm in which knowledge is considered as being constructed by interactions with others. Problem-based learning is influenced by philosophers such as Dewey, cognitive psychologists, and scientific evidence, but also grounded in practice and inspired by what others tried when innovating education in the time and context in which it is situated (Servant-Miklos & Schmidt, 2016).

Problem-based learning has been implemented on a large scale for decades. While it has been implemented worldwide, its exact format has been adjusted to the needs and practicalities of particular contexts. Nowadays, we see many new approaches being implemented next to problem-based learning, such as challenge-based education and transdisciplinary learning. In this theoretical paper, we explain that all three approaches belong to a family of student-centred approaches that are characterized by four related underlying principles: contextual, constructive, collaborative and self-regulated learning (CCCS principles), theoretical principles fitting within the social-constructivist paradigm (Dolmans et al., 2005, Dolmans, 2019, Dolmans et al., 2021, Schmidt, 1993).

In this paper, we also refer to scientific evidence behind these principles and make a plea on how to bridge the four principles with practice and the three approaches to teaching. We aim at combining and bridging constructivism with pragmatism, given that we need to make decisions on what works in practice, preferably based on justifying why it might work. Explaining and justifying why an approach might work will contribute to a better understanding of how the approach might work in a local context, and how it might work in other contexts.

This theoretical paper is aimed at explaining the CCCS principles and illustrates how these principles fit with problem-based learning, challenge-based education and transdisciplinary learning and equip students for wicked problems. It starts with an explanation of the four CCCS principles underlying student-centred approaches and how they might support students in developing competencies needed to navigate wicked problems. We will then explain problem-based learning, challenge-based education and transdisciplinary learning as examples of student-centred approaches in higher education that fit well with the four CCCS principles. Finally, we will argue that the success of these approaches ultimately depends on how the four principles are implemented in practice, and that there is no one-size fits all solution, and

we will reflect on the limitations of the four CCCS principles and their implementation in practice.

The CCCS principles and how they could contribute to equipping students for wicked problems

How should higher education prepare students to better understand wicked problems? Bowman et al. (2024) argue that we should offer teaching approaches with room for discovery, experimentation, learning from mistakes, and students taking agency to understand different perspectives and adapt to changes. Instead of reducing complexities, uncertainties and value differences in higher education, we should embrace teaching approaches that prepare students for change by confronting them with open learning practices in which they address new, unknown challenges. These approaches prepare students to be creative, open-minded, curious, flexible, adaptive, and teach them to embrace uncertainties, which are important when dealing with wicked problems (Bowman et al., 2024). In the next paragraphs, we will explain the principles of contextual, constructive, collaborative and self-regulated (CCCS) learning and, how these principles may have the potential to prepare higher education students to better understand wicked problems.

Contextual learning

The principle of contextual learning emphasises the importance of organising learning around authentic, real-world problems, tasks or projects derived from professionally or societally relevant contexts. In traditional curricula, subjects tend to be delivered in separate strands or disciplines and detached from meaningful contexts. For example, knowledge is transferred in lectures, whereas skills are developed in separate skills training sessions. The risk of this compartmentalised approach is that there is limited transfer of what is learnt to practice. Contextual learning supports students in developing an integrated set of knowledge, skills and attitudes which is known to enhance transfer of learning to similar as well as new situations or contexts (Van Merriënboer & Kirschner, 2017). In other words, when designing education, teachers ideally start from a varied set of meaningful, authentic problems that are relevant for the future profession or society to enhance integration and transfer of what is learnt to practice and support students to transfer what they learn to an increasingly varied set of real-world problems or equip them for wicked problems (Van Merriënboer & Kester, 2008).

Constructive learning

The second principle, constructive learning, concerns the importance of encouraging students to actively construct and restructure their knowledge and mental models. This principle is known to stimulate students to gain a deep understanding of the subject they are studying (Dolmans et al., 2016, Gijbels et al., 2005, Hung et al, 2019). This can be done by stimulating students to activate their prior knowledge and encouraging them to generate meaningful relations between their prior knowledge and new knowledge. Constructive learning can also be enhanced by asking students to explain in their own words what they have learnt, by stimulating them to ask and answer critical questions, and by having them discuss cognitive disagreements to gain a deeper understanding about the why behind certain phenomena. Understanding the why is known to enhance transfer to novel problems which prepares students for future learning (Carbonell et al., 2014).

Collaborative learning

The third principle refers to students learning from, with and about each other, while discussing problems. Collaborative learning is beneficial when students build on each other's ideas through open dialogues around complex problems. Conditions for effective collaborative learning are that students are mutually dependent and that they have a common goal (Dillenbourg, 1999). Preferably, students engage, interact and exchange ideas with other students, teachers and researchers and other stakeholders from diverse backgrounds, such as societal partners or industries, and both within and outside academia. Learning with others can also have beneficial effects on the students' needs to feel related to others which is known to enhance students' autonomous motivation (Ryan & Deci, 2017).

Self- regulated learning

The final principle is about students learning to self-direct or self-regulate their learning. The emphasis in self-*directed* learning is on students' role in choosing learning tasks of their own interest that fit with their learning needs (Loyens et al, 2008). Self-*regulated* learning is about setting goals, planning and conducting learning activities, monitoring, reflecting on, and evaluating learning, from a meta-cognitive perspective (Zimmerman, 2002). As self-directed and self-regulated learning have many aspects in common, we use the term self-regulated learning in this paper. Stimulating students to self-regulate their learning will support them to take control and agency of their own learning. Students can be facilitated to become self-regulated learners by stimulating them to choose which learning activities fit their needs, for example, but also by encouraging them to set goals that need further study, to select relevant sources

to study, and to self-monitor and reflect on their performance and set new goals. This principle is complex as we need to find the right balance between stimulating students to self-regulate their learning and simultaneously offering students support to scaffold their learning. The amount of support needs to be adapted to the student's level of self-regulation. Not only cognitive self-regulation is important, but also the regulation of students' motivation. Making students feel autonomous, related and competent is known to enhance their autonomous motivation (Ryan & Deci, 2017).

When the four CCCS principles are all integrated in teaching approaches, this could support higher education institutions in delivering graduates that are equipped to understand wicked problems. By organising curricula around complex real-life tasks, students' ability to learn to deal creatively with the wickedness of today's challenges is benefited (Bowman et al., 2024). In other words, this may contribute to 'helping foster an education for society' (Tassone et al., 2018, p.344) and to developing students' 'sensibilities to manage challenges and the unknown wickedness' (Bowman et al., 2024, p. 1374). Learning around real-world problems prepares students to become familiar with and learn how to approach new, unpredictable wicked problems (Veltman et al., 2025). Teachers have an important role to play when it comes to students' engagement in student-centered teaching approaches, they need content expertise, but also to know how to deal with this expertise, i.e. by asking questions, and they should know how to facilitate the students' learning, i.e. by asking students to give arguments (Dolmans et al., 2002). Collaborative learning, and especially when students are encouraged to collaborate within an interdisciplinary team and with various external stakeholders within and beyond academia, ensures that students learn how to cross boundaries between the potentially varying values, interests and perspectives of parties that are involved in today's and tomorrow's major challenges (Bowman et al., 2024; Penttilä & Kairisto-Mertanen, 2013). Finally, self-regulated learning, achieved by ensuring that students have autonomy in determining their own learning goals to address problems, and teachers stimulating students to take the lead themselves, contributes to a desirable sense of agency and autonomous motivation in students (Ryan & Deci, 2017; Zhu et al., 2025). In sum, the four principles of contextual, constructive, collaborative and self-regulated (CCCS) learning have the potential to prepare higher education students to better understand wicked problems.

Implementing these principles in practice is not easy. Education is complex in nature given that many different variables are at play and interact with one another: student characteristics, teacher characteristics, the content and format of learning materials, the way in which students are assessed, the intended learning outcomes etc. Cianciolo and Regehr (2019) emphasise the importance

of making a distinction between principles and techniques when analysing learning environments. Principles, such as the CCCS principles explained above, could be considered as theories about how pedagogical and didactical choices in complex contexts affect students' learning and development. Principles offer explanations about how learning environments might enhance student learning. Principles can be used to generalise or transfer findings from one context to another. However, Cianciolo and Regehr (2019) acknowledged that the way in which principles are implemented in practice can vary significantly. They captured this idea with the term technique, which refers to the way in which education is eventually shaped and looks like in daily practice. Large groups of students might hinder students to deeply interact with each other, students who are used to lecture-based education might also face difficulties when being confronted with student-centered teaching, and the same holds for teachers; i.e. their prior experiences and beliefs might hinder them to adapt to student-centered approaches.

The CCCS principles have been described in the literature as important principles underlying problem-based learning (Dolmans et al., 2005, Dolmans, 2019, Dolmans et al., 2021, Schmidt, 1993). We would like to argue that the CCCS principles also fit well with more recently introduced types of student-centred approaches, including challenge-based education and transdisciplinary learning in which wicked problems are used as the starting point of learning. The three approaches have many similarities but also unique characteristics. In the following section, we will describe these approaches in more detail. We will give examples of what each approach could look like in practice.

Three student-centred approaches in higher education

Problem-based learning

In problem-based learning (PBL), a problem or case – typically a description of a set of phenomena that need to be explained – serves as starting point and provides a meaningful context for learning. This can be a written case, a simulated case or a real case. Students meet in groups of 10-12 students to discuss the problem, facilitated by a teacher. Students typically activate their prior knowledge and discuss their knowledge gaps and what to further explore during self-study. In a next meeting they report to each other what they have learnt, raise questions and discuss disagreements. One of the students leads the team discussions. The teacher stimulates the students' thinking by asking critical questions and provides support to guide the process and the group dynamics. The primary aim of this approach is to help students to learn to better understand the problem and to learn how to apply knowledge in practice,

rather than to encourage the development of problem-solving skills (Neville et al., 2019). Although PBL might look slightly different across contexts, in essence all students will work on problems in small groups of students, facilitated by a teacher.

PBL was introduced in the field of health professions education and has been implemented on a large scale for decades. When this teaching approach was introduced over fifty years ago it was largely based on assumptions about what type of learning environment supports student learning best. Years of extensive research have taught us that the CCCS principles discussed earlier can be beneficial to student learning. Dependent on how these principles are implemented in a certain setting, PBL can result in a high level of student satisfaction and deep learning in students (Dolmans et al., 2016, Gijbels et al., 2005, Hung et al, 2019). In addition, it has been shown that PBL can enhance acquisition of generic competencies, such as effective communication and dealing with uncertainties (Hmelo-Silver, 2004; Gijbels et al., 2005, Dolmans et al., 2016).

Problem-based learning in practice – Example

> In groups of 10 and facilitated by a teacher, students work on a professionally relevant, complex problem. In this case, they are expected to learn about elderly living in their own home and the various cognitive, physical and social challenges they are facing in their daily life. This problem is studied from multiple perspectives or disciplines (psychology, nursing, geriatrics, social work). Students meet several times to discuss this problem. During the first meeting they analyse the problem, activate their prior knowledge and formulate issues in need of further self-study. After self-study they meet again to discuss their findings and synthesize what they learnt. Next to these meetings, additional learning activities in relation to this problem are offered, such as expert meetings or a skills training session. This hypothetical example is inspired by Claeys et al. (2022).

Challenge-based education

In challenge-based education (CBE), interdisciplinary student teams learn around real-world, open-ended problems for which solutions are not readily available. Within CBE, students learn through collaboration with other students and stakeholders outside academia (Gallagher & Savage, 2020). The unique characteristics of this approach are its focus on including external stakeholders who are often the problem owners. Students, teachers and external stakeholders or problem owners collaborate in finding solutions for the challenge that is mostly provided by the external stakeholder. There is a strong focus on helping

students to connect knowledge and theories available within universities with real world practices. Student teams are encouraged to find innovative solutions for challenges faced in practice by stakeholders outside academia. Students are assumed to take the lead in their own learning, to acquire and apply knowledge relevant to the challenge, and to transfer this knowledge to practice (Helker et al., 2024). CBE is primarily implemented in higher education institutions that focus on STEM education (i.e. science, technology, engineering and math) (Gallagher & Savage, 2020).

Challenge-based learning in practice – Example

> Students work on a challenge that is provided by a company that develops robots and other technological solutions that could potentially address elderly people who face loneliness. This company is an external stakeholder and the so-called problem owner. The group is expected to develop an innovative technological solution to the problem. Students work together during multiple sessions over a period of several weeks to develop an innovative prototype. They are offered various activities to guide their work, for instance design-thinking activities. The students in the group come from different disciplines and collaborate closely with entrepreneurs of the company and a teacher from the university. The external partner can be consulted for advice, while the teacher's role is to coach the students. This hypothetical example is inspired by Claeys et al. (2022).

Transdisciplinary learning

Transdisciplinary learning (TDL) encourages students to learn from addressing complex, open-ended real-world challenges while collaborating with stakeholders from both within and beyond academia. The unique characteristics of this approach is its focus on co-learning. In transdisciplinary learning, the learning of all stakeholders is key. All stakeholders should feel responsible and learn from and with each other to establish an environment in which co-learning between students and external partners takes place (Gulikers et al, 2025). Besides academic knowledge, experiential knowledge is considered highly relevant. Integration and co-construction of scientific and experiential knowledge is core, with the aim of creating impact on society (Bernstein, 2015; Visscher et al., 2022; Visscher, 2024). Transdisciplinary learning fosters a process in which learning not only happens in students, but in all stakeholders (Visscher, 2024). In participatory transdisciplinary learning, all participants are learners in co-creation processes (Gulikers et al., 2025). This journey requires coaching and a supportive learning environment, that is open to experimentation, ambiguity and uncertainty (Veltman et al., 2021). Students in transdisciplinary settings are offered opportunities to discover what their

personal values and motivations are and learn to deal with major challenges (Gulikers & Oonk, 2019).

Transdisciplinary learning (TDL) in practice – Example

> Students from different disciplines, for instance nursing, occupational therapy, social work and dietetics, work together on a complex challenge faced by elderly. They meet several times with elderly people who are living at home, as well as with their caregivers, to gain a better understanding of the needs of the elderly. They discuss the needs of the elderly and together search for solutions. Students collaborate closely with the network of the elderly to make a positive impact on their lives, for instance by supporting them to strengthen their social relations or health management. As not only the learning needs of the students are addressed but also the needs of the patients, co-learning or mutual learning is assumed to take place. A teacher or coach facilitates the student learning. This process usually takes multiple sessions over a period of weeks. This example is adjusted from Claeys et al. (2022).

Reflection and conclusion

The world is facing wicked problems. Instead of reducing complexities, higher education should emphasise uncertainties and differences in values to equip students with the competencies needed to navigate their demanding role in an unpredictable future (Gulikers & Oonk, 2019; Van Rijnsoever et al., 2023). In this paper, we explained the CCCS principles and illustrated how these principles fit with problem-based learning, challenge-based education and transdisciplinary learning and equip students for wicked problems. These approaches have many elements in common but also have unique characteristics. In PBL, problems derived from real life are discussed that should be studied by students from multiple perspectives or disciplines. In challenge-based education, the focus lies on challenges owned by external stakeholders that need innovative solutions. And finally, in transdisciplinary learning, making societal impact takes centre stage by emphasizing the importance of co-learning among students, teachers and societal partners. Although, the examples might suggest that challenge-based education is typically applied in technical education and transdisciplinary learning in a social context, this is not the case. Challenge-based education and transdisciplinary learning can be applied in social or technology settings.

Despite the potential of these approaches in equipping students to better understand wicked problems, we also emphasise that the approaches described

above are continuously on the move and in practice have many different shades. Which approach might work best, depends on the intended learning outcomes, and on how they are implemented in practice. In particular, it is important that the learning activities, intended learning outcomes and the assessment are well aligned (Biggs, 1996). For instance, although problem-based learning is often associated with active and deep learning, this might not happen when students perceive a high workload or when they perceive that their assessment is not rewarding deep learning. The students' and teachers' prior learning experiences as well as their beliefs about problem-based learning also shape their behaviours to adopt a student- or teacher centered approach to teaching in problem-based learning.

We would like to draw attention to a few final aspects in relation to this theoretical paper.

First, it is important to consider the authors' backgrounds, as these might have influenced their thinking. All three authors work in a context in which problem-based learning has been implemented for many years. The authors have investigated problem-based learning for many years, not only in Maastricht but also in other countries, such as Indonesia, and they all have experience with teaching in problem-based learning in practice.

Second, we acknowledge that the principles and approaches described in this manuscript are not exhaustive, and that they have evolved over time and will further evolve, based on philosophical views or paradigms, scientific evidence, and experiences in diverse contexts. All approaches to teaching are continuously being reinvented, based on our ideas about knowledge, scientific evidence, experiences in practice, what we value and societal changes.

The CCCS principles allow for a fluid, flexible and variable implementation, for instance problem-based learning and challenge-based education can be offered in a multi-, inter- or transdisciplinary manner. There are many approaches that might work and more principles that matter, but within this theoretical paper we explain why and how these four CCCS principles fit well with three contemporary approaches to teaching.

Third, success of a particular approach in one context does not guarantee success elsewhere; there is no one-size fits all approach that works in any given context (Dolmans et al, 2021). The success of teaching approaches depends on factors such the intended learning outcomes, didactical and pedagogical expertise of teachers, and potential constraints, such as the assessment format,

the experience and beliefs of the student and the teacher, that might limit implementing an approach in a particular context. It would be suboptimal, for

example, to administer individual knowledge tests when the intended learning outcome is to make societal impact or to find an innovative better solution for a challenge faced by an external stakeholder.

Finally, the four principles and three approaches, problem-based learning, challenge-based education and transdisciplinary learning, might prepare students for their future contribution in a complex society with wicked problems in which they have to better understand complex problems and have to learn to deal with uncertainties, but further research is needed on how to optimize the design of these approaches to enhance student learning.

References

Bernstein, J. H. (2015). Transdisciplinarity: A review of its origins, development, and current issues. *Journal of Research Practice*. *11*(1), 1-20.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher education*, *32*, 347-364. https://doi.org/10.1007/BF00138871

Bowman, S., Salter, J., Stephenson, C., & Humble, D. (2024). Metamodern sensibilities: toward a pedagogical framework for a wicked world. *Teaching in Higher Education*, *29*(5), 1361-1380. https://doi.org/10.1080/13562517.2022.2151835

Carbonell, K. B., Stalmeijer, R. E., Könings, K. D., Segers, M., & van Merriënboer, J. J. (2014). How experts deal with novel situations: A review of adaptive expertise. *Educational Research Review*, *12*, 14-29. https://doi.org/10.1016/j.edurev.2014.03.001

Cianciolo, A. T., & Regehr, G. (2019). Learning theory and educational intervention: producing meaningful evidence of impact through layered analysis. *Academic Medicine*, *94*(6), 789-794.

Claeys, T., Dolmans, D. H., & de Nooijer, J. (2022). Design and evaluation of a team-based interprofessional practice placement: A design-based research approach. *Medical Teacher*, *44*(8), 866-871. https://doi.org/10.1080/0142159X.2022.2041188

Dolmans, D. H., Gijselaers, W. H., Moust, J. H., Grave, W. S. D., Wolfhagen, I. H., & Vleuten, C. P. V. D. (2002). Trends in research on the tutor in problem-based learning: conclusions and implications for educational practice and research. *Medical Teacher*, *24*(2), 173-180. https://doi.org/10.1080/01421590220125277

Dolmans, D. H., De Grave, W., Wolfhagen, I. H., & Van Der Vleuten, C. P. (2005). Problem-based learning: Future challenges for educational

practice and research. *Medical education*, *39*(7), 732-741. https://doi.org/10.1111/j.1365-2929.2005.02205.x

Dolmans, D. H., Loyens, S. M., Marcq, H., & Gijbels, D. (2016). Deep and surface learning in problem-based learning: a review of the literature. *Advances in Health Sciences Education*, *21*(5), 1087-1112. https://doi.org/10.1007/s10459-015-9645-6

Dolmans, D. H. (2019). How theory and design-based research can mature PBL practice and research. *Advances in health sciences education*, *24*, 879-891. https://doi.org/10.1007/s10459-019-09940-2

Dolmans, D, Woei, H, Frambach, J.H. (2021). Problem-based learning. In: Dent, J., Harden, R. M., & Hunt, D. (Eds.). *A Practical Guide for Medical Teachers: A Practical Guide for Medical Teachers,* Chapter 19, pages 155-162. E-Book. Elsevier health sciences.

Dillenbourg, P. (1999). What do you mean by collaborative learning?. In Dillenbourg, P., *Collaborative learning: Cognitive and Computational Approaches.*, Oxford: Elsevier, pp.1-19

Dolmans, D., Hung, W., Frambach, J.H. (2021). Problem-based learning. In Dent, J., Harden, R. M., & Hunt, D. (Eds.), *A Practical Guide for Medical Teachers: A Practical Guide for Medical Teachers,* Chapter 19, pages 155-162. E-Book. Elsevier health sciences.

Gallagher, S. E., & Savage, T. (2020). Challenge-based learning in higher education: an exploratory literature review. *Teaching in Higher Education*, *28*(6), 1135–1157. https://doi.org/10.1080/13562517.2020.1863354

Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of educational research*, *75*(1), 27-61. https://doi.org/10.3102/00346543075001027

Gulikers, J., & Oonk, C. (2019). Towards a rubric for stimulating and evaluating sustainable learning. *Sustainability*, *11*(4), 969. https://doi.org/10.3390/su11040969

Gulikers, J., Khaled, A., Visscher, K., & Visscher-Voerman, I. (2025). Transdisciplinary learning environments that stimulate co-creation and co-learning between students and external partners: an empirical exploration. *Humanities and Social Sciences Communications*, *12*, 1768. https://doi.org/10.1057/s41599-025-06079-x

Head, B. W., & Alford, J. (2015). Wicked problems: Implications for public policy and management. *Administration & society*, *47*(6), 711-739. https://doi.org/10.1177/0095399713481601

Helker, K., Bruns, M., Reymen, I. M., & Vermunt, J. D. (2025). A framework for capturing student learning in challenge-based learning. *Active Learning in Higher Education*, *26*(1), 213-229. https://doi.org/10.1177/14697874241230459

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational psychology review*, *16*(3), 235-266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hung, W., Dolmans, D. H., & Van Merriënboer, J. J. (2019). A review to identify key perspectives in PBL meta-analyses and reviews: trends, gaps and future research directions.*Advances in Health Sciences Education*, *24*(5), 943-957. https://doi.org/10.1007/s10459-019-09945-x

Jonassen, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm?. *Educational technology research and development*, *39*(3), 5-14. https://doi.org/10.1007/BF02296434

Lönngren, J., & van Poeck, K. (2020). Wicked problems: a mapping review of the literature. *International Journal of Sustainable Development & World Ecology*, *28*(6), 481–502. https://doi.org/10.1080/13504509.2020.1859415

Loyens, S. M., Magda, J., & Rikers, R. M. (2008). Self-directed learning in problem-based learning and its relationships with self-regulated learning. *Educational psychology review*, *20*, 411-427. https://doi.org/10.1007/s10648-008-9082-7

Neville, A., Norman, G., & White, R. (2019). McMaster at 50: lessons learned from five decades of PBL. *Advances in health sciences education*, *24*, 853-863. https://doi.org/10.1007/s10459-019-09908-2

O'Neill, G., & Short, A. (2023). Relevant, practical and connected to the real world: what higher education students say engages them in the curriculum. *Irish Educational Studies*, 1–18. https://doi.org/10.1080/03323315.2023.2221663

Penttilä, T., & L. Kairisto-Mertanen (2013). Developing Innovation Competences Through Boundary Crossing in a Social Learning Environment. In Lehto, A., & Penttilä, T. (Eds.), *Pedagogical Views on Innovation Competencies and Entrepreneurship. Innovation Pedagogy and Other Approaches*, 34–44. Turku: Turku University of Applied Science.

Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy sciences*, *4*(2), 155-169. https://doi.org/10.1007/BF01405730

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford publications. https://doi.org/10.1521/978.14625/28806

Schmidt, H. G. (1993). Foundations of problem-based learning: Some explanatory notes. *Medical Education*, *27*(5), 422-432. https://doi.org/10.1111/j.1365-2923.1993.tb00296.x

Servant-Miklos, G., & Schmidt, H. (2016). Revisiting 'Foundations of problem-based learning: some explanatory notes'. *Medical Education*, *50*(7), 698-701. https://doi.org/10.1111/medu.12803

Tangney, S. (2014). Student-centred learning: a humanist perspective. *Teaching in higher Education*, *19*(3), 266-275. https://doi.org/10.1080/13562517.2013.860099

Tassone, V. C., O'Mahony, C., McKenna, E., Eppink, H. J., & Wals, A. E. (2018). (Re-) designing higher education curricula in times of systemic dysfunction: A responsible research and innovation perspective. *Higher Education*, *76*, 337-352. https://doi.org/10.1007/s10734-017-0211-4

UN DESA, (2024). The Sustainable Development Goals Report 2024 – June 2024. New York, USA: UN DESA. https://unstats.un.org/sdgs/report/2024/.

Van Merriënboer, J. J., & Kester, L. (2008). Whole-task models in education. In Jonassen D., Spector, M.J., Driscoll, M., Merrill, M.D., van Merriënboer, J.J., & Driscoll, M. P. (Eds.), *Handbook of research on educational communications and technology* (pp. 441-456). Routledge.

Van Merriënboer, J. J., & Kirschner, P. A. (2017). *Ten steps to complex learning: A systematic approach to four-component instructional design*. Routledge. https://doi.org/10.4324/9781315113210

Van Rijnsoever, F. J., Sitzler, S., & Baggen, Y. (2023). The change agent teaching model: Educating entrepreneurial leaders to help solve grand societal challenges. *The International Journal of Management Education*, *21*(3), 100893. https://doi.org/10.1016/j.ijme.2023.100893

Veltman, M. E., Van Keulen, J., & Voogt, J. M. (2019). Design principles for addressing wicked problems through boundary crossing in higher professional education. *Journal of Education and Work*, *32*(2), 135-155. https://doi.org/10.1080/13639080.2019.1610165

Veltman, M. E., Van Keulen, J., & Voogt, J. M. (2021). Using problems with wicked tendencies as vehicles for learning in higher professional education: Towards coherent curriculum design. *The Curriculum Journal*, *32*(3), 559-583. https://doi.org/10.1002/curj.100

Veltman, M. E., Van Keulen, J., Smits, A. E. H., & Voogt, J. M. (2025). Examining student profiles for dealing with wickedness. *Journal of Vocational Education & Training*, *77*(3), 819-845. https://doi.org/10.1080/13636820.2024.2320898

Visscher, K., Johnson, C., MacLeod, M., & van der Veen, J. (2022). Multi-, inter- and transdisciplinarity in challenge-based engineering education. In H.-M. Järvinen, S. Silvestre, A. Llorens, & B. Nagy (Eds.), SEFI 2022 50th Annual Conference of The European Society for Engineering Education, 19-22 September, Barcelona, Spain: Towards a new future in engineering education, new scenarios that European alliances of tech universities open up, Proceedings (pp. 1786-1794). European Society for Engineering Education (SEFI). https://doi.org/10.5821/conference-9788412322262.1176

Visscher, K. (2024). Transdisciplinaire uitdagingen voor onderwijsvernieuwers. Inaugural lecture.

Zhu, Y., Dolmans, D., Kusurkar, R. A., Köhler, S. E., Abidi, L., & Savelberg, H. (2025). Promoting students' autonomous motivation for the ongoing curriculum using a 'Societal Impact Project'with basic psychological needs characteristics. *Medical Teacher*, *47*(6), 955-962. https://doi.org/10.1080/0142159X.2024.2388804

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into practice*, *41*(2), 64-70. https://doi.org/10.1207/s15430421tip4102_2

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 38-64
doi.org/10.54337/ojs.jpblhe.v14i1.10158

EIPA-PBL: An Embedded, Real-Time Approach to Individualised Performance Assessment in Problem-Based Learning Tutorials

A Pilot Instrument-Development Study

Colin Greengrass * | RCSI Medical University of Bahrain (RCSI-MUB), Bahrain

Abstract

Problem-based learning (PBL) tutorials are designed to make learning visible through collaborative inquiry, yet the evidence generated in these settings is often collective, distributed and difficult to attribute to individual students. Programmes must nevertheless make defensible individual judgements for feedback, remediation, progression and, in some contexts, summative assessment. This creates a persistent assessment problem: the process evidence most relevant to PBL is difficult to capture, while the scores required for institutional decision-making risk compressing collaborative performance into overly simple or performative measures. Existing approaches, including peer ratings, group products, post-session tutor judgements and lengthy item-based instruments, may provide limited individualisation or impose substantial rater burden. This pilot instrument-development study reports the design and initial evaluation of EIPA-PBL, an Embedded Individualised Performance Assessment approach for PBL tutorials. EIPA-PBL uses a schematic seating map and a small set of observable indicators to record individual learning-relevant behaviours during tutorials. Individualisation refers to the generation of

* Corresponding author:
Colin Greengrass, Email: cgreengrass@rcsi-mub.com

Received 4 May 2025 | Accepted 22 June 2026 | Available online in Early View 3 July 2026 | Published 26 November 2026
© 2026 The Author. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

individual evidence profiles within a shared indicator framework, rather than the use of different criteria for different students. Data from 37 medical students across five PBL modules yielded 43 student-module enrolment records and approximately 7,000 coded indicator events. Intraclass correlation coefficients showed indicator-specific cross-session patterns, while exploratory factor analysis suggested coherent clustering of background knowledge, ideas and minor contributions, with major contributions and questions requiring refinement. Student feedback provided preliminary acceptability evidence. The study broadly supports feasibility and preliminary construct exploration, but inter-rater reliability, response-process evidence and consequences research remain necessary. EIPA-PBL is presented as a candidate framework for formative, portfolio and bounded low-stakes summative use.

Keywords: problem-based learning; individualized assessment; group work assessment; tutorial assessment; observational assessment; collaborative learning; performance indicators

Introduction

Problem-based learning (PBL) tutorials are designed around collaborative inquiry, wherein learners engage with complex and often ill-structured problems (Savery, 2006) to identify learning needs, undertake self-directed study and return to the group to test explanations, revise understanding and develop shared accounts of the problem (Barrows & Tamblyn, 1980; Dolmans et al., 2005; Hmelo-Silver, 2004). Dillenbourg (1999) highlighted that collaborative learning allows components of cognition to become externalised through articulation at multiple levels within the process, requiring students to explain their thinking to others. In this regard, tutorial participation is not peripheral to learning in PBL – it is one of the principal means by which students make developing understanding available for negotiation and revision, through explanation, questioning and the collaborative construction of problem scaffolds (Chi & Wylie, 2014; Hmelo-Silver & Barrows, 2008; Webb, 1989).

This creates a specific assessment challenge. PBL activity is fundamentally collaborative, whereas institutional decisions about progress, feedback, and remediation are invariably made at the individual-student level. Shared outputs, such as group explanations, whiteboard summaries, learning objectives or presentations, cannot easily show how each student contributed to the collaborative task (Dijkstra et al., 2016; Strijbos, 2011). In PBL tutorials, evidence of individual contribution is often scattered across brief moments of interaction, different phases of the tutorial, and both formal and informal roles.

Assessment therefore needs to recognise the group collaborative setting while still preserving evidence of each student's contribution within it.

The need for individual-level evidence is further underscored by the documented impact of assessment on participation within PBL. Czabanowska et al. (2012) noted the presence of free riders who may feign active involvement, whilst Savin-Baden (2004) observed that without assessment, students are more prone to rote memorisation, description rather than critique, and selective attendance. Van Berkel and Schmidt (2000) further demonstrated that individual commitment is the most potent determinant of achievement in PBL sessions – supporting the view that assessment within PBL may be necessary to ensure active participation.

A further difficulty is that assessment of performance in teams may be negatively impacted by approaches requiring uniform behavioural demonstration from all group members. A specific set of behaviours outlined in a rubric may lead group members to adhere to a mental checklist they feel obligated to demonstrate, potentially hindering the natural flow of collaborative activities (Bearman & Ajjawi, 2018; Torrance, 2007). Teamwork theory describes performance as a dynamic process involving differentiated and complementary transition, action and interpersonal processes varying with task phase and group need (Kozlowski & Ilgen, 2006; Marks et al., 2001; Salas et al., 2005). Within a single session, different students may advance the same collaborative task through entirely different contributions, none of which need be displayed uniformly.

Various methods of assessment of performance in PBL sessions have been documented within review articles (MacDonald, 2005; Nendaz & Tekian, 1999), with process-oriented instruments most commonly utilising post-session tutor ratings or peer evaluation (Segers & Dochy, 2001). TUTOTEST, for example, provides a structured approach to tutorial assessment, but its 44-item format illustrates the burden generated when tutors must judge several students across multiple domains (Hébert & Bravo, 1996). More recent instruments such as the Collaborative Learning Development Exercise (CLeD-EX) provide structured tutor feedback on collaborative learning behaviours in medical students after the session (Pervaz Iqbal et al., 2020), and observational tools have been developed to code instructor and student behaviours in classroom and PBL contexts (Alimoglu et al., 2014). Nevertheless, many of these approaches remain post-session or retrospective, requiring tutors to translate complex interaction into global ratings after the event. Eva (2001) described potential psychometric weaknesses arising from tutors being expected to evaluate numerous qualities simultaneously for multiple students, with assessors prone to recall bias and anchoring to memorable events from tutorials that may have taken place

several weeks earlier (Eva et al., 2007; Gingerich et al., 2014; Norman et al., 2006; Tavares & Eva, 2013).

In this study, a form of assessment was designed to address these limitations by recording performance variables for individuals in real time, without assuming that all students must demonstrate the same indicators in the same way. EIPA-PBL is an embedded, real-time observational assessment approach using a schematic representation of the tutorial seating arrangement and a limited shared repertoire of performance indicators. It enables each group member to contribute within naturally assumed roles and collaborative task demands, while preserving individual-level evidence within the collective activity. The construct of interest is observable individual performance within collaborative PBL taskwork – the behaviours through which a student contributes to the group's work of constructing, testing and revising explanations of a problem. EIPA-PBL is therefore intended to record observable performance within the tutorial process, not to provide a comprehensive measure of student learning, motivation or personal qualities as a team member.

In practical terms, individualised assessment means that the tutor records what each student actually does during the tutorial, using the same set of indicators for everyone, and then interprets each student's pattern of evidence in relation to their role, opportunities and contribution to the group task. It does not mean that different students are assessed by different standards; rather, it means that students may demonstrate valuable performance through different combinations of observable behaviours. Fairness is therefore understood as assessment of the same underlying construct through a transparent interpretive framework, rather than as a requirement that all students display the same behaviours.

This pilot study developed EIPA-PBL and explored its feasibility, cross-session indicator behaviour and preliminary internal structure during live PBL tutorials. The study addressed three development questions: (1) Could EIPA-PBL be completed during live PBL sessions while still allowing tutorial facilitation? (2) How did its indicators behave across repeated tutorial sessions, given the expected context-sensitivity of PBL performance? (3) What preliminary internal structure was suggested by exploratory factor analysis, and what did this imply for instrument refinement?

Theoretical framing

Externalised cognition and observable tutorial performance

The theoretical basis for observing performance in PBL is that tutorial discourse externalises parts of the learning process. Collaborative learning requires students to explain, justify, question, compare and revise ideas, making aspects of cognition visible to peers and tutor (Dillenbourg, 1999; Hmelo-Silver & Barrows, 2008; Mercer, 2000). These explanations support elaboration and restructuring of knowledge, whilst peer interaction prompts learners to identify gaps and refine understanding (Slavin, 1996; Webb, 1989). The ICAP framework distinguishes passive, active, constructive and interactive modes of engagement, providing theoretical support for the view that interactive and constructive behaviours offer stronger evidence of learning activity than attendance or silent exposure alone (Chi & Wylie, 2014). Crucially, ICAP's argument rests on overt, observable student behaviours as proxies for cognitive engagement modes – a position which directly supports the validity of event-level behavioural recording as meaningful evidence of learning-relevant activity.

This does not mean that all learning is visible. Silent listening, private reflection and internal cognitive reorganisation may be educationally important. The construct claim for EIPA-PBL is therefore deliberately bounded: the instrument records learning-relevant behaviours that occur within tutorial activity, not the totality of student learning.

Distributed cognition and individualised assessment within a shared framework

PBL tutorial activity can be understood as a distributed cognitive system in which understanding is constructed across participants, artefacts (whiteboard, notes, concept maps) and shared talk (Hutchins, 1995; Stahl, 2006). Within such a system, individual contributions are best interpreted relationally: their significance depends on the state of the group task, the role being occupied, and the contribution's effect on the developing shared explanation. This is consistent with team-process theory, which treats collective performance as phase-sensitive and role-differentiated rather than behaviourally uniform (Kozlowski & Ilgen, 2006; Marks et al., 2001; Salas et al., 2005). If assessment is interpreted as requiring every student to demonstrate every behaviour, it risks imposing behavioural uniformity on a process that functions through differentiation. The implication for EIPA-PBL is that the shared indicator framework provides a common language for observation, while each student's profile records the particular pathway through which they contributed to the

group task. This addresses the long-recognised "individual within the collective" problem in collaborative learning assessment (Strijbos, 2011) and aligns with collaborative-learning design frameworks that embed assessment within the collaborative task to support equitable participation and valid interpretation of individual roles (de Hei et al., 2016), as well as sustainable assessment approaches emphasising longitudinal, profile-based evidence of learner development (Boud & Soler, 2016).

Rubrics, performativity and the need for a bounded claim

A structured indicator set inevitably resembles a rubric in some respects, and it is important to acknowledge both the utility and the limitations of this parallel. Indicator sets provide a common language for judgement and can support transparency and consistency (Jonsson & Svingby, 2007; Reddy & Andrade, 2010); the claim for EIPA–PBL is not that it avoids structure, but that it uses structure differently. It is an embedded recording schema for contemporaneous evidence capture, not a post–hoc checklist requiring every student to perform every descriptor.

This distinction matters because preset criteria can have unintended educational consequences. Although criteria can support transparency and consistency, they may also narrow attention, encourage strategic compliance and create the misleading impression that complex judgement has been reduced to objective measurement (Bearman & Ajjawi, 2018; Sadler, 2009; Torrance, 2007). Thus, assessed participation can become public performance, particularly where students perceive that visible behaviour is being continuously monitored (Macfarlane, 2015). EIPA-PBL does not remove this risk. However, its indicators are intended to record contributions that materially support the tutorial task, rather than visible activity for its own sake. In this sense, the instrument may direct students towards productive forms of participation, such as questioning, explanation, synthesis, use of background knowledge and responsibility for group process, while making purely performative behaviour less useful unless it contributes to collaborative inquiry.

Most performativity research, however, examines post-hoc rubric-driven assessment; live observational assessment is a comparatively under-developed sub-literature, and the consequences of this design choice require specific examination in real-time tutorial conditions. EIPA-PBL should therefore be understood as a tool that structures tutor observation and feedback while acknowledging that observation may itself influence the behaviour being observed.

Development of EIPA–PBL

Design principles

The development of EIPA–PBL was driven by four practical requirements. The instrument needed to capture evidence during the tutorial rather than relying on memory after the event; employ a manageable number of indicators so that the tutor could continue facilitating whilst recording; document individual evidence within the spatial and social arrangement of the tutorial; and support individualised feedback without requiring uniform behavioural performance from all group members.

The cognitive demand placed on the tutor was central to the design rationale. During a PBL tutorial, tutors must facilitate inquiry, monitor group dynamics, attend to content accuracy, support psychological safety and observe individual learners (Hmelo-Silver & Barrows, 2006). An embedded assessment instrument must therefore be usable under conditions of limited working memory and ongoing interactional demand (Cowan, 2010; Tavares & Eva, 2013). Cognitive load theory further suggests that instructional or assessment designs should minimise unnecessary processing demands so that limited cognitive resources can be directed toward the task itself (van Merriënboer & Sweller, 2010). This is particularly important in rater–based assessment, where judgement is shaped by attention, memory, interpretation and workload (Gingerich et al., 2014; Tavares & Eva, 2013). Criterion efficiency is therefore essential: each additional indicator imposes a continuous cognitive cost while the tutorial unfolds. For this reason, EIPA–PBL uses a small indicator set and a schematic spatial layout. Spatial representations can support memory and interpretation by organising semantic and spatial relations in a single visual field (Kulhavy & Stock, 1996; Scott & Schwartz, 2007).The seating map reduces the need to translate student identity into rows in a table and provides a visual organiser for linking observed events to individual students.

Selection of performance indicators

Indicators were selected to represent observable manifestations of collaborative cognition and taskwork in PBL, whilst remaining feasible for real–time recording. The intention was not to measure every desirable interpersonal quality; rather, indicators were chosen to represent behaviours through which students make thinking visible, advance problem analysis, support group process and contribute to task completion. These categories should be understood as event classes rather than broad personality traits or fixed competencies, selected because each represents a plausible and observable route through which a student may contribute to collaborative inquiry. The criteria utilised are as follows:

Responsibility refers here to observable process–regulation behaviours rather than to a general personal quality. It includes actions that organise, direct or stabilise the group's work, such as guiding the group through problem analysis, prompting the next step, supporting the leader or scribe, keeping the group aligned with the learning task and helping the group transition from discussion to identification of self–directed learning needs. In this sense, responsibility is used as practical shorthand within the EIPA–PBL schematic for process leadership or task regulation. It should not be interpreted as a judgement that a student is generally "responsible", nor should isolated or opportunistic gestures be over–valued where they do not materially support the group's taskwork. This interpretation is grounded in team–process theory and self–regulated learning, in which effective collaboration requires planning, monitoring and regulation (Johnson & Johnson, 2005; Marks et al., 2001).

Background knowledge records the use of relevant factual or conceptual knowledge during the tutorial. The PBL process depends on the activation of prior knowledge and elaboration through discussion (Schmidt, 1983; Schmidt et al., 2011); where students introduce relevant facts, mechanisms, definitions or clinical relationships, they provide resources which the group can test, connect and use in constructing an explanation. This indicator therefore represents an important pathway through which individual preparation and prior knowledge become visible within the group.

Ideas and creative thinking records generative reasoning. In PBL, students do not merely retrieve facts; they propose hypotheses, construct explanations, identify alternative interpretations and build problem representations (Hmelo-Silver, 2004; Nijstad & Stroebe, 2006). This criterion records acts that redirect the group's reasoning, propose new explanatory frames, challenge an erroneous line of thought, support development of a problem scaffold or produce a useful representation on the whiteboard.

Questions are recorded because questioning is central to inquiry within PBL. A question can reveal a knowledge gap, test an assumption, request clarification, challenge a claim or direct the group toward deeper reasoning (Chin & Osborne, 2008; King, 1994). This criterion aligns with metacognitive monitoring, in which learners use questions to check and regulate their comprehension (Schraw & Dennison, 1994), and with elaborative interrogation, where generating explanatory questions promotes deeper learning.

Minor contributions and *major contributions* were included for a pragmatic reason rooted in the realities of real–time observation. As Gingerich et al. (2014, p. 1058) note, "there can be no such thing as 'objective' observation of performance"; raters must, in real time, decide how to categorise events whilst subsequent events continue to occur. *Minor contribution* (notation – open circle) therefore

serves as a low–inference record of brief or difficult–to–classify participation, preventing data loss when an event cannot confidently be coded under a more specific indicator within the available time. *Major contribution* records extended or substantial turns. These categories were not designed to replace the more specific indicators but to maintain the feasibility of embedded recording under time pressure; their later behaviour in factor analysis is therefore particularly informative for instrument refinement, as discussed below.

The schematic format and the null marker

The instrument is presented as a schematic map of the tutorial space (Figure 1). Each student is represented in a position corresponding to the seating arrangement, and the tutor marks indicators directly within the student's space on the schematic. This format affords the tutor immediate visual awareness of emerging participation patterns, including students with sparse records, dominant speakers and students not yet invited into the discussion. The schematic is therefore not merely a visual style – it is part of the instrument's cognitive and equity logic, enabling real–time awareness of participation balance across the group.

The null marker was included to distinguish between not being invited to participate and declining or not responding when directly invited. Non–participation may reflect social loafing (Karau & Williams, 1993; Latané et al., 1979), low confidence, limited preparation, language barriers, exclusion by the group (Visschers-Pleijers et al., 2006) or internal processing. The null marker is primarily diagnostic and formative: it is intended to prompt tutor attention to participation equity and to enable timely corrective intervention, rather than to function as a negative score in any summative system.

Operational definitions

In applying operational definitions, *background knowledge* is acceptable when the student introduces knowledge helping the group clarify the problem, test an explanation, identify a mechanism or decide what must be learned next; it should not reward disconnected fact–listing. *Ideas and creative thinking* is acceptable when the student produces generative movement in group understanding – proposing a hypothesis, reframing the problem, challenging a mistaken assumption, connecting previously separate points or producing a useful whiteboard representation. The terms *minor* and *major contribution* should not be understood as simple measures of value: a *minor contribution* (notation – open circle) records a brief, relevant act that supports the tutorial but cannot be sufficiently classified under a more specific indicator in real time, whilst a *major contribution* (notation – closed circle) records an extended or

substantial act which – as the factor analysis forthwith makes clear – is not always equivalent to higher–order collaborative performance.

Negative behaviour was operationalised narrowly because negative marking carries greater interpretive and ethical risk than the recording of positive task contributions. The marker was reserved for repeated or clearly disruptive observable acts that materially impeded collaborative inquiry, such as persistent interruption after redirection, dismissive responses to peer contributions, verbal dominance that prevented others from participating, or actions that repeatedly derailed the task. It was not intended to capture isolated lapses, enthusiasm-driven interruptions, anxiety-related behaviours, neurodivergent communication patterns, second-language processing or cultural differences in interaction style. The same surface behaviour may have different meanings in different contexts; negative marking should therefore be treated as a contextual judgement about behaviour within the specific tutorial task setting, not as evidence of personality, motivation or professionalism. This reflects a central principle of EIPA-PBL: indicators are operational categories for observable tutorial performance, not labels for stable personal traits.

Use of EIPA–PBL data and scoring

EIPA–PBL has formative, portfolio and bounded summative uses. Because the instrument generates indicator–specific records, it can support targeted feedback on the pattern of a student's performance; i.e. frequent use of background knowledge but limited questioning, strong responsibility for the group process but limited synthesis, or meaningful questions with few extended explanations. Such profiles are more useful for development than a single global participation score and align with sustainable, longitudinal assessment approaches (Boud & Soler, 2016).

In the implementation reported here, EIPA–PBL data contributed to a low–stakes summative score alongside other forms of assessment. Indicators were assigned weights reflecting their differing importance in the successful conclusion of activities: minor contribution (1), major contribution (2), responsibility (1), ideas and creative thinking (2), background knowledge (2), relevant question (1), negative behaviour (−1) and null response (0). The null marker did not contribute to summative totals, serving only as a diagnostic prompt. It should be noted that where a numerical summary is retained, it represents a compression of the richer evidence profile and should not be treated as the assessment in itself; the profile is the more educationally informative output. Optimal use is formative and portfolio–based, with summative use bounded and undertaken only alongside multiple other sampling points.

Methods

Context and participants

The study took place within an undergraduate medical programme in Riyadh, Saudi Arabia in which PBL formed a core curricular component. Tutorials followed a conventional PBL cycle, consistent with the Maastricht seven-jump logic (Schmidt, 1983), involving initial clarification and problem analysis, identification of learning needs, self-directed preparation between sessions, and subsequent reporting or synthesis phases. Formal roles, including group leader and scribe, were used and rotated across sessions.

Before the main study, two pilot cohorts of 10 students each were assessed to explore whether EIPA–PBL scores showed associations with external performance measures, and how these associations compared with a rubric–based assessment used locally. These pilot data were analysed correlationally and are reported as preliminary construct–relevant evidence only.

The main study included 37 medical students across five PBL modules. Six students completed two modules each, yielding 43 student-module enrolment records across six PBL sessions per module. This produced 258 student-session records in total. Groups ranged in size from 8 to 10 students. Across these records, the schematic generated approximately 7,700 coded indicator events. The dataset was nested, where multiple coded events came from the same student within the same session, and multiple sessions came from the same student and module. These coded events provided a dense observational record, but they were not treated as statistically independent observations.

Ethics, consent and feedback

The study received institutional ethics approval. EIPA–PBL was used as part of normal programme–required low–stakes assessment, regardless of whether students agreed to research participation. Consent therefore covered only the use of routinely collected EIPA–PBL data for research purposes, not participation in any additional activity. All 37 students within the author's assigned PBL groups were invited to consent to the use of their data; all provided written informed consent, and none subsequently withdrew.

Declining consent had no consequence for students' teaching, assessment or relationship with the author. Nevertheless, because the study was conducted within an assessed educational setting in which the author also held a teaching role, students' perceived freedom to decline may have been constrained. To mitigate this, students retained the right to withdraw their data after completion of the programme, when they had progressed into Year 3 Semester

2 clinical placements and were no longer being taught or assessed by the author. This right was reiterated in writing at the point of transition.

Completed EIPA-PBL schematics were used to support brief post-session feedback to students. Feedback focused on patterns of observed contribution, including use of background knowledge, questioning, ideas generation, responsibility for group process and balance of participation, rather than on isolated marks.

Student feedback on the instrument was then collected during brief post-session group discussions in the fourth week of each PBL sequence, broadly following a truncated focus-group format (Stewart et al., 2007). Discussion prompts asked whether EIPA-PBL provided reliable and timely feedback, allowed students to participate freely without consciously performing to assessment criteria, and encouraged participation. Students were also invited to identify negative aspects of the instrument.

Data analysis

Data were analysed using SPSS. Intraclass correlation coefficients (ICC, two–way mixed, average measures, absolute agreement) were calculated to examine indicator–specific patterns across the six sessions. Cross–session ICC values are not interpreted here as a simple test of behavioural stability: PBL performance is expected to vary with case content and prior knowledge (Norman et al., 2006; Schmidt et al., 2011), with formal role assignment (Marks et al., 2001), and with tutorial phase and group dynamics (Hmelo-Silver & Barrows, 2008; Visschers-Pleijers et al., 2006). ICCs are therefore interpreted as descriptive evidence about context–sensitive behavioural profiles rather than as reliability estimates in the conventional sense.

Exploratory factor analysis (EFA) was used to examine the preliminary internal structure of the indicators, serving an epistemological function: to interrogate whether the instrument's theoretically derived categories correspond to functional patterns in observed performance. Indicator counts were converted to within–session proportions, yielding 258 case–observations. Both varimax and oblimin rotations were performed (Costello & Osborne, 2005). Three methodological constraints should be noted. First, the Kaiser–Meyer–Olkin index (KMO = .596) is marginally below the conventional .60 threshold; the analysis is therefore exploratory rather than confirmatory. Second, case–observations are nested within a three–level structure (sessions within enrolments within 37 students, six of whom contributed to two modules), violating the EFA independence assumption at two levels. Third, within–session proportions are compositionally constrained, which can bias factor structure in known ways. These constraints define the EFA as construct

exploration, not validation (Borsboom et al., 2004; Cook et al., 2016; Kane, 2013). A secondary analysis excluding major contributions was also conducted. Given the explicitly exploratory purpose of the analysis and the theoretical interpretability of the emerging structure, both factors were retained for examination.

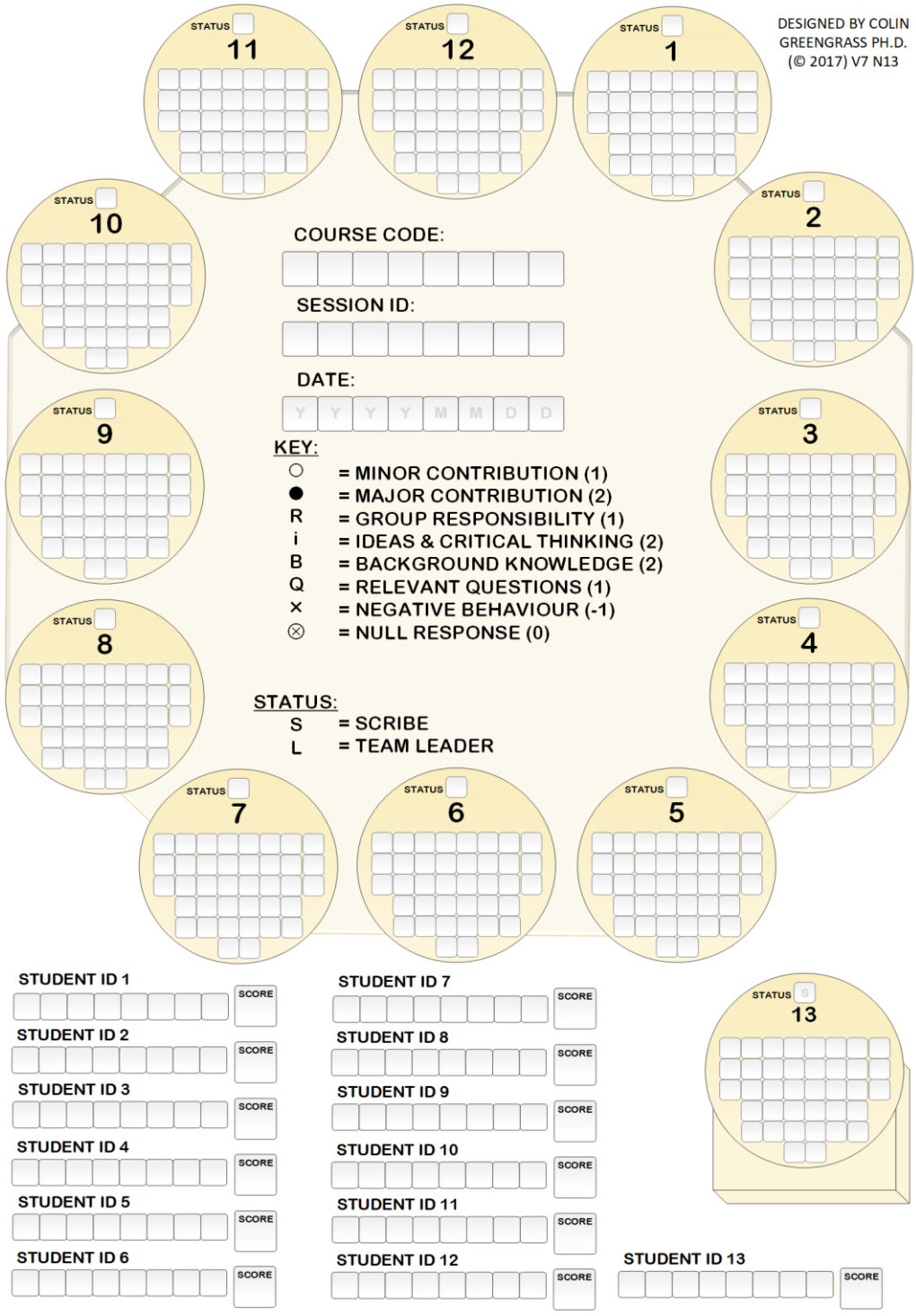


Figure 1. The EIPA-PBL recording schematic.

Positions represent students seated around the tutorial table, with the offset position representing the scribe. Within each student's cell, the tutor records contemporaneous events using the indicator key: minor contribution, major contribution, responsibility, ideas/critical thinking, background knowledge, relevant question, negative behaviour and null response. Numerical values indicate the low–stakes scoring weights used in the implementation reported here; the null marker is diagnostic and does not contribute to the score. The status field records formal tutorial role, such as scribe or leader, allowing indicator patterns to be interpreted alongside role assignment. The schematic is a recording schema, not a grading rubric: students are not expected to display every indicator within a single session. Detailed implementation guidance is available from the author.

Results

Pilot validation evidence

Two pilot cohorts of 10 students each were assessed prior to the main study to explore whether EIPA–PBL scores showed meaningful associations with external performance measures. It is of note that in the first cohort, EIPA–PBL total scores correlated more strongly with final examination performance ($r = .859$, $p < .001$) than did a comparator rubric–based assessment commonly used within the programme ($r = .636$, $p < .05$) – suggesting that the instrument may have captured performance information not represented by the rubric. In the second cohort, this was reinforced: EIPA–PBL scores correlated robustly with both seminar scores ($r = .886$, $p < .01$) and final examination scores ($r = .807$, $p < .05$), whilst the comparator rubric showed no significant correlation with either measure ($r = .18$ and $r = .177$ respectively). Within this second cohort, minor contributions ($r = .712$, $p < .05$) and background knowledge ($r = .759$, $p < .05$) correlated significantly with final examination scores, whilst ideas and questions showed positive but non–significant trends ($r = .626$ and $r = .643$ respectively), suggesting a theoretically interpretable pattern in which the more specific knowledge–oriented indicators were the stronger predictors. Given the small sample sizes, these findings are reported as preliminary construct–relevant evidence rather than validation in the psychometric sense.

Cross–session patterns

In the main study, intraclass correlation coefficients showed indicator–specific patterns across the six sessions. Minor contributions showed high cross–session repeatability (ICC = .884, 95% CI .82–.93). Background knowledge and questions showed moderate repeatability (ICC = .613, 95% CI .388–.778; ICC = .500, 95%

CI .193–.717). Ideas and creative thinking showed lower repeatability (ICC = .486, 95% CI .208–.698). Major contributions showed poor repeatability (ICC = .345, 95% CI –.005–.615), and responsibility showed very poor repeatability (ICC = .149, 95% CI –.370–.517).

These findings are consistent with the design expectation that role–dependent indicators would show lower cross–session stability than role–independent ones. Responsibility is expected to vary with formal role assignment: a student not assigned to a leader or scribe role may have fewer opportunities to display the behaviour in a given session. Major contributions are expected to vary with the case and the phase of the tutorial, as reporting opportunities cluster at particular moments and case complexity varies. Direct testing of these interpretations – by linking ICC values to per–session role assignment and case complexity – was not undertaken and represents a priority for further work. With this caveat, the ICC pattern is consistent with EIPA–PBL being sensitive to the shifting opportunities of tutorial taskwork rather than uniformly unreliable.

Consistency in scores for minor contributions demonstrated a tendency for students who made brief visible contributions in one session to do so similarly in others, suggesting a consistent tendency toward brief visible participation. The moderately good repeatability for background knowledge may more plausibly reflect recurring preparation or prior knowledge. The moderate repeatability for questions implies that subjects who ask questions will consistently do so across sessions, though as discussed below, this consistency may mask multidimensional constructs within the criterion.

Changes across consecutive sessions

A one–way repeated measures ANOVA across six consecutive sessions revealed significant differences for major contributions (Wilks' lambda = .427, $p < .001$, $\eta 2 = .156$), with session 5 showing notably higher counts compared to all other sessions – consistent with the interpretation that major contributions were frequently recording prepared reporting activity concentrated in specific phases. Background knowledge showed significant session effects, but these were not interpreted further because the study was not designed to separate session sequence from case content or tutorial phase. Ideas and creative thinking yielded a significant W–shaped cubic trend ($f(1,42) = 29.73$, $p < .001$, $\eta 2 = .157$), an interesting pattern which may reflect the alternating brainstorming and reporting structure of the sessions. Minor contributions showed no significant session differences. These patterns were calculated from data pooled across five cohorts. The present analysis cannot determine whether session differences reflected the content of particular cases, the roles students occupied,

or the position of the session within the module. Further work would need to model these effects separately.

Internal structure

Exploratory factor analysis loadings are reported in Table 1. Both varimax and oblimin solutions yielded a two–factor structure. Eigenvalues for the retained factors were 1.671 and 1.244, accounting for 34.50% and 24.89% of total variance respectively (approximately 59.4% combined).

Criterion	Varimax F1	Varimax F2	Oblimin F1	Oblimin F2	Oblimin (no major) F1	Oblimin (no major) F2
Minor contributions	.676	.174	.676	.167	.559	.361
Background knowledge	.752	–.170	.752	–.178	.724	.125
Ideas/creative thinking	.527	–.028	.527	–.034	.751	–.293
Questions	.409	.640	.408	.636	–.008	.904
Major contributions	–.322	.768	–.324	.772	–	–
KMO	.596		.596		.617	
Eigenvalues	1.671	1.244	1.671	1.244	1.724	.936
% total variance	34.50	24.89	34.50	24.89	43.11	23.40

Table 1. Exploratory factor analysis loadings for EIPA–PBL indicators. Loadings ≥ .30 are reported and interpreted as suggestive within an exploratory framework, in light of the methodological constraints described in Methods.

Three patterns in the loadings are notable. First, minor contributions, background knowledge and ideas and creative thinking cluster on the first factor. This is theoretically plausible: minor contributions – the low–inference real–time category – appear to be capturing brief instances of knowledge use or idea generation that were difficult to classify under more specific indicators during recording. Their clustering with knowledge and ideas suggests that the

pragmatic decision to include a low–inference category captured meaningful learning–relevant participation rather than random noise.

Second, major contributions loaded on the second factor and against the first (oblimin loadings of –.324 on factor 1 and .772 on factor 2). Rather than clustering with the knowledge–ideas group as a more substantial version of those behaviours, major contributions appears to represent a distinct construct. The component 1 axis is proposed to represent constructs based upon use and synthesis of background knowledge, whilst component 2 may represent a dimension in which higher–order collaborative cognition and lower–order reporting activity sit at opposing ends.

Third, questions loaded moderately on both factors (varimax .409/.640), suggesting it does not behave as a simple unitary construct. Removal of major contributions and re–running the oblimin analysis yielded a structure with KMO = .617, an improvement on the full–set value. In this reduced solution, ideas and creative thinking and background knowledge loaded strongly on the first factor whilst questions loaded almost exclusively on the second (oblimin .904).

Acceptability and implementation

In brief post-session focus-group discussions, students reported that EIPA-PBL provided timely feedback, allowed them to participate without consciously performing to assessment criteria, and encouraged greater engagement in the tutorial process. Open discussion also emphasised the importance of EIPA–PBL occupying a low–stakes position within the programme. Because the discussions were tutor–facilitated within an ongoing assessment relationship, they cannot be interpreted as independent evaluation; they are best treated as preliminary acceptability evidence.

EIPA–PBL was also trialled informally by two additional tutors, who reported that completing the schematic did not prevent monitoring discussion, interacting with students or redirecting thinking strategies (Hmelo-Silver & Barrows, 2006). Only the author's dataset was retained because no formal rater training or inter–rater reliability procedure had been established; inter–rater reliability therefore remains untested.

Discussion

Main contribution

This pilot study contributes an embedded real–time approach to a persistent problem in PBL tutorial assessment: how to generate individual–level evidence within a collaborative learning process. EIPA–PBL does not eliminate standardisation or judgement; it uses a shared indicator repertoire to record individual performance evidence as the tutorial unfolds, supporting profile–based assessment and targeted feedback. This framing preserves comparability whilst recognising that students may contribute differently to group task completion – addressing the long–recognised "individual within the collective" problem (Dijkstra et al., 2016; Strijbos, 2011) through shared construct, transparent indicators and individual evidence profiles.

Several existing instruments share related goals. TUTOTEST and shorter tutorial assessment tools provide structured post–session ratings of tutorial performance (Hébert & Bravo, 1996; Sim et al., 2006; St-Onge et al., 2014); CLeD–EX provides structured feedback on collaborative learning behaviours after the session (Pervaz Iqbal et al., 2020); and observational tools have been developed to code engagement through time–sampled snapshots of selected students (Alimoglu et al., 2014). To the author's knowledge, no published PBL assessment instrument has combined real–time event capture, schematic spatial recording of the seating arrangement, and indicator–type profiling within the live tutorial – these three design features combined within a shared framework to generate individual evidence profiles as the session unfolds.

Factor analysis as construct interrogation

Factor analysis is central to the present argument. It performs an epistemological function: interrogating whether the instrument's theoretically derived categories correspond to functional patterns in observed performance. As Borsboom et al. (2009) argued, many forms of assessment focus only upon adherence to nomological networks rather than interrogating whether the underlying behaviours actually correspond to the theorised constructs. Applied to EIPA–PBL, EFA was utilised to determine not what we believed was occurring within PBL sessions, but what is actually functioning as evidence within the data.

Where indicators cluster as expected, the structure is consistent with the intended interpretation. Where they cluster differently, the data are surfacing construct ambiguity, instrument refinement needs, or a theoretically interesting feature the original design did not anticipate; none of these outcomes is failure.

Validation must accumulate different types of evidence over multiple studies, and EFA contributes one source within this argument (Cook et al., 2016; Kane, 2013).

Indicator–by–indicator interpretation

The clustering of minor contributions with background knowledge and ideas and creative thinking is theoretically interpretable and, in this regard, represents a reassuring finding. The minor category was designed as a low–inference real–time backstop for relevant events that the tutor could not classify under a more specific indicator within the time available; its clustering with knowledge and ideas suggests that this design decision functioned precisely as intended, capturing learning–oriented acts rather than random noise.

The behaviour of major contributions is more challenging and theoretically informative. The indicator separates from the knowledge–ideas cluster and shows poor cross-session reliability — and it is of note that both findings converge on the same interpretation, observed by the author during scoring: that major contributions frequently captured extended reporting from prepared external materials during the reporting phase, rather than substantive participation in the collaborative reasoning process.

This raises a question that factor analysis can identify but not resolve: what is actually occurring when a student produces a major contribution? One possibility is that a student who contributed little to problem analysis may use the reporting phase to gain credit on the strength of reporting – a form of the silent free-riding problem (Czabanowska et al., 2012; Latané et al., 1979), in which strategic visibility substitutes for genuine collaborative cognition. A second possibility is that a student who understands the material but lacks confidence during analysis may hedge by reserving their contribution for the reporting phase, where the social risk is lower; marks are gained but preparation was genuine. The current instrument cannot distinguish among these, and the factor structure suggests it should not try to do so under a single criterion. A dedicated reporting criterion in future iterations would clarify whether reporting–phase behaviour correlates with, or substitutes for, collaborative–phase reasoning in the same student – and might address the more fundamental question of whether presentation of prepared external material constitutes valid evidence of collaborative cognition at all.

The *questions* criterion did not behave as a simple unitary construct, loading on both factors – consistent with the theoretical multidimensionality of questioning (Chin & Osborne, 2008; King, 1994; Schraw & Dennison, 1994), where some questions reflect high–level metacognitive monitoring, others are simple clarifications, and still others may be asked strategically to appear active

rather than from genuine inquiry. Tentatively, the second component may capture a cognitive–depth dimension along which clarification questions and extended reporting sit at opposing ends. Future development could split the criterion or retain it supplemented by anchor examples.

Responsibility showed very low cross–session repeatability, as expected when roles rotate. This supports interpreting the indicator as process regulation within specific task and role contexts rather than as a stable personal attribute. Future iterations should ensure that responsibility captures substantive actions that organise and guide the group's taskwork, rather than isolated visible gestures.

A validity argument for EIPA–PBL

Within Kane's argument–based validity framework (Kane, 2013; Messick, 1995), the present study contributes principally to three inferences. The scoring inference is supported in design: the structured indicator set, schematic format and operational definitions support reliable event recording, although same–event scoring agreement is not directly tested here. The generalisation inference is supported descriptively: multiple sessions can build a profile, although the number of sessions required for stability remains unknown. The extrapolation inference is partially supported: several indicators show internal–structure evidence consistent with intended interpretations; others (major contributions, questions) require refinement. The implications and consequences inferences are not yet addressed. Inter–rater reliability, response–process evidence and consequences research are required before stronger claims (Cook et al., 2016; Govaerts & van der Vleuten, 2013).

Performativity, equity and consequences

A live observational assessment may shape the behaviour it records. Most performativity research treats post–hoc rubric–driven assessment (Macfarlane, 2015; Torrance, 2007); if students treat the indicators as a checklist, they may speak strategically or interrupt inquiry to make performance visible. EIPA–PBL is therefore most defensibly used as a formative, portfolio or low–stakes summative tool within a broader programme (Schuwirth & van der Vleuten, 2011; Uijtdehaage & Schuwirth, 2018; van der Vleuten & Schuwirth, 2019).

The instrument attempts to avoid privileging talkativeness. Quiet students, those working in a second language, and those from cultures where rapid verbal assertion is less normative may contribute through synthesis, careful questioning or support for group process. Because EIPA–PBL is profile–based, such students can be visibly recorded under those indicators rather than penalised for low frequency on speech–dominant criteria. The schematic format

itself surfaces students with sparse records, providing a basis for tutor inquiry. The null marker distinguishes students who are repeatedly passed over from those who decline to respond when invited, prompting tutor questions about group facilitation strategy (Visschers-Pleijers et al., 2006).

Implications for use

EIPA–PBL suits feedback because it records specific behaviours rather than global impressions, and is available immediately after the session rather than reconstructed from memory. A student may be encouraged to move from brief factual contributions toward synthesis, to ask elaborative questions, or to take a more active role in responsibility for the group process. Across multiple sessions, EIPA–PBL generates a profile of how a student contributes across tasks, roles and cases – a basis for coaching aligning with sustainable assessment principles (Boud & Soler, 2016) and with the recommendation that tutors keep systematic records of a core set of behavioural domains (Eva et al., 2007). Low–stakes summative use may be defensible with repeated observations; high–stakes summative use is not currently defensible without further evidence.

Limitations and handover protocol

This study has several important limitations. The main analysed dataset came from a single tutor; inter–rater reliability was not established and is the most significant missing evidence for any stronger summative use. Student feedback was brief and tutor–facilitated and may have been shaped by the assessment relationship. EIPA–PBL records observable behaviours and cannot capture all learning, reflection or internal reasoning. The findings are based on a single PBL context. The sample comprised 37 unique students across 43 enrolment records; six students participated in two modules each, creating a three–level nesting structure that the EFA and ICC analyses were not designed to model explicitly. The EFA was additionally constrained by a sub–threshold KMO and compositional within–session proportions.

Although written consent was obtained and students retained the right to withdraw after the teaching relationship had ended, the study was conducted in a setting where teaching, assessment and research roles overlapped. This may have influenced perceptions of voluntariness despite the zero–consequence design. Future studies should consider independent consent procedures and independently facilitated feedback.

The author no longer works in a PBL programme and cannot extend data collection in this setting; the present article therefore positions EIPA–PBL as a handover framework for further evaluation by other PBL programmes. A

minimal next–stage programme should include: (1) rater training using written vignettes or video clips; (2) same–event scoring studies with multiple raters; (3) repeated live tutorial sampling across cases and roles; and (4) consequences research examining performativity, perceived fairness and group dynamics – steps that map directly onto the inferences of an argument–based validity programme.

Conclusion

EIPA-PBL provides a candidate approach for recording individual performance within live PBL tutorial activity. Its contribution lies in combining real-time event capture, schematic spatial recording and indicator-type profiling within a shared framework for individualised assessment. The pilot findings suggest that several indicators functioned in theoretically interpretable ways, while others, particularly major contributions and questions, may require refinement. Factor analysis is therefore used not to confirm the instrument as validated, but to examine how theoretically derived categories functioned as evidence within observed tutorial performance. In this respect, EIPA-PBL offers a way of testing assumptions about what appears to matter in PBL tutorials against the patterns generated by actual recorded events. At this stage, EIPA-PBL should be understood as a formative, portfolio and bounded low-stakes assessment tool. Further work should establish inter-rater reliability, response-process evidence, consequences for group dynamics and the conditions under which profile-based evidence can support defensible judgement across PBL contexts.

References

Alimoglu, M. K., Sarac, D. B., Alparslan, D., Akman Karakas, A., & Altintas, L. (2014). An observation tool for instructor and student behaviors to measure in-class learner engagement: A validation study. *Medical Education Online*, *19*, 24037. https://doi.org/10.3402/meo.v19.24037

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education*. Springer.

Bearman, M., & Ajjawi, R. (2018). From seeing through to seeing with: Assessment criteria and the myths of transparency. *Frontiers in Education*, *3*, 96. https://doi.org/10.3389/feduc.2018.00096

Borsboom, D., Cramer, A. O. J., Kievit, R. A., Zand Scholten, A., & Franic, S. (2009). The end of construct validity. In R. W. Lissitz (Ed.), *The concept of validity* (pp. 135–170). Information Age Publishing Inc. https://doi.org/10.1108/978-1-61735-269-020251010

Borsboom, D., Mellenbergh, G. J., & van Heerden, J. (2004). The concept of validity. *Psychological Review*, *111*(4), 1061–1071. https://doi.org/10.1037/0033-295x.111.4.1061

Boud, D., & Soler, R. (2016). Sustainable assessment revisited. *Assessment & Evaluation in Higher Education*, *41*(3), 400–413. https://doi.org/10.1080/02602938.2014.999746

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, *49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Chin, C., & Osborne, J. (2008). Students' questions: A potential resource for teaching and learning science. *Studies in Science Education*, *44*(1), 1–39. https://doi.org/10.1080/03057260701828101

Cook, D. A., Kuper, A., Hatala, R., & Ginsburg, S. (2016). When assessment data are words: Validity evidence for qualitative educational assessments. *Academic Medicine*, *91*(10), 1359–1369. https://doi.org/10.1097/acm.0000000000001175

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research & Evaluation*, *10*(1), 7. https://doi.org/10.7275/jyj1-4868

Cowan, N. (2010). The magical mystery four: How is working memory capacity limited, and why? *Current Directions in Psychological Science*, *19*(1), 51–57. https://doi.org/10.1177/0963721409359277

Czabanowska, K., Moust, J. H., Meijer, A. W., Schröder-Bäck, P., & Roebertsen, H. (2012). Problem-based learning revisited: Introduction of active and self-directed learning to reduce fatigue among students. *Journal of University Teaching & Learning Practice*, *9*(1), Article 6. https://doi.org/10.53761/1.9.1.6

de Hei, M., Strijbos, J.-W., Sjoer, E., & Admiraal, W. (2016). Thematic review of approaches to design group learning activities in higher education: The development of a comprehensive framework. *Educational Research Review*, *18*, 33–45. https://doi.org/10.1016/j.edurev.2016.01.001

Dijkstra, J., Latijnhouwers, M., Norbart, A., & Tio, R. A. (2016). Assessing the 'I' in group work assessment: State of the art and recommendations for practice. *Medical Teacher*, *38*(7), 675–682. https://doi.org/10.3109/0142159x.2016.1170796

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1–19). Elsevier.

Dolmans, D. H. J. M., De Grave, W., Wolfhagen, I. H. A. P., & van der Vleuten, C. P. M. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical Education*, *39*(7), 732–741. https://doi.org/10.1111/j.1365-2929.2005.02205.x

Eva, K. W. (2001). Assessing tutorial-based assessment. *Advances in Health Sciences Education*, *6*(3), 243–257. https://doi.org/10.1023/A:1012743830638

Eva, K. W., Solomon, P., Neville, A. J., Ladouceur, M., Kaufman, K., Walsh, A., & Norman, G. R. (2007). Using a sampling strategy to address psychometric challenges in tutorial-based assessments. *Advances in Health Sciences Education*, *12*(1), 19–33. https://doi.org/10.1007/s10459-005-2327-z

Gingerich, A., Kogan, J., Yeates, P., Govaerts, M., & Holmboe, E. (2014). Seeing the 'black box' differently: Assessor cognition from three research perspectives. *Medical Education*, *48*(11), 1055–1068. https://doi.org/10.1111/medu.12546

Govaerts, M. J. B., & van der Vleuten, C. P. M. (2013). Validity in work-based assessment: Expanding our horizons. *Medical Education*, *47*(12), 1164–1174. https://doi.org/10.1111/medu.12289

Hébert, R., & Bravo, G. (1996). Development and validation of an evaluation instrument for medical students in tutorials. *Academic Medicine*, *71*(5), 488–494. https://doi.org/10.1097/00001888-199605000-00020

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hmelo-Silver, C. E., & Barrows, H. S. (2006). Goals and strategies of a problem-based learning facilitator. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1), 21–39. https://doi.org/10.7771/1541-5015.1004

Hmelo-Silver, C. E., & Barrows, H. S. (2008). Facilitating collaborative knowledge building. *Cognition and Instruction*, *26*(1), 48–94. https://doi.org/10.1080/07370000701798495

Hutchins, E. (1995). *Cognition in the wild*. MIT Press. https://doi.org/10.7551/mitpress/1881.001.0001

Johnson, D. W., & Johnson, R. T. (2005). New developments in social interdependence theory. *Genetic, Social, and General Psychology Monographs*, *131*(4), 285–358. https://doi.org/10.3200/MONO.131.4.285-358

Jonsson, A., & Svingby, G. (2007). The use of scoring rubrics: Reliability, validity and educational consequences. *Educational Research Review*, *2*(2), 130–144. https://doi.org/10.1016/j.edurev.2007.05.002

Kane, M. T. (2013). Validating the interpretations and uses of test scores. *Journal of Educational Measurement*, *50*(1), 1–73. https://doi.org/10.1111/jedm.12000

Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, *65*(4), 681–706. https://doi.org/10.1037/0022-3514.65.4.681

King, A. (1994). Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain. *American*

Educational Research Journal, *31*(2), 338–368. https://doi.org/10.3102/00028312031002338

Kozlowski, S. W. J., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest*, *7*(3), 77–124. https://doi.org/10.1111/j.1529-1006.2006.00030.x

Kulhavy, R. W., & Stock, W. A. (1996). How cognitive maps are learned and remembered. *Annals of the Association of American Geographers*, *86*(1), 123–145. https://doi.org/10.1111/j.1467-8306.1996.tb01748.x

Latané, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, *37*(6), 822–832. https://doi.org/10.1037/0022-3514.37.6.822

MacDonald, R. (2005). Assessment strategies for enquiry and problem-based learning. In T. Barrett, I. Mac Labhrainn, & H. Fallon (Eds.), *Handbook of enquiry and problem-based learning: Irish case studies and international perspectives* (pp. 85–94). Centre for Excellence in Learning and Teaching, NUI Galway, in association with the All Ireland Society for Higher Education.

Macfarlane, B. (2015). Student performativity in higher education: Converting learning as a private space into a public performance. *Higher Education Research & Development*, *34*(2), 338–350. https://doi.org/10.1080/07294360.2014.956697

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management Review*, *26*(3), 356–376. https://doi.org/10.5465/amr.2001.4845785

Mercer, N. (2000). *Words and minds: How we use language to think together*. Routledge.

Messick, S. (1995). Validity of psychological assessment: Validation of inferences from persons' responses and performances as scientific inquiry into score meaning. *American Psychologist*, *50*(9), 741–749. https://doi.org/10.1037/0003-066X.50.9.741

Nendaz, M. R., & Tekian, A. (1999). Assessment in Problem-Based Learning Medical Schools: A Literature Review. *Teaching and Learning in Medicine*, *11*(4), 232–243. https://doi.org/10.1207/S15328015TLM110408

Nijstad, B. A., & Stroebe, W. (2006). How the group affects the mind: A cognitive model of idea generation in groups. *Personality and Social Psychology Review*, *10*(3), 186–213. https://doi.org/10.1207/s15327957pspr1003_1

Norman, G., Bordage, G., Page, G., & Keane, D. (2006). How specific is case specificity? *Medical Education*, *40*(7), 618–623. https://doi.org/10.1111/j.1365-2929.2006.02511.x

Pervaz Iqbal, M., Velan, G. M., O'Sullivan, A. J., & Balasooriya, C. (2020). The collaborative learning development exercise (CLeD-EX): An educational

instrument to promote key collaborative learning behaviours in medical students. *BMC Medical Education*, *20*(1), 62. https://doi.org/10.1186/s12909-020-1977-0

Reddy, Y. M., & Andrade, H. (2010). A review of rubric use in higher education. *Assessment & Evaluation in Higher Education*, *35*(4), 435–448. https://doi.org/10.1080/02602930902862859

Sadler, D. R. (2009). Indeterminacy in the use of preset criteria for assessment and grading. *Assessment & Evaluation in Higher Education*, *34*(2), 159–179. https://doi.org/10.1080/02602930801956059

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there a big five in teamwork? *Small Group Research*, *36*(5), 555–599. https://doi.org/10.1177/1046496405277134

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Savin-Baden, M. (2004). Understanding the impact of assessment on students in problem-based learning. *Innovations in Education and Teaching International*, *41*(2), 221–233. https://doi.org/10.1080/1470329042000208729

Schmidt, H. G. (1983). Problem-based learning: Rationale and description. *Medical Education*, *17*(1), 11–16. https://doi.org/10.1111/j.1365-2923.1983.tb01086.x

Schmidt, H. G., Rotgans, J. I., & Yew, E. H. J. (2011). The process of problem-based learning: What works and why. *Medical Education*, *45*(8), 792–806. https://doi.org/10.1111/j.1365-2923.2011.04035.x

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, *19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033

Schuwirth, L. W. T., & van der Vleuten, C. P. M. (2011). Programmatic assessment: From assessment of learning to assessment for learning. *Medical Teacher*, *33*(6), 478–485. https://doi.org/10.3109/0142159X.2011.565828

Scott, B. M., & Schwartz, N. H. (2007). Navigational spatial displays: The role of metacognition as cognitive load. *Learning and Instruction*, *17*(1), 89–105. https://doi.org/10.1016/j.learninstruc.2006.11.008

Segers, M., & Dochy, F. (2001). New Assessment Forms in Problem-based Learning: The value-added of the students' perspective. *Studies in Higher Education*, *26*(3), 327–343. https://doi.org/10.1080/03075070120076291

Sim, S. M., Azila, N. M. A., & Lee, M. S. (2006). A simple instrument for the assessment of student performance in problem-based learning tutorials. *Annals of the Academy of Medicine, Singapore*, *35*(9), 634–641. https://doi.org/10.47102/annals-acadmedsg.V35N9p634

Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, *21*(1), 43–69. https://doi.org/10.1006/ceps.1996.0004

St-Onge, C., Frenette, E., Cote, D. J., & De Champlain, A. (2014). Multiple tutorial-based assessments: A generalizability study. *BMC Medical Education*, *14*, 30. https://doi.org/10.1186/1472-6920-14-30

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. MIT Press. https://doi.org/10.7551/mitpress/3372.001.0001

Stewart, D. W., Shamdasani, P. N., & Rook, D. W. (2007). *Focus groups: Theory and practice, 2nd ed*Sage Publications, Inc. https://doi.org/10.4135/9781412991841

Strijbos, J.-W. (2011). Assessment of (computer-supported) collaborative learning. *IEEE Transactions on Learning Technologies*, *4*(1), 59–73. https://doi.org/10.1109/tlt.2010.37

Tavares, W., & Eva, K. W. (2013). Exploring the impact of mental workload on rater-based assessments. *Advances in Health Sciences Education*, *18*(2), 291–303. https://doi.org/10.1007/s10459-012-9370-3

Torrance, H. (2007). Assessment as learning? How the use of explicit learning objectives, assessment criteria and feedback in post-secondary education and training can come to dominate learning. *Assessment in Education: Principles, Policy & Practice*, *14*(3), 281–294. https://doi.org/10.1080/09695940701591867

Uijtdehaage, S., & Schuwirth, L. W. T. (2018). Assuring the quality of programmatic assessment: Moving beyond psychometrics. *Perspectives on Medical Education*, *7*(6), 350–351. https://doi.org/10.1007/s40037-018-0485-y

Van Berkel, H. J. M., & Schmidt, H. G. (2000). Motivation to commit oneself as a determinant of achievement in problem-based learning. *Higher Education*, *40*(2), 231–242. https://doi.org/10.1023/A:1004022116365

van der Vleuten, C. P. M., & Schuwirth, L. W. T. (2019). Assessment in the context of problem-based learning. *Advances in Health Sciences Education*, *24*(5), 903–914. https://doi.org/10.1007/s10459-019-09909-1

van Merriënboer, J. J. G., & Sweller, J. (2010). Cognitive load theory in health professional education: Design principles and strategies. *Medical Education*, *44*(1), 85–93. https://doi.org/10.1111/j.1365-2923.2009.03498.x

Visschers-Pleijers, A. J. S. F., Dolmans, D. H. J. M., De Grave, W. S., Wolfhagen, I. H. A. P., Jacobs, J. A., & van der Vleuten, C. P. M. (2006). Student perceptions about the characteristics of an effective discussion during the reporting phase in problem-based learning. *Medical Education*, *40*(9), 924–931. https://doi.org/10.1111/j.1365-2929.2006.02548.x

Webb, N. M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research*, *13*(1), 21–39. https://doi.org/10.1016/0883-0355(89)90014-1

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 65-89
doi.org/10.54337/ojs.jpblhe.v14i1.10709

PBL Teachers' Perceptions of Education and Learning Based on Educational Background

Nicolaj Riise Clausen * | Aalborg University, Denmark
Mia Thyrre Sørensen | Aalborg University, Denmark
Niels Erik Ruan Lyngdorf | Aalborg University, Denmark

Abstract

This study investigates how teachers' own educational backgrounds shape their perceptions of education and learning within a problem- and project-based learning (PBL) environment. Drawing on a large-scale survey of 895 teaching staff at Aalborg University, we identify a consistent yet modest pattern: AAU-educated staff place slightly greater emphasis on project-based and collaborative learning, whereas colleagues educated elsewhere assign comparatively more weight to coursework, theoretical grounding, and individual study. These differences suggest that teachers' prior educational experiences inform pedagogical beliefs. We discuss these results in light of the idea that "teachers teach the way they were taught" and of research showing that teacher beliefs emerge from a complex interplay of prior learning experiences, disciplinary cultures, institutional norms, and workplace conditions. By situating educational background within this wider context and

* Corresponding author:
Nicolaj Riise Clausen, Email: nclausen@plan.aau.dk

Received 29 August 2025 | Accepted 5 May 2026 | Available online in Early View 9 June 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

making these perspectives visible, the study adopts a nuanced view and contributes to discussions on faculty onboarding and diversity of teaching practices in pedagogically specific institutions, offering actionable insights for faculty development, onboarding design, and the cultivation of pedagogical cultures capable of leveraging diversity.

Keywords: Teacher Beliefs; PBL; Educational Background

Introduction

In this article, we focus on educators' perceptions of education and learning and examine whether their own educational experiences as students influence their perceptions as teachers. More specifically, we investigate the differences and similarities in perceptions between teachers at a project- and problem-based learning (PBL) university who have received education in this specific environment and those who do not possess an educational background from the same institution. Research on both teacher identity development and faculty teaching practices suggests that teacher beliefs and approaches to teaching are shaped by prior experiences, both as students and as teachers (Flores & Day, 2006; Oleson & Hora, 2014). Former teachers have a strong socialising effect by serving as models of what to do (or not do), and personal learning experiences serve as a lens through which teachers assess new pedagogical ideas (Flores & Day, 2006). Faculty are significantly influenced by their student experiences, which contribute insights that aid in the development of their pedagogical toolkit. Similarly, their personal study habits and learning preferences shape how they engage with students and influence their behaviour in the lecture hall (Oleson & Hora, 2014). While these influential studies establish clear connections between personal histories and teaching practices, fewer have connected such findings to broader beliefs about practising education at an institutional level and to the potential tensions between teachers' personal beliefs and alignment with specific institutional pedagogical models such as PBL. Furthermore, existing research has largely relied on small-scale and in-depth qualitative methods covering personal narratives and case studies (Beijaard et al., 2004; Yan, 2024), which have uncovered the complexities of teacher identity development but have been limited in terms of the generalisability of findings. This study aims to complement existing research using a large quantitative data set. The study is based at Aalborg University (AAU) in Denmark, which, since its establishment in 1974, has been characterised by a project- and problem-based model that is practised and continuously developed throughout the university. The dataset is part of the PBL-future project (2017-2020), a strategic development initiative involving

researchers from various faculties to develop new research-based directions for PBL in a digital age (Kolmos & Ryberg, 2023).

At the beginning of the project, a survey was distributed to establish a baseline for any changes, focusing on staff and students' perceptions of the practices of PBL. An exploratory analysis of the staff survey data from the baseline study revealed significant differences between staff educated at AAU (AAU educated) and staff without an educational background from the institution (non-AAU educated). In this article, we aim to investigate these differences further, guided by the research question:

What are the differences in perceptions of education and learning between teachers who have an educational background from AAU and those educated elsewhere?

The AAU PBL model

To contextualise this study, it is important to briefly introduce the educational model at AAU, since the teachers' perceptions are examined in relation to this framework and help readers to interpret the findings.

Since AAU's inception in 1974, the systemic problem-based group project model has provided the foundational framework. AAU was founded after a wave of student protests in 1968, driven by students' demands for greater influence and control over their education. Inspired by a Marxist critique of bourgeois education, these protesters rejected the traditional professorial model (Servant-Miklos et al., 2019). This critique, along with a steep rise in the number of university students, led to the establishment of Roskilde University Centre in 1972 and AAU in 1974. Both universities were founded on the ideals of a pioneering educational experiment rooted in Illeris' (1974) pedagogical ideas of problem orientation and participant direction, where students start with a self-chosen, authentic, and exemplary problem for their group projects. The AAU model has been developed continuously since then, with shifts in theoretical focus from Marxist influences to theories that emphasise learning as experience and social learning (Kolmos et al., 2004; Servant-Miklos et al., 2019).

Emphasising the problem-based project work in groups, AAU students collaborate in smaller teams, typically comprising 4 to 6 members, on an authentic and exemplary problem. Most project periods begin with a group formation workshop in which the students are either assigned to groups or organise themselves based on interest in overarching themes, either suggested by the faculty or by the students (Bundgaard et al., 2021). In a relatively recent survey of students across all educational programs and semesters at AAU, more than 75% of the respondents reported having extensive or full self-determination during the team-formation process (Clausen & Kolmos, 2019b).

The problem at the outset of the project is typically defined within the scope of a broad thematic framework, and its exemplary nature ensures that the project outcomes apply to similar situations and can be utilised in broader contexts beyond the specific project. As a general rule, the semester comprises 50% project work and 50% coursework, with course activities designed to support students' project work, including introductions to relevant theories and methodologies (Kjaersdam & Enemark, 1994). AAU students report working on projects in more than 90% of semesters, and 70% of students surveyed in a recent study reported spending more than 50% of their study time on project work (Clausen & Kolmos, 2019b). Typically, the students work on a single project each semester, which spans approximately 3 to 4 months. During this period, students engage in various forms of inquiry, such as identifying, defining, and analysing problems; collecting and analysing data; and discussing current results. The results are usually documented in a shared project report, which serves as the basis for an oral group examination (Barge, 2010; Kolmos et al., 2004, 2019). During project work, the group is assigned a supervisor who provides both academic and procedural guidance and who, in collaboration with the group, directs its efforts (Boelt & Clausen, 2023; Illeris, 1981). As in other implementations of PBL, supervisors in AAU PBL generally encourage the students to take on a continuously larger portion of the responsibility and direction while they gradually take on a more facilitative role (Dolmans & Schmidt, 2000; Kolmos et al., 2008; Loyens et al., 2008; Olsen & Pedersen, 2018). The organisation and implementation of this pedagogical approach vary across the university, tailored to suit different programs and contexts. Variations may pertain to project duration, the initial selection and formulation of the problem, and work organisation. A common element is the high level of participant control and student autonomy. Students, given significant autonomy, manage their project activities and collaboration, choosing meeting locations, timing, and methods. An ethnographic study reveals a significant diversity in students' orchestration of group work (Sørensen, 2022; Sørensen et al., 2023). Students organise and manage their work in diverse ways, including meeting frequency, locations, routines, and task division, often balancing social and academic needs. Students adapt practices, finding what works best through ongoing negotiation, combining planning and improvisation, and striking a balance between independence and collaboration.

Previous research on the outcomes of studying in an AAU PBL environment has shown that students become increasingly inclined towards self-direction in learning during their first years at AAU, initially becoming more proficient in self-regulating and subsequently becoming increasingly confident in their ability to direct and influence their success (Clausen, 2021). Another study, albeit exclusively on engineering students, showed that AAU students, when

compared to all other Danish engineering students, self-report a higher level of preparedness for using generic and contextual competences but a lower level of preparedness for using competences more closely related to their natural science domain (Kolmos et al., 2021). Widening the scope, research suggests that PBL can help students become more self-reliant and develop flexible understandings (Hmelo-Silver, 2004), better library skills and study strategies (Blumberg, 2000), and enhance their deep learning (Dolmans et al., 2016).

Methodology

Research design

For this paper, an analysis of a cross-sectional survey study was conducted, drawing on the PBL-future baseline questionnaire distributed to all academic staff at AAU in 2018. As part of the PBL-future initiative, researchers sought to establish a statistical benchmark or baseline prior to experimenting with several strategic teaching interventions. This paper presents the results of an analysis conducted on the staff baseline data, examining differences between staff who reported having completed an education at AAU and those who did not.

Participants

The questionnaire was distributed to 2545 scientific and teaching personnel in May 2018 via SurveyXact (Rambøll Management Consulting, 2018), with two reminders distributed over a two-and-a-half-month collection window. Participation was voluntary, and all participants were synonymised throughout. The email invitation described the purpose, estimated completion time (~15 min) and data protection compliance. In total, 1159 staff responded (45.5 % overall response rate), of whom 1057 confirmed they had taught or supervised within the previous four years. Responses from staff who indicated no teaching activity in the last four years (n = 102) were excluded to ensure current PBL experience. Of those, 895 respondents answered the question "Have you completed an education at Aalborg University?" and as such comprise our sample for this analysis:

Group	**n**	**%**	**Mean age (years)**	**Female %**
Educated at AAU	508	56.8 %	42.5	38.2
Not educated at AAU	387	43.2 %	50.5	35.7

Table 1. Respondent answer to the question: "Have you completed an education at Aalborg University?"

Age and gender profiles follow the general AAU staff population (Clausen & Kolmos, 2019a). The overrepresentation of younger academics within the AAU-educated group is addressed in the limitations section.

Survey construction

The staff baseline questionnaire was co-developed by researchers from all five PBL-future sub-projects. The questionnaire was developed in part to service the entirety of the PBL-future project and was validated and piloted internally in the project. The list of competencies was adapted from previous competency frameworks developed by OECD and UNESCO, previously applied in the PROCEED-2-WORK project, with additional competencies suggested by project participants, reflecting the aims of the project and AAU's digital-age PBL agenda (Clausen & Kolmos, 2019a; OECD, 2014; UNESCO, 2016). After bilingual forward–backwards translation, the questionnaire was offered in Danish and English; respondents could switch language at any point. For additional information on the background, construction, distribution and results from the survey, see Clausen & Kolmos (2019a).

Statistical analysis

All analyses were conducted in SPSS 29 (IBM Corp., 2025). After verifying normality and homogeneity assumptions, we compared AAU educated and non-AAU educated staff on each survey item using independent samples t-tests. The analysis relies on two different results that each provide a statistical answer for their own specific questions, and one qualifies the relevance of the other. Initially, to determine whether there is a difference in answer tendencies between the two populations beyond what can be statistically attributed to chance variance, we provide p-values. The p-values are interpreted in line with commonly applied thresholds for significance testing ($p < 0.05$, $p < 0.01$, $p < 0.001$). Subsequently, to access the magnitude of the relationship, or rather to answer how large the differences we have identified as statistically significant are, we calculate effect sizes using Cohen's d. While p-values indicate whether a difference is unlikely to be due to chance, an effect size indicates how large the difference is in units of the overall spread of the data. Cohen's d is calculated as the difference between group means divided by the pooled standard deviation, so while d=0 means there are no differences between the groups, d=0.5 means that the group's mean is half a standard deviation higher than the second group's. A positive d means the AAU educated group has a higher mean than the non-AAU educated group on that particular question (and a negative d the reverse). As a rule of thumb, $d = 0.20$ reflects a small, $d = 0.50$ a moderate, and $d = 0.80$ a large difference in many psychological experimental contexts (Cohen, 1969). In educational research, however, effects are often smaller, so smaller d-values can still be substantively meaningful (Kraft, 2020, 2023).

Cohen, who developed the measurement and benchmarks, stated that he would recommend his benchmarks only for cases where no better basis for assessing an effect size index could be established (Cohen, 1988). Cohen's benchmarks were derived from a handful of small, tightly controlled psychology lab experiments in the 1960s. In the last two decades, there have been substantial and relevant discussions about the interpretation of effect sizes in educational research, and several benchmarks have been proposed. Early work by Lipsey and Wilson (1993) suggested that the standardised benchmarks developed and revised by Cohen (1969) were appropriate, but later studies have suggested that substantially smaller effect sizes should be expected in educational research (Kraft, 2020, 2023). Kraft argues that educational research is very rarely conducted in environments as tightly controlled as those Cohen used, and that there is now sufficient cumulative evidence to suggest different, contextually specific benchmarks (Kraft, 2020). Based on this understanding and an empirical review of empirical educational studies, he therefore suggests benchmarks that are much more sensitive to smaller differences and thus classifies smaller differences as practically significant. We, however, prefer to exercise caution in this study and consequently employ benchmarks to interpret the effect sizes that fall between those proposed by Cohen and Kraft, as illustrated in Table 2. We also note that any practical inferences from effect sizes should be tempered by contextual factors and ideally substantiated by multiple measurements/questions. Therefore, in this study, we do not base our conclusions on any single data point but rather discuss the overall tendencies revealed by the collective profiling of the questionnaire.

Considering the above-mentioned perspectives, we will in this study report ultimate effect sizes for all statistically significant differences identified, but for the sake of readability, we will apply the following definition of small, moderate and large effect sizes, merging the perspectives of Cohen (1969) and Kraft (2020):

	Cohen (1969)	**Kraft (2020)**	**Intervals applied in this study**
Small	0,2	< 0,05	< 0,1
Moderate	0,5	0,05 - 0,2	0,25 – 0,5
Large	0,8	> 0,2	> 0,5

Table 2. Standardised benchmark overview.

Analysis

For the sake of transparency, we have included all questions from the questionnaire batteries where significant differences were found in the analysis,

highlighting the variables that were both statistically significant (p-value) and practically relevant (effect size). The highlighted variables are, for the sake of readability, split into two colours: Blue for all the variables where the mean values are higher for the AAU educated group and orange for the variables where the mean values for the non-AAU educated group are higher.

Included questions:

1. Please indicate to what extent you agree or disagree with each statement.
2. Please indicate how important you think the following competencies are for students' future work.
3. Here are some statements about project supervision. Please indicate to what extent you agree or disagree with each statement.
4. Which of the following elements do you think should be important priorities in the development of the AAU model of the future?
5. Here are a few questions about the students' learning in the group-based project work. Please indicate to what extent you agree or disagree with each statement.
6. To what extent do you think the following activities help to make the students ready for their future work?

Please indicate to what extent you agree or disagree with each statement 1: Completely disagree - 5: Completely agree				
	AAU?	Mean	Significance	Effect size (Cohens d)
Courses are the basis for project work	Yes	3.79	*	-154
	No	3.94		
There is too much project work for the students to learn enough disciplinary knowledge	Yes	2.11	***	-491
	No	2.69		
Projects are the primary source of the students' learning	Yes	3.65	***	305
	No	3.34		
It is primarily through courses that students learn theoretical knowledge	Yes	3.06	***	-239
	No	3.33		
The use of digital media (video, soundbites, podcasts e.g.) is important for my courses	Yes	3.00		
	No	2.96		
There is a good correlation between the contents of the courses and the students' projects	Yes	3.66		
	No	3.65		
It is crucial that there is a connection between projects and courses	Yes	4.22		
	No	4.34		

Table 3. AAU/Non-AAU educated teaching staff "Please indicate to what extent you agree or disagree with each statement". N=882-890. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Across the seven course-versus-project statements (5-point agreement scale), four showed statistically significant group differences. AAU educated staff agreed more that **"Projects are the primary source of the students' learning"** (M = 3.65 vs 3.34, $p < .001$, $d = 0.31$, moderate). In contrast, non-AAU educated staff agreed more that **"Courses are the basis for project work"** (3.79 vs 3.94, $p < .05$, $d = –0.15$, small), **"There is too much project work for the students to learn enough disciplinary knowledge"** (2.11 vs 2.69, $p < .001$, $d = –0.49$, moderate), and **"It is primarily through courses that students learn theoretical knowledge"** (3.06 vs 3.33, $p < .001$, $d = –0.24$, small–moderate).

For the remaining statement, no significant mean differences emerged. Overall, the pattern suggests that staff who have themselves experienced AAU's problem-based learning environment as students favour project-orientation and less so courses in their pedagogical beliefs, with effect sizes of the group differences ranging from small to moderate.

Please indicate how important you think the following competencies are for students' future work 1: not at all important – 5: extremely important				
	AAU?	Mean	Significance	Effect size (Cohens d)
Ability to perform experiments	Yes	3.51		
	No	3.43		
Business knowledge	Yes	3.57		
	No	3.46		
Knowledge of social issues	Yes	3.70		
	No	3.80		
Creativity	Yes	4.04		
	No	4.00		
Design	Yes	3.18		
	No	3.11		
Theoretical analysis	Yes	3.94		
	No	4.02		
Discipline specific methods	Yes	4.18		
	No	4.17		
Ethics	Yes	3.75		
	No	3.85		
Knowledge of global contexts	Yes	3.59		
	No	3.62		
Lifelong learning	Yes	4.06		
	No	3.97		
Problem solving	Yes	4.67	***	255
	No	4.51		
Knowledge of sustainability	Yes	3.39		
	No	3.42		
Social responsibility	Yes	3.69		
	No	3.77		
Communication	Yes	4.38	*	148
	No	4.27		
Teamwork	Yes	4.44	***	262
	No	4.26		
Innovative thinking	Yes	4.08		
	No	3.98		
Planning	Yes	4.17		
	No	4.14		
Knowledge sharing	Yes	4.20	*	158
	No	4.09		

Management	Yes	3.54		
	No	3.51		
Adaptability to changing tasks	Yes	4.12		
	No	4.03		
Adaptability to changing work forms	Yes	3.96		
	No	3.91		
Strategic thinking	Yes	3.83		
	No	3.85		
Networking	Yes	3.81		
	No	3.75		
Problem analysis	Yes	4.42		
	No	4.41		
Problem formulation	Yes	4.11		
	No	4.13		
Critical thinking	Yes	4.56	**	208
	No	4.43		

*Table 4 - AAU/Non-AAU educated teaching staff * "Please indicate how important you think the following competencies are for students' future work". N=882-890. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Across the 26 competencies listed (5-point importance scale), AAU educated staff rated five competencies significantly more important than did their non-AAU educated colleagues:

- **"Problem solving"** (M = 4.67 vs 4.51, $p < .001$, $d = 0.26$, moderate)
- **"Teamwork"** (4.44 vs 4.26, $p < .001$, $d = 0.26$, moderate)
- **"Critical thinking"** (4.56 vs 4.43, $p < .01$, $d = 0.21$, small–moderate)
- **"Knowledge sharing"** (4.20 vs 4.09, $p < .05$, $d = 0.16$, small)
- **"Communication"** (4.38 vs 4.27, $p < .05$, $d = 0.15$, small)

No competencies were rated significantly higher by the non-AAU educated group, and no other competencies showed statistically significant differences. Taken together, the pattern indicates that staff who previously experienced AAU's PBL environment place moderately greater value on generic, collaboration-oriented, and higher-order cognitive abilities, whereas views on technical or discipline-bound skills remain comparable across groups.

Here are some statements about project supervision. Please indicate to what extent you agree or disagree with each statement 1: Completely disagree – 5: Completely agree				
	AAU?	Mean	Significance	Effect Size (Cohens d)
As a supervisor, I consider it a very important task to get students to think about their work processes	Yes	4.39		
	No	4.33		
Students' learning of the process is more important than the product of the project	Yes	3.91	*	156
	No	3.75		
There is too little time to complete qualified supervision	Yes	3.30		
	No	3.29		
Projects are often theoretically weak when theory is selected on the basis of a problem	Yes	2.30	***	-264
	No	2.61		
It is difficult to formulate project proposals with real-world problems	Yes	2.14		
	No	2.30		
It costs me less resources to give course lessons than to supervise projects	Yes	2.64		
	No	2.69		
It is important that the students work with real-world problems	Yes	4.26	**	218
	No	4.05		
It is easier to involve my research in project supervision than in courses	Yes	3.21	**	230
	No	2.94		
Broad project frameworks make projects more difficult to supervise	Yes	2.77		
	No	2.93		
It is important for me to work at an educational institution with problem-based learning	Yes	4.15	***	396
	No	3.72		

Table 5. AAU/Non-AAU educated teaching staff "Here are some statements about project supervision. Please indicate to what extent you agree or disagree with each statement". N=882-890. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Across the ten statements on project supervision (5-point agreement scale), five showed statistically significant group differences. Compared with colleagues who had not studied at AAU, AAU educated staff agreed more that **"Students' learning of the process is more important than the product of the project"** (M = 3.91 vs 3.75, $p < .05$, $d = 0.16$, small), **"It is important that the students work with real-world problems"** (4.26 vs 4.05, $p < .01$, $d = 0.22$, small), **"It is easier to involve my research in project supervision than in courses"** (3.21 vs 2.94, $p <$

.01, d = 0.23, small), and that **"It is important for me to work at an educational institution with problem-based learning"** (4.15 vs 3.72, p < .001, d = 0.40, moderate). They were less inclined to agree that **"Projects are often theoretically weak when theory is selected on the basis of a problem"** (2.30 vs 2.61, p < .001, d = –0.26, moderate).

The remaining five statements showed no statistically significant mean differences. Taken together, these results suggest that staff educated at AAU hold stronger process-oriented, contextually grounded, and research-integrative supervision beliefs and express less concern about theoretical dilution.

Which of the following elements do you think should be important priorities in the development of the AAU model of the future? 1: Not at all important – 5: Extremely important				
	AAU?	Mean	Significance	Effect Size (Cohens d)
More group-based project work	Yes	3.30	***	438
	No	2.83		
Increased interdisciplinarity across faculties	Yes	3.27		
	No	3.15		
More interaction with companies and institutions	Yes	3.53	*	159
	No	3.38		
Greater integration of practice-based elements	Yes	3.42		
	No	3.34		
Strengthening of theoretical disciplines and relation to research	Yes	3.65	*	150
	No	3.77		
An increase in individual study work	Yes	2.41	***	-453
	No	2.86		
Incorporation of new IT-based teaching methods	Yes	2.96		
	No	2.82		
A better link between course teaching and projects	Yes	3.69		
	No	3.71		
Greater integration of digital group work	Yes	2.63		
	No	2.73		

*Table 6. AAU/Non-AAU educated teaching staff * "Which of the following elements do you think should be important priorities in the development of the AAU model of the future?". N=882-890. * p < 0.05, ** p < 0.01, *** p < 0.001.*

Across the nine proposed priorities in Table 6 (5-point importance scale), four showed statistically significant differences. AAU-educated staff placed a higher priority on **"More group-based project work"** (M = 3.30 vs 2.83, p < .001, d =

0.44, moderate) and **"More interaction with companies and institutions"** (3.53 vs 3.38, $p < .05$, $d = 0.16$, small). Conversely, non-AAU educated staff gave greater weight to **"Strengthening of theoretical disciplines and relation to research"** (3.65 vs 3.77, $p < .05$, $d = –0.15$, small) and **"An increase in individual study work"** (2.41 vs 2.86, $p < .001$, $d = –0.45$, moderate).

No statistically significant differences emerged for the five remaining items. Overall, AAU alumni favoured expanding collaborative, externally engaged project work, whereas colleagues educated elsewhere emphasised bolstering theoretical coursework and individual study time.

Here are a few questions about the students' learning in the group-based project work. Please indicate to what extent you agree or disagree with each statement 1: Completely disagree – 5: Completely agree				
	AAU?	Mean	Significance	Effect Size (Cohens d)
The students learn the most with very broad project frameworks	Yes	2.95		
	No	2.86		
The knowledge the students gain through project work is too specialized	Yes	2.02	***	-339
	No	2.37		
Project examination is suitable as a form of student evaluation	Yes	4.20	***	332
	No	3.88		
Too many students can "hide" in the group work and therefore get through their studies too easily	Yes	2.86	***	-392
	No	3.32		
Project work promotes student learning of collaboration and communication	Yes	4.61	***	374
	No	4.36		
Project work promotes important skills for lifelong learning	Yes	4.37	***	449
	No	4.00		
Project work prepares the students for their future work life	Yes	4.56	***	400
	No	4.27		
Project work promotes student learning of project leadership and management	Yes	4.30	***	259
	No	4.10		
Access to group rooms is essential for student study intensity (how much time they spend on their studies)	Yes	3.99	***	346
	No	3.64		
Access to group rooms is crucial for student learning	Yes	3.93	***	290
	No	3.63		

*Table 7. AAU/Non-AAU educated teaching staff * "Here are a few questions about the students' learning in the group-based project work. Please indicate to what extent you agree or disagree with each statement". N=882-890. * p < 0.05, ** p < 0.01, *** p < 0.001.*

Across the ten statements on students' learning in group-based project work (5-point agreement scale), nine showed statistically significant differences. AAU educated staff expressed stronger agreement that **"Project examination is suitable as a form of student evaluation"** (M = 4.20 vs 3.88, $p < .001$, $d = 0.33$, moderate), **"Project work promotes student learning of collaboration and communication"** (4.61 vs 4.36, $p < .001$, $d = 0.37$, moderate), **"Project work promotes important skills for lifelong learning"** (4.37 vs 4.00, $p < .001$, $d = 0.45$, moderate), **"Project work prepares the students for their future work life"** (4.56 vs 4.27, $p < .001$, $d = 0.40$, moderate), **"Project work promotes student learning of project leadership and management"** (4.30 vs 4.10, $p < .001$, $d = 0.26$, moderate), **"Access to group rooms is essential for student study intensity (how much time they spend on their studies)"** (3.99 vs 3.64, $p < .001$, $d = 0.35$, moderate), and **"Access to group rooms is crucial for student learning"** (3.93 vs 3.63, $p < .001$, $d = 0.29$, moderate).

By contrast, non-AAU educated staff agreed more that **"The knowledge the students gain through project work is too specialized"** (2.02 vs 2.37, $p < .001$, $d = –0.34$, moderate) and that **"Too many students can 'hide' in the group work and therefore get through their studies too easily"** (2.86 vs 3.32, $p < .001$, $d = –0.39$, moderate)

No significant difference emerged for the statement **"The students learn the most with very broad project frameworks"**. Overall, staff who have experienced AAU's PBL environment as students view project work as a more potent and broadly beneficial learning medium, whereas colleagues educated elsewhere express greater concern about over-specialisation and free riding. The observed contrasts are uniformly moderate in magnitude.

To what extent do you think the following activities help to make the students ready for their future work? 1: Not at all – 4: To a great extent				
	AAU?	Mean	Significance	Effect Size (Cohens d)
Internship (more than a month)	Yes	3.26		
	No	3.23		
Cooperation with external partners	Yes	3.36	*	143
	No	3.26		
Project work on bachelors level (3rd - 6th semester)	Yes	3.21	*	166
	No	3.08		
Project work on masters level (7th - 9th semester)	Yes	3.58	***	248
	No	3.43		
Master project	Yes	3.51		
	No	3.48		
Group-based project work	Yes	3.65	***	491
	No	3.36		
Individual project work	Yes	2.74	***	-264
	No	2.95		
Basic courses (across disciplines)	Yes	2.85		
	No	2.93		
Subject-specific theoretical courses	Yes	3.23		
	No	3.30		

*Table 8. AAU/Non-AAU educated teaching staff * "To what extent do you think the following activities help to make the students ready for their future work?". N=882-890. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Across the nine curricular-activity items (4-point contribution scale), five showed statistically significant group differences. AAU educated staff regarded four activities as more helpful for preparing students for future work: **"Group-based project work"** (M = 3.65 vs 3.36, $p < .001$, $d = 0.49$, moderate), **"Project work on masters level (7th – 9th semester)"** (3.58 vs 3.43, $p < .001$, $d = 0.25$, small–moderate), **"Cooperation with external partners"** (3.36 vs 3.26, $p < .05$, $d = 0.14$, small), and **"Project work on bachelors level (3rd – 6th semester)"** (3.21 vs 3.08, $p < .05$, $d = 0.17$, small). Conversely, non-AAU educated staff rated **"Individual project work"** higher (2.95 vs 2.74, $p < .001$, $d = –0.26$, moderate).

No significant differences emerged for the remaining items. Overall, the pattern indicates that alumni of AAU's PBL environment place greater value on collaborative, externally engaged project formats, whereas colleagues educated elsewhere see more benefit in solitary project work.

Summary of findings

Before interpreting the findings, it is essential to stress that the difference observed between AAU educated and non-AAU-educated teaching staff is relative, modest and situated in a pedagogically specific environment. Although statistically significant differences appear across several domains, the effect sizes are primarily small to moderate, and both groups of teachers demonstrate substantial support for PBL. The pattern presented should therefore be understood as subtle shifts in emphasis rather than sharply delineated pedagogical orientations.

Within this caveat, our analysis reveals a consistent set of tendencies. Educators who completed their studies at AAU tend to place greater emphasis on project work, collaboration, engagement with problems and process-oriented supervision. They also place greater value on competencies such as problem-solving, teamwork, and communication. In contrast, colleagues educated elsewhere display comparatively higher endorsement of coursework, theoretical grounding, and individual study activities, and express stronger concerns about overspecialisation and free-riding in group-based project formats. To illustrate these differences, Figure 1 positions the two groups along two intersecting axes: (1) Individual work versus Collaborative work and (2) Coursework versus Problem-based project work. Both groups cluster near the centre of the same pedagogical space, with the AAU educated group leaning toward collaborative, project-based orientations and the non-AAU-educated group leaning comparatively toward individual and course-oriented practices.

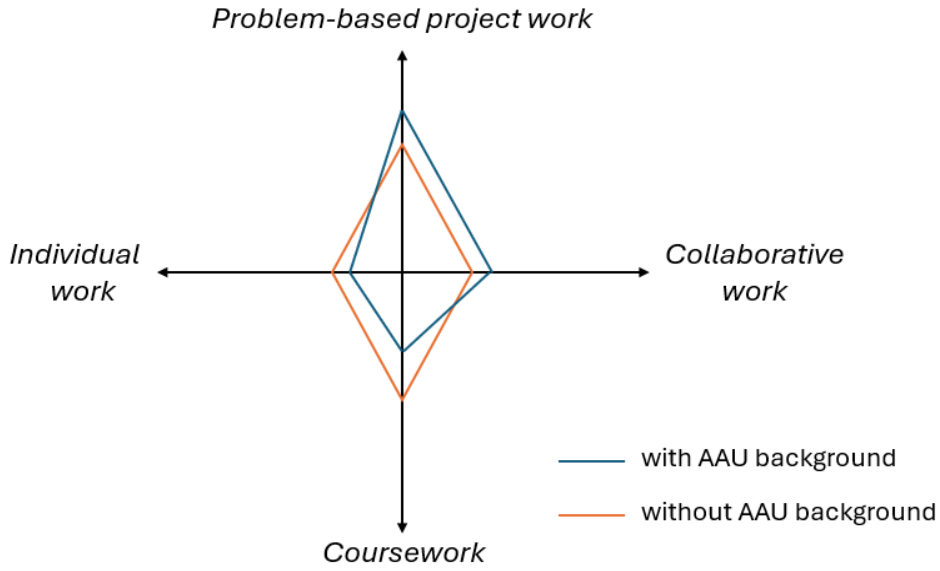


Figure 1. Generalised Illustration of differences in profiles of AAU and non-AAU educated teaching staff. The figure does not depict absolute positions; instead, it visualises the relative shift in emphasis between the two groups.

Discussion

The role of educational background: Teaching the way they were taught?

One possible explanation for the observed tendencies relates to the influence of personal learning histories on teachers' beliefs. As outlined in the introduction, previous research has shown that educators' perceptions of teaching are shaped by their experiences as students (Flores & Day, 2006; Oleson & Hora, 2014). Against this backdrop, it is plausible that AAU alumni, having been educated within a systemic PBL model, place greater value on project-based and collaborative learning activities. Staff without an AAU educational background likewise express support for the core principles of PBL pedagogy, potentially even more strongly than peers from their original institutions, although this remains an open question for future research. One plausible explanation for the differences observed could be the influence of AAU's onboarding practices, peer influence and ongoing pedagogical development initiatives. Our findings can therefore invite consideration from two perspectives: one that foregrounds the modest differences identified, and another that emphasises the broad areas of convergence between the two groups.

Nevertheless, our findings should not be interpreted as evidence of straightforward linear causality. The well-known adage that "teachers teach as

they were taught" serves as a useful heuristic; however, it is overly simplistic if regarded as a deterministic mechanism. Further investigation into teachers' perception of education and learning reveals that teachers' beliefs constitute a complex web of influences. Research has established links between teachers' perceptions of learning and various factors, including knowledge on the work environment, and the learning context (Flores & Day, 2006), disciplinary culture and their understanding of subject structure (Oleson & Hora, 2014; Lindblom-Ylänne et al., 2006), attitudes toward research, and perceptions of the academic setting, including teaching workload, class sizes, and departmental focus on student learning (Ramsden et al., 2007; Trigwell & Prosser, 2020). Moreover, Lyngdorf et al. (2022) found that professional staff development programs can influence teachers' ontological and epistemological beliefs about teaching, purpose and goals as a teacher, self-perceptions and definitions, and perceived action possibilities. At AAU, all senior staff are required to have completed a comprehensive professional development program, and such structured professional learning opportunities may help align teachers' beliefs and practices over time, regardless of their prior educational experiences. Our findings might also support explanations for "hidden curriculum practices" (Snyder, 1971) at pedagogically specific educational institutions such as AAU. If educational beliefs between staff and the institution are misaligned, it is likely that actual teaching and learning practices are affected, as teachers may be less inclined to enact practices that they do not believe in. While Kirkpatrick & Kirkpatrick (2006) do not address teacher beliefs, their evaluation model emphasises that learning, or understanding, does not automatically translate into behavioural change. In this sense, their work supports the broader idea that beliefs and actual practices do not necessarily align, which must be kept in mind when drawing conclusions from this study. In line with this broader perspective, our results indicate that educational background is a relevant factor, but it operates within a complex, interdependent ecology of contextual influences that shape teachers' beliefs. The findings of this study also elucidate how variations in educational pathways can manifest nuanced differences in emphasis and priorities.

It is not the aim of this study to problematise the diversity of beliefs about education or stigmatise either of the two groups described; instead, it aims to provide insights and foster awareness. Such insights may be valuable for designing onboarding procedures, faculty development initiatives, and dialogues concerning shared pedagogical values, as well as for effectively leveraging teacher diversity. Lyngdorf et al. (2022) emphasise that professional development initiatives can encounter cultural resistance, serving as either a catalyst or a barrier to learning, depending on how individuals understand and relate to cultural community norms. In such situations, perceived or assumed differences in educational beliefs may lead some teachers to resist adopting new

pedagogical beliefs, while others may take an oppositional stance toward the local norm, using contrast as a basis for redefining their own practice. In this connection, this study might provide a starting point for dialogue about possible differences and similarities, and for engaging with cultural resistance. Taken together, the results of this study have possible implications for practice. First, the variation in pedagogical beliefs can be seen as a resource that broadens the institutional pedagogical repertoire; newcomers who bring alternative pedagogic knowledge and practices can enrich local interpretations of PBL. Conversely, the results can also be useful for change management in institutions seeking greater coherence in teaching practice. Second, onboarding and professional development activities should assume different starting points. By recognising the differences, programs can begin with brief diagnostic sessions to explore participants' starting points. This could be used to offer differentiated and more culturally responsive pathways. Third, awareness of differences in beliefs can make tacit beliefs and "hidden curriculum practices" more visible and serve as a starting point for more transparent dialogues about pedagogical expectations and constructive pedagogical development and alignment, eventually leading to greater coherence across courses and programmes.

Conclusion

This study supports the view that teachers' perceptions of teaching and learning are shaped by their own educational backgrounds and experiences, particularly when these stem from pedagogically distinctive institutions such as Aalborg University. Our analysis showed that, relative to their colleagues educated elsewhere, as illustrated by figure 1, AAU educated staff place comparatively greater emphasis on project-based, collaborative, and contextually grounded learning. Conversely, staff without an AAU educational background place relatively greater importance on coursework, theoretical grounding, and individual study. A strength of the study is the noteworthy consistency between the two profiles as they relate to the features of AAU PBL.

Importantly, the findings point to the lasting influence of studying in a systemic PBL environment, which appears to continue shaping educational beliefs and practices long after graduation.

While the patterns found between the two groups in this study should not necessarily be interpreted as reflections of broader trends in the general population, a contribution of the study is the large-scale quantitative design, which complements earlier qualitative research on teacher identity development. For higher education institutions strongly committed to particular pedagogical models such as PBL, these insights raise important

considerations for faculty onboarding, professional development practices, and discussions about fostering coherent and pluralistic teaching cultures.

Limitations

It is essential to stress that our findings do not imply that teachers without an educational background from AAU do not value PBL or assign it little importance. What we have demonstrated is simply that statistically and practically significant differences exist between the two groups relative to each other. Our results do not address how these differences are relative to the general population, and as such, both groups might, relative to everyone else, value PBL greatly. The differences we have identified offer insights into the potential impact of having completed an education at AAU, or not, prior to teaching at AAU. Additional methodological and contextual limitations should be considered and temper the interpretation of our findings:

- The AAU educated group was, on average, approximately eight years younger ($M = 42.49$ years) than the non-AAU educated group ($M = 50.54$ years). Across a sample as large as ours, this is quite a large difference, and given that age often covaries with career stage, pedagogical training opportunities and exposure to educational reforms, it could thus moderate or mediate the relationship between educational background and teaching perceptions. Future studies should attempt to disentangle this effect by examining career stage, previous places of employment, and so on.
- In the non-AAU educated group, the proportion of self-reported professors was noticeably higher than in the AAU educated group (14.7% vs. 8.5%). Although some statistically significant differences emerged when comparing professors' perceptions with those of other respondents, these patterns did not align with the group differences identified in our study. Consequently, while these distinctions may be of independent interest, they do not account for or explain the differences observed between AAU educated and non-AAU educated staff.
- With a 45% response rate, it is possible that some elements of social desirability have affected the results or that staff who feel strongly about PBL, be it positively or negatively, were more likely to participate. Moreover, given AAU's institutional commitment to project-based learning, respondents might overstate the perceived value of PBL-aligned practices.

Taken together, these limitations mean that the differences reported here should probably be interpreted as upper-bound estimates of the true

differences attributable to having studied in an AAU PBL environment until supported by further findings in the future. In light of these considerations, we have exercised caution and adopted effect size interpretations that generally underestimate differences relative to the guidelines established in the field, as outlined in the methodology section.

References

Barge, S. (2010). Principles of problem and project-based learning: The Aalborg model for problem and project-based learning. In L. Krogh & A. Aarup Jensen, *Visions, challenges and, and strategies: PBL principles and methodologies in a danish and global perspective* (pp. 377–392). Aalborg: Aalborg University Press.

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education*, *20*(2), 107–128. https://doi.org/10.1016/j.tate.2003.07.001

Blumberg, P. (2000). Evaluating the Evidence That Problem-Based Learners are Self-Directed Learners: A Review of the Literature. In D. H. Evensen & C. E. Hmelo-Silver (Eds.), *Problem-based Learning—A Research Perspective on Learning Interactions* (pp. 199–226). Routledge.

Boelt, A. M., & Clausen, N. R. (2023). Participant Direction. In A. Kolmos & T. Ryberg (Eds.), *PBL in a Digital Age* (pp. 39–52). Aalborg Universitetsforlag.

Bundgaard, S. B., Dahl, B., Krogh, L., & Ravn, O. (2021). *Exploring PBL Group Formation Processes*. Aalborg Universitetsforlag.

Clausen, N. R. (2021). Progression of Self-Directed Learning in PBL: Comparing Consecutive Semesters at AAU. *Journal of Problem Based Learning in Higher Education*, *9*(1), 24-41. https://doi.org/10.5278/ojs.jpblhe.v9i1.6373

Clausen, N. R., & Kolmos, A. (2019a). PBL Future work report 1: Preliminary findings of the staff survey: Presentation of frequencies on faculty level from the staff survey. In *PBL Future work report 1: Preliminary findings of the staff survey* [Report]. Aalborg Universitet.

Clausen, N. R., & Kolmos, A. (2019b). PBL Future work report 2: Preliminary findings of the student survey. Presentation of frequencies on faculty level. In *PBL Future work report 2* [Report]. Aalborg Universitet.

Cohen, J. (1969). *Statistical power analysis for the behavioral sciences*. Academic Press.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). L. Erlbaum Associates.

Dolmans, D. H. J. M., Loyens, S. M. M., Marcq, H., & Gijbels, D. (2016). Deep and surface learning in problem-based learning: A review of the literature. *Advances in Health Sciences Education: Theory and Practice*, *21*(5), 1087–1112. https://doi.org/10.1007/s10459-015-9645-6

Dolmans, D. H. J. M., & Schmidt, H. G. (2000). What directs self-directed learning in a Problem-Based Curriculum? In *Problem-based Learning—A Research Perspective on Learning Interactions* (pp. 251–262).

Flores, M. A., & Day, C. (2006). Contexts which shape and reshape new teachers' identities: A multi-perspective study. *Teaching and Teacher Education*, *22*, 219–232. https://doi.org/10.1016/j.tate.2005.09.002

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

IBM Corp. (2025). *IBM SPSS Statistics* (Version 29) [Computer software]. IBM Corp. https://www.ibm.com/products/spss-statistics

Illeris, K. (1981). *Modkvalificeringens pædagogik. Problemorientering, deltagerstyring og eksemplarisk indlæring*. Unge Pædagoger.

Illeris, K. (1974). *Problemorientering og deltagerstyring - oplæg til en alternativ didaktik*. Munksgaards Forlag.

Kjaersdam, F., & Enemark, S. (1994). *The Aalborg Experiment: Project Innovation in University Education*. Aalborg Universitetsforlag.

Kolmos, A., Bøgelund, P., & Spliid, C. M. (2019). Learning and Assessing Problem-Based Learning at Aalborg University. In *The Wiley Handbook of Problem-Based Learning* (pp. 437–458). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119173243.ch19

Kolmos, A., Du, X., Holgaard, J. E., & Jensen, L. P. (2008). *Facilitation in a PBL environment*. UCPBL UNESCO Chair in Problem Based Learning.

Kolmos, A., Fink, F. K., & Krogh, L. (2004). The Aalborg model. In Kolmos, A., Fink, F. K., & Krogh, L. (Eds.), *The Aalborg model: Progress, diversity and challenges* (pp. 9–18). Aalborg Universitetsforlag.

Kolmos, A., Holgaard, J. E., & Clausen, N. R. (2021). Progression of student self-assessed learning outcomes in systemic PBL. *European Journal of Engineering Education*, *46*(1), 67–89. https://doi.org/10.1080/03043797.2020.1789070

Kolmos, A., & Ryberg, T. (2023). New Realities and PBL Futures. In A. Kolmos & T. Ryberg (Eds.), *PBL in a Digital Age* (pp. 11–26). Aalborg University Press.

Kraft, M. A. (2020). Interpreting Effect Sizes of Education Interventions. *Educational Researcher*, *49*(4), 241–253. https://doi.org/10.3102/0013189X20912798

Kraft, M. A. (2023). The Effect-Size Benchmark That Matters Most: Education Interventions Often Fail. *Educational Researcher*, *52*(3), 183–187. https://doi.org/10.3102/0013189X231155154

Kirkpatrick, D., & Kirkpatrick, J. (2006). *Evaluating training programs: The four levels*. Berrett-Koehler Publishers.

Lindblom-Ylänne, S., Trigwell, K., Nevgi, A., & Ashwin, P. (2006). How approaches to teaching are affected by discipline and teaching context. *Studies in Higher Education, 31*(3), 285–298. https://doi.org/10.1080/03075070600680539

Lipsey, M. W., & Wilson, D. B. (1993). The efficacy of psychological, educational, and behavioral treatment: Confirmation from meta-analysis. *American Psychologist*, *48*(12), 1181–1209. https://doi.org/10.1037/0003-066X.48.12.1181

Loyens, S. M. M., Magda, J., & Rikers, R. M. J. P. (2008). Self-Directed Learning in Problem-Based Learning and its Relationships with Self-Regulated Learning. *Educational Psychology Review*, *20*(4), 411–427. https://doi.org/10.1007/s10648-008-9082-7

Lyngdorf, N. E. R., Ruan, Y., Chen, J., Du, X., & Kolmos, A. (2022). Engineering Teachers' Professional Learning and Role Identity Change in An Intercultural (Study-abroad) PBL Program. *International Journal of Engineering Education*, *38*(4), 959-973. https://www.ijee.ie/contents/c380422.html

OECD. (2014). Competency Framework. *Talent*, (October), 22. https://doi.org/10.1016/j.talanta.2009.11.058

Oleson, A., & Hora, M. T. (2014). Teaching the way they were taught? Revisiting the sources of teaching knowledge and the role of prior experience in shaping faculty teaching practices. *Higher Education, 68*, 29-45. https://doi.org/10.1007/s10734-013-9678-9

Olsen, P. B., & Pedersen, K. (2018). *Problemorienteret Projektarbejde: En værktøjsbog*. Samfundslitteratur. https://samfundslitteratur.dk/bog/problemorienteret-projektarbejde-0

Rambøll Management Consulting. (2018). *SurveyXact* (Version 2018) [Computer software]. https://www.surveyxact.dk

Ramsden, P., Prosser, M., Trigwell, K., & Martin, E. (2007). University teachers' experiences of academic leadership and their approaches to teaching. *Learning and Instruction, 17*(2), 140–155. https://doi.org/10.1016/j.learninstruc.2007.01.004

Servant-Miklos, V., Norman, G. R., & Schmidt, H. G. (2019). A Short Intellectual History of Problem-Based Learning. In *The Wiley Handbook of Problem-Based Learning* (pp. 3–24). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119173243.ch1

Snyder, B. R. (1971). *The Hidden Curriculum*. Alfred A. Knopf. ISBN 0-394-42842-0.

Sørensen, M. T. (2022). *Students' orchestration of groupwork and the role of technology*. https://doi.org/10.54337/aau478414538

Sørensen, M. T., Bruun-Pedersen, J. R., Ryberg, T., & Velmurugan, G. (2023). New forms of collaboration. In A. Kolmos & T. Ryberg (Eds.), *PBL in a digital age* (pp. 69–87). Aalborg University Press.

Trigwell, K., & Prosser, M. (2020). *Exploring university teaching and learning: Experience and context*. Springer Nature. https://doi.org/10.1007/978-3-030-50830-2

UNESCO. (2016). *UNESCO Competency Framework*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000245056

Yan, Y. (2024). Bibliometric review of teacher professional identity scholarship over two decades. *Sage Open*, *14*(2). https://doi.org/10.1177/21582440241241173

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 90-112
doi.org/10.54337/ojs.jpblhe.v14i1.10580

Graduate Students' Perceptions of the Project-Based Learning (PjBL) Model

A Phenomenological Study in the Context of Puerto Rico

Isabel Delgado Quiñones * | University of Puerto Rico
Emanuel Santos De Jesús | University of Puerto Rico

Abstract

Project-Based Learning (PjBL) model is highly recommended to frame STEM learning experiences to achieve transformative education at all levels. This qualitative phenomenological study describes the perceptions and experiences of graduate students, mostly science teachers, towards the PjBL model implemented in the graduate course they were enrolled during the academic year 2022-2023 at the College of Education of a public university of Puerto Rico. The study involved 12 graduate students, 6 master's and 6 doctoral students, who took one of the core courses of their program in Curriculum and Teaching with a subspecialty in Science Education. The findings indicate that the PjBL model was perceived as a constructivist learning model that allowed greater learning of the course content. Motivation and collaborative learning are two elements that stand out as essential to their learning process.

Keywords: Project-based learning; Graduate students; Science curriculum

* Corresponding author:
Isabel Delgado Quiñones, Email: isabel.delgado@upr.edu

Received 16 July 2025 | Accepted 16 January 2026 | Available online in Early View 27 February 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

Introduction

A new vision for science education is presented in the document *A Framework for Science Education: Practices, Cross-Cutting Concepts, and Disciplinary Core Ideas* (NRC, 2012). The idea is that students will learn about science by doing engineering and science activities that help them understand natural phenomena and solve problems. The Next Generation Science Standards (NGSS, 2013) guide science teachers, science teacher educators, researchers, and leaders to achieve the goals stated in the *Framework* for all students. Among the many initiatives to advance science education reform, one that stands out is the design and implementation of curriculum units with the Project-Based Learning model (PjBL) (Bender, 2017; Larmer et al., 2015). In fact, the PjBL model has been highly recommended to frame STEM learning experiences to transform science education (Carpraro et al., 2013; Edmunds et al., 2017; Jiang et al., 2024; Surmani et al., 2023). But even when extensive research suggests the effectiveness and promises of PjBL, many science teachers still feel challenged to design and implement PjBL curriculum units (Condliffe et al., 2017; Kurt & Akoglu, 2023; Tamim & Grant, 2013). One way to attend these challenges is to provide pre-service and in-service science teachers with constructivist learning experiences framed in problem or project-based learning principles. Precisely, the purpose of this study is to analyze the experience and perceptions of graduate students with the PjBL model and how it enhances their learning of the course content, that includes the model itself.

This paper is guided by the following research questions: 1) What are the graduate students' perceptions of the Project-Based Learning Model as part of their experience with a curriculum unit designed with this model in a required Science Education graduate course? and 2) How does the PjBL model facilitate the learning of the content of the course in which it was implemented? Some of the graduate students are active in-service science teachers at the middle or high school level, while others are not. One of the most interesting things about this study is that it looks at both, their experiences as graduate students learning about the PjBL model as part of their course work and, as science teachers designing a curriculum unit using a constructivist instructional model, including PjBL, in Puerto Rico, where research studies on this topic are scarce.

Overview of the Project-Based Learning Model (PjBL) and its implementation in different contexts

Project and problem-based learning are terms that have been used interchangeably in the literature up until the early 2010s, thus creating some confusion regarding the differences between these approaches (Condliffe et al., 2017; Thomas, 2000). Generally speaking, problem/project learning

environments are characterized as student-centered or constructivist pedagogies; use real-world problems to engage students in inquiry; involve collaborative or cooperative learning structures; teachers assume the role as facilitators; are used for interdisciplinary curriculum design; among other characteristics (Bender, 2012; Blumenfeld et al., 1991; Condliffe et al., 2017). Some key differences between problem-based learning (PBL) and project-based learning (PjBL) are: 1. PBL is problem-driven, while PjBL is project-driven (Dole et al., 2016), 2. PBL can be seen as a teaching and learning strategy inserted into the PjBL model (Barron et al., 1998; Krajcik & Czerniak, 2007; Mitchell & Tilley, 2024), 3. PBL implementation time is usually less than the required time for PjBL implementation (Dole et al., 2016; Mitchell & Tilley, 2024) and 4. PjBL, can be used to: design a semester course or curriculum units (Baumgartner & Zabin, 2008; Svihla & Reeve, 2016; Vázquez-Alvarado, 2020); can be used as primary pedagogy to deliver the curriculum in some schools, for example, the New Tech Network schools (Culclasure et al., 2019; Lee et al., 2019) or even used to design undergraduate programs (Mitchell & Tilley, 2024).

Even when there have been different approaches or meanings to what PjBL means (Condliffe et al., 2017; Larmer et al., 2015; Thomas, 2000), there is consensus among researchers (Bender, 2012; Blumenfeld et al., 1991; Krajcik & Czerniack, 2007) on key elements that define PjBL. These are: a) a driving question based on a real-world problem, b) sustained inquiry, and c) the creation of final products that are central to the curriculum.

At the K-12 level, the design and implementation of the PjBL curriculum units are more evident and frequent, as many studies suggest (Condliffe et al.; 2017; Craig & Marshall, 2019; Culclasure et al., 2019; Krajcik & Czerniak, 2007; Kurt & Akoglu, 2023). But literature suggests that the implementation of project-based learning is less prominent at the undergraduate level and even more scarce at the graduate level (Lee et al., 2014; Surmani et al., 2023). Some studies at the graduate level with PjBL are focused on teacher education programs such as the one conducted by Major & Mulvihill (2019) in Botswana; Surmani et al. (2023) in Indonesia, and Lee et al. (2014) with different undergraduate and graduate programs, including the College of Education, from the University of Indianapolis at Indiana, USA. Other studies at the graduate level focus on the use of the PjBL model to design online courses to determine how the experience enabled students to learn the content and develop 21st-century skills (problem-solving, collaboration, critical thinking, among others) in these online courses (Dabbagh & Williams, 2010; Wu et al., 2023). Our PjBL study in Puerto Rico is an attempt to enrich the PjBL research literature at the graduate level. In the next section, we discuss more details of the initiatives toward integrating the PjBL model at different levels in the context of Puerto Rico.

Research gaps on Project-Based Learning in Puerto Rico

The adoption of Problem (PBL) and Project-Based Learning (PjBL) methodologies in Puerto Rico has been a growing interest in science education (Velázquez & Figarella, 2018). However, research on the design and implementation of PjBL curricula remains scarce compared to international contexts. Despite various efforts to promote active learning strategies, formal research on their application across different educational levels in Puerto Rico is still limited and fragmented.

Since the 1990s, Puerto Rico has attempted to modernize science education by implementing student-centered methodologies, such as Project-Based Learning (PjBL). However, these initiatives have often been short-lived due to shifts in the Puerto Rico Department of Education (PRDE) leadership, budget constraints, and a lack of continuity in teacher training (Díaz Díaz, 2021; Vázquez & Figarella, 2018). A big problem that has kept PjBL from being effectively and permanently integrated into science curriculums at all levels is that teachers haven't had access to structured and ongoing professional development (Rivera González, 2022). The PRDE's 2016 Science Program Circular recognized the importance of active learning strategies like PjBL. However, large-scale implementation has faced persistent challenges, including inadequate teacher training and resistance to moving away from traditional, memorization-based instruction (PRDE, 2022). Teachers often lack sufficient preparation and institutional support to confidently design and execute PjBL units, leading to inconsistent adoption across schools. As a result, many science educators continue relying on conventional lecture-based approaches, despite growing evidence that PjBL enhances student engagement, problem-solving skills, and scientific literacy (Díaz Díaz, 2021).

Despite these challenges, some studies have highlighted successful attempts to implement PjBL in Puerto Rico. For instance, Vázquez-Alvarado (2020) examined how PjBL, combined with digital tools like Minecraft Education, significantly improved student engagement in science learning. However, he also pointed out that without clear guidelines, sufficient teacher training, and institutional backing, the large-scale adoption of PjBL remains difficult.

At the university level, Rivera González (2022) explored PjBL through Service-Based Learning (SBL) in an analytical chemistry course. The author noted that at this level, PjBL remains underutilized, with few structured frameworks guiding its application in STEM disciplines. This limited adoption is largely attributed to insufficient teacher training, which affects both the confidence and capacity of educators to integrate PjBL effectively into their curricula. Consequently, teacher preparation has emerged as one of the biggest obstacles to the widespread implementation of PjBL in Puerto Rico.

Similarly, Díaz Díaz, (2021) indicate that science teachers struggle with implementing PjBL due to insufficient training and a lack of resources in public schools. This author examined its use in middle school science, noting increased student motivation and critical thinking, particularly in renewable energy and sustainability projects.

Despite individual successes, PjBL efforts in Puerto Rico remain isolated to specific schools and universities, such as the laboratory schools (K-6th and 7th-12th grade) of the University of Puerto Rico (Velázquez & Figarella, 2018). There is no comprehensive database systematically documenting its effectiveness across different educational levels, limiting efforts to expand these methodologies nationwide. The lack of longitudinal studies further prevents the development of educational policies that support sustained PjBL implementation. Additionally, the traditional focus of teacher education programs in Puerto Rico provides little exposure to active methodologies like PjBL (Rivera González, 2022).

One way to increase science teacher's confidence and knowledge in implementing PjBL curriculum units is to have them experience the model as students themselves. As Major & Mulvihill (2018) state, "If PjBL is the desired approach, then it ought to be demonstrated in regular use in teacher education programs" (p. 2). Thus, the purpose of this study is to examine graduate students' perceptions of the PjBL model as part of their required courses in the Science Education Graduate Programs at one campus of the University of Puerto Rico (public university).

Many schools and researchers (Craig & Marshall, 2019; Culclasure et al., 2019; Virtue et al., 2019) now use the Gold Standard PBL framework to define and think about project-based learning. This framework was developed by the Buck Institute of Education (BIE), which has more than 30 years of experience as a leading PBL implementation organization. Thus, it is used to frame our study.

Gold standard PBL: Theoretical framework

The Gold Standard PBL framework (www.pblworks.org) includes three essential aspects: 1) the learning goals at the center, 2) the seven essential design elements, and 3) the teaching practices required to support the implementation process. The following diagrams describe the seven key design elements and teaching practices required for the successful implementation of PjBL according to BIE. For a PjBL project to be rigorous and meet the Gold Standard PBL framework, it must comply with seven key elements as illustrated in the right diagram below. These elements are 1. a challenging problem or question, 2.

sustained inquiry, 3. authenticity, 4. student voice and choice, 5. reflection, 6. critique and revision, and 7. a public product (www.pblworks.org). These are what Larmer et al. (2015) describe as the key design elements to take into account when designing PjBL curriculum units. These authors highlight at the center of the project the learning goals, which include both the discipline or subject matter standards and what they call success skills, which are also denominated as 21st-century skills, which involve the 4Cs (communication, collaboration, creativity, and critical thinking) among others. A few years later, Boss & Larmer (2018) detailed the seven teaching practices required to sustain rigorous and successful PjBL projects. The left diagram below details these practices. First, the project must be aligned to standards, and the following teaching practices are needed: 1. Build the culture, 2. manage activities, 3. scaffold student learning, 4. engage and coach students, 5. design and plan, and 6. assess the student learning outcomes (Boss & Larmer, 2018).

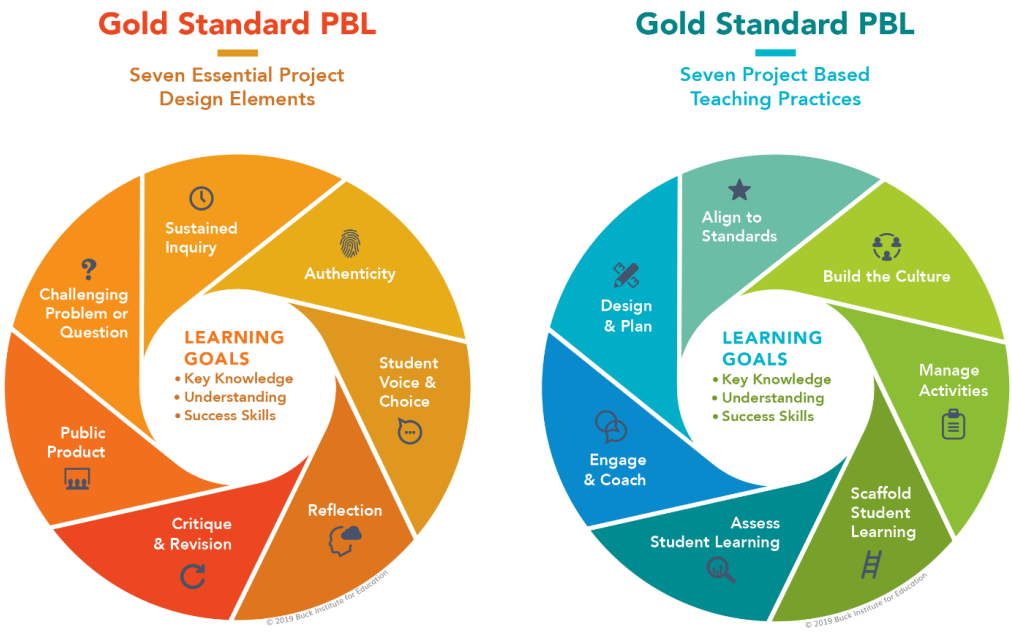


Figure 1. The key elements of the Gold Standard PBL.

Note: This figure represents the key elements of the Gold Standard PBL: Design Elements (figure at the right) and Seven Project Teaching Practices (figure at the left) that support the design and implementation of project-based learning curriculum units. From https://www.pblworks.org/what-is-pbl/gold-standard-project-design

Context of the study

The study was conducted in the Graduate Program (Master and Doctorate) of the College of Education of the University of Puerto Rico (UPR). The two

required courses for the Master's and Doctorate Programs were offered during the academic year 2022-2023 in which the designed PjBL curriculum unit were implemented. Course A (Master) and Course B (Doctorate) are required courses of the Curriculum and Teaching with a subspecialty in Science Education Program. Course A was offered in the first semester and Course B in the second semester of 2022-2023 academic year. Both courses include the topic of theories and instructional methodologies for science education at the secondary level (high school) as part of their course syllabus. These constructivist instructional methodologies include problem-based learning (PBL), project-based learning (PjBL), the 5E inquiry model (Bybee et al., 2006), and cooperative learning, among others. Despite slight differences in the syllabus of the courses, both share similar content.

A key design element of the Gold Standard PBL Framework is authenticity and that the project must respond to a real-world problem or call to action. In this particular case, a memorandum of understanding (MOU) was signed between Corazon Latino, a non-profit organization that had the task of developing lesson plans to attend to four major themes selected by the communities near El Yunque and the Graduate Program of the College of Education These themes were: 1. Biodiversity of El Yunque, 2. Climate Change, 3. Soils, and 4. Connectivity. In the MOU, graduate students of the UPR would collaborate on the design and development of curriculum units that addressed Corazon Latino's curriculum project.

This unique opportunity provided the setting to incorporate this project into both courses and design a PjBL curriculum unit that would combine the needs of the organization and the learning goals of each course content, creating a real-world context for the project. For the design of the PjBL unit, the resources available at pblworks.org were used to design the curricular unit for both courses. These resources are of free access and available to modify by any user. In this case, the resources used (Planning Tool template and Project Wall template) were translated to Spanish by the lead author.

Research design

The study is guided by the following research questions:

1) What are the graduate students' perceptions of the Project-Based Learning (PjBL) model as part of their experience with a curriculum unit designed with this model in a required Science Education graduate course?
2) How does the PjBL model facilitate the learning of the content of the course in which it was implemented?

A qualitative study with a phenomenological design was selected among the different qualitative study designs (case study, action research, ethnography, among others), because the first research question is aimed at understanding the perceptions and experiences of the participants of the study (Creswell, 2012). According to Merriam & Tisdell (2016), phenomenology is a qualitative research design that focuses on the lived experience of the participants, which is the principal focus of this study, understanding the lived experience of participants with the PjBL model. Also, a phenomenological design helps us to better understand their perceptions about the Project-Based Learning (PjBL) model that framed the design and implementation of one curriculum unit in one of the courses in which they were enrolled. The study protocol was submitted and approved by the Institutional Review Board (IRB protocol #2223-016).

To ensure a rigorous study and obtain reliable results, it is essential to use a variety of data collection techniques. In this research, the following data collection techniques were used: 1. semi-structured interviews (two interviews per participant—initial and final), 2. non-participatory observations (2 conducted during the implementation of the PjBL unit), 3. document analysis (reflective notebooks and final products), and 4. one focus group two months after the completion of Course A. The focus group after the completion of Course B was not conducted due to scheduling difficulties with participants. All these data sources were used to triangulate the results as a strategy to ensure reliability. In terms of the protocols (semi-structured interviews, observation and focus group) used to gather data, all were aligned to the Gold Standard PBL framework key design elements as a way to have validity of construct.

All graduate students (15- 6 for Course A and 8 for Course B) enrolled in both courses were invited to participate in the study. Even when all students signed the consent forms, only data from 12 participants who completed the first and final interviews was considered in the data analysis. The final products of the PjBL curriculum unit for each course consisted of a high school science curriculum unit designed in collaborative groups in which they had to apply the content and skills learned in the course. Therefore, even when not all students were able to become full participants in the study, all curriculum units or final products were part of the data analysis because they were elaborated collaboratively. Table 1 shows important demographic information about the participants of the study.

Course	Participants	Gender	General Background Formation of Participants
A Master Program	6 3 in service teachers 3 not active in-service teachers	3- men 3- women	4- Bachelor degree in Natural Sciences (Biology or Chemistry) 2- Bachelor degree in Elementary Education (4-6th grade)
B Doctorate Program	6 3 in service teachers 3 not active in-service teachers	4- men 2- women	4 Bachelor degree in Natural Sciences (Physics and Biology) 2 Bachelor degree in Education
	Total: 12 participants 5 women 7 men		

Table 1. Demographic information of participants of the study.

Note: Table 1 illustrates important demographic information of the participants of the study.

Data Analysis

The process of data analysis included both deductive and inductive coding cycles as recommended by Saldaña (2021). The analytical process incorporated multiple strategies to ensure depth and consistency. First, the Gold Standard PBL seven design elements were employed as a framework for deductive coding analysis of both the initial and final interview transcripts for both courses (see Appendices A and B). This approach facilitated a comparative analysis to determine learning growth in participants' understanding of the Project-Based Learning model. Then, an inductive *In Vivo* coding technique (Saldaña, 2021) was implemented for both sets of interviews to determine the categories and themes that emerged from the data. Other sources of data, document analysis (reflective notebooks and final products), focus group transcripts, and non-participant observations were used for data triangulation purposes, which is considered an important reliability data analysis technique. Also, the deductive and inductive coding cycles described above were conducted independently by each researcher to compare data analysis and ensure reliability of results. Peer debriefing meetings among researchers was conducted on several occasions to share insights and results of the coding cycles. Finally, an analysis assisted by artificial intelligence, Anthropic AI's Claude.ai tool was used, applying the CORIF strategy (Context, Objective, Role,

Information, and Format) proposed by Etesse (2024), to optimize AI (Artificial Intelligence) training, which resulted in more relevant and precise analyses. The AI tool was used after conducting independent data analysis and it served only to verify the findings that the researchers have already concluded. Having a strong theoretical framework (Gold Standard PBL) to guide the data analysis and using the qualitative data analysis techniques described above, alongside the AI Claude tool, helped researchers in ensuring reliability of the findings that are presented in the next section.

Potential biases and how they were addressed

The lead author is both the principal investigator and the professor of the graduate courses in which the study was conducted. We recognize that the dual role could create potential biases. To address this potential bias, the data was collected by the first author but was not analysed until each course finished, thus separating the role of researcher and professor. This precaution was part of the IRB protocol.

Findings

This study examined the perceptions of graduate students of a Science Education Program regarding the Project-Based Learning (PjBL) model implemented in a graduate course as well as how the model facilitated the learning of the content of the course. The findings are presented to answer each research question. To describe the perceptions of graduate students and their experience with the PjBL model, the analysis of the initial interview transcripts shows that participants from both courses had limited knowledge or understanding of the PjBL model before its implementation in each course. None of them had previous experience with the model as students themselves (K-12), but all had positive attitudes towards PjBL in regard to wanting to learn more. Nonetheless, they perceived some challenges towards the implementation of PjBL, such as time constraints, lack of training, and uncertainty on how to implement it in their school contexts. Only two participants from course A had previous experience with PjBL at the undergraduate level, and both were formed as elementary science teachers. Two participants from Course B had implemented PjBL, or what they believed it was, with their students as in-service science teachers. For example, one participant from Course B stated, "When this came to Puerto Rico, they (PRDE) gave us some workshops at the school, but they were very superficial. They didn't exactly explain how to implement it."

When comparing the design elements of the Gold Standard PBL framework from initial and final interviews through deductive coding, the data shows that

participants were able to identify five or more design elements after going through the experience of a PjBL unit in their course. Before launching the project, the two design elements identified by participants were the final product and sustained inquiry. Also, only one participant highlighted the design element of reflection from the PjBL experience, which is interesting due to the fact that a reflection journal was part of the unit. Figure 2 illustrates a bubble diagram that highlights the similarities and differences among the participants from both courses.

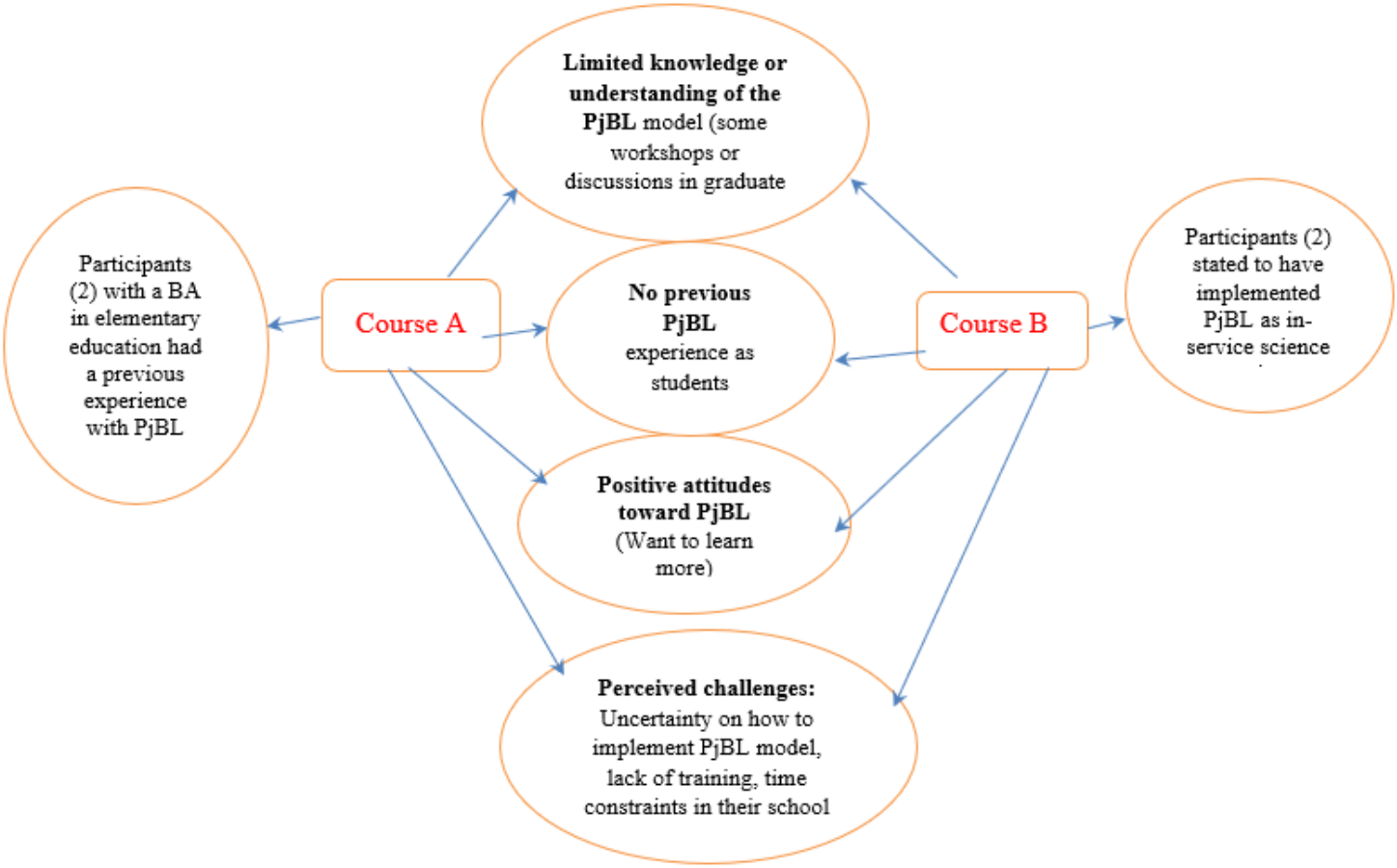


Figure 2. Comparison of initial interviews from the two graduate courses (Bubble Map).

Note: This figure was created by Delgado-Quiñones (lead author) to compare findings from the initial interviews between Course A and B. The bubbles in the middle represent the similarities, while the bubbles at the left of each rectangle represent the differences found between the participants from each Course.

In terms of the lived experience, our findings indicate a predominantly positive experience, highlighting collaborative dynamics, active learning, acquisition of

21st-century skills, and connection to real world contexts as valued aspects. When asked to describe their experience in the course, participants stated, "Unique experience," "I loved it," "It was challenging," and "Good balance in the collaborative work." To summarize, one participant from course B stated, "I loved it because everything was really dynamic; at no point was anything boring; it was quite entertaining and motivating."

This overall positive perception suggests that the PjBL model successfully captured students' interest and engagement, a crucial element for the success of any pedagogical approach. Regarding the learning of the PjBL model itself, variations were observed in understanding specific implementation stages of the PjBL model, suggesting the need for explicit reinforcement of its structure and design elements. Nevertheless, participants reported greater confidence in implementing the model in their own classes after the experience. For example, one participant from course B stated, "I feel quite confident," when asked about their ability to implement the model. In fact, participants of the focus group from course A affirm that they were already implementing PjBL with their students during the second semester. They stated that students were really engaged, but the biggest challenge was in the phase of creating the final products. This is similar to the challenges they faced themselves as part of the PjBL course experience, which include the development of the final product, coordinating the collaborative work, effective communication, and content contextualization. Mostly, they enjoyed the dynamic and collaborative activities in class, the feedback given by peers and experts, and field experiences, which included a guided visit to El Yunque National Forest, this was evident in the reflective notebooks, non-participant observations and individual interviews.

To answer the second research question, the implementation of the PjBL curriculum unit in each course served to promote learning course content. Multiple data sources (final interviews, document analysis, and non-participant observations) showed that participants' learning of different teaching strategies and models was significant. They were able to explain and compare different teaching and learning strategies for science education, which provides evidence of their understanding of different pedagogical approaches facilitated by the PjBL model. For example, one participant (in-service science teacher) from Course B stated, "I think the most important thing I learned is to maybe not compromise oneself with only one model," while another participant from Course A stated, "My greatest learning gain in this experience was learning the model itself, because I did not understand it." Table 2 summarizes the final products (projects—curriculum units designed) for each graduate course. The final products were part of the data analysis of the study and were used to triangulate the findings with other data sources. Each collaborative group would choose the theme provided by Corazon Latino for the curriculum design.

The design is guided by the theoretical principles of the instructional methodology used (5E Inquiry Model, PBL, PjBL or other). An important guideline provided to students for the development of the final product is that the curriculum unit designed had to be aligned to PRDE Science Curriculum Standards.

Course A	**Theme and instructional methodology used to design the curriculum unit - final product**	**Course B**	**Theme and instructional methodology used to design the curriculum unit - final product**
Group 1	Climate Change **Project Based Learning** 12 th grade Environmental Science	Group 1	The effects of climate change **Problem based learning** 12th grade Environmental Science
Group 2	Biodiversity of el Yunque 12th grade Environmental Science **PROCIC Model** (López-Tosado, 1997)	Group 2	Connectivity: From the mountains to the coastal area 12th grade Environmental Science **Learning cycle - ECA Exploration, Conceptualization and Application** (Villarini-Jusino, 1991)
Group 3	Soil **Project Based Learning** 9th grade Earth Science	Group 3	Biodiversity of moses at El Yunque and the impact of climate change 12th grade Environmental Science **PROCIC Model** (López-Tosado, 1996)
2 curriculum units designed with PjBL, 2 with PROCIC Model, 1 with PBL and 1 with ECA Learning cycle strategy. PROCIC and ECA were developed by Puerto Rican authors.			

Table 2. Final product description for each graduate course.

Note: Table 2 summarizes the topic and the constructivist learning model or strategy that guided its design. This content is part of the Syllabus of each Course. The final products were part of the data analysis of the study.

An interesting finding from the analysis of the final products is that students integrated into their lesson plans, cooperative learning techniques they experienced themselves through the implementation of the PjBL curriculum unit. For example, two curriculum units from Course A, groups 1 and 2, integrated the Fishbowl Protocol used in the course into their final product. In

the case of the final products of Course B, groups 1 and 2 integrated the Tuning Protocol that was implemented as part of the PjBL unit. Figure 3 illustrates a bubble diagram that compares their learnings and perceptions of PjBL experience in the course. The diagram allows us to answer both research questions as well.

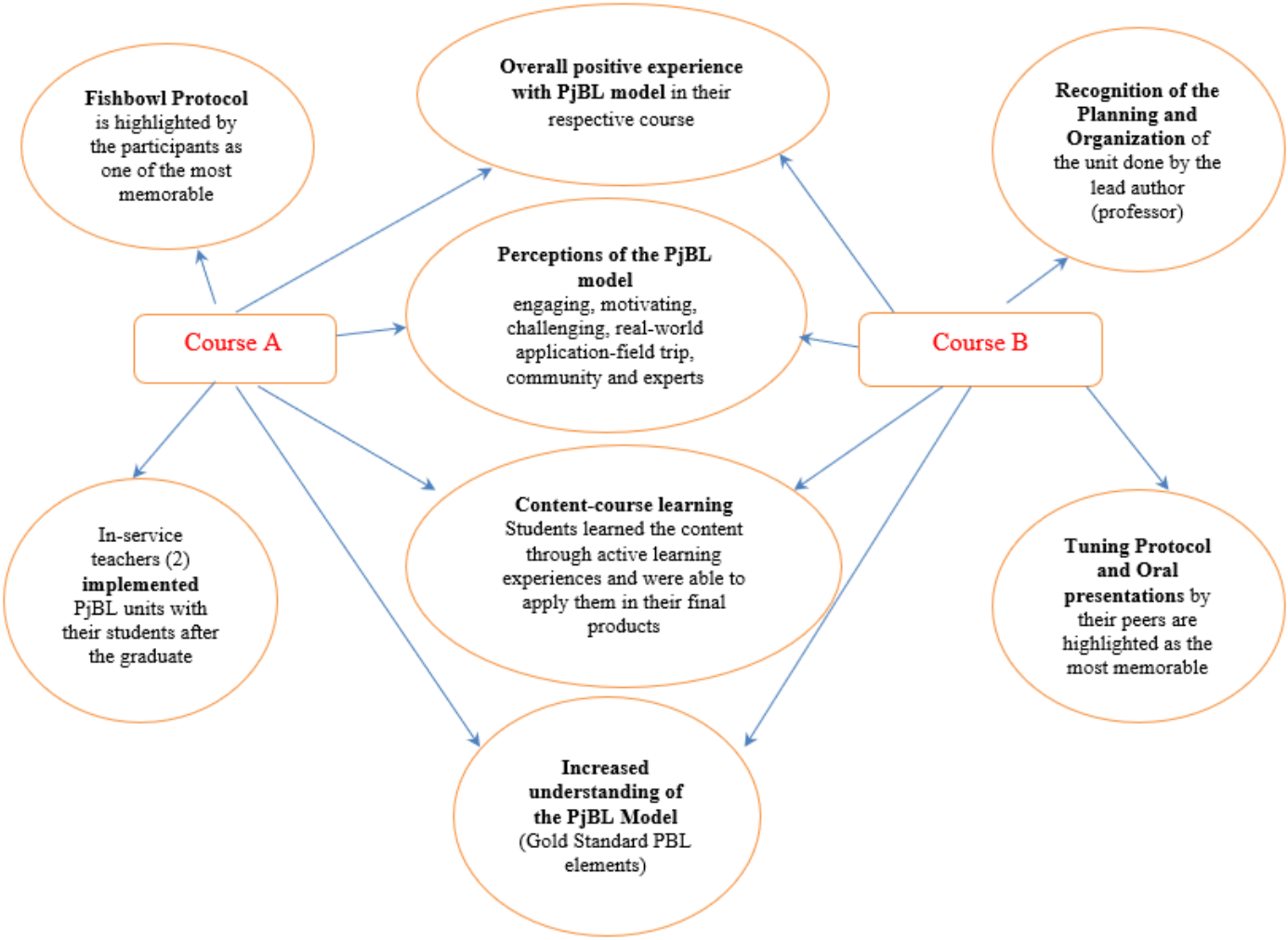


Figure 3. Comparison of overall findings among Course A and B.

Note: This figure was created by Delgado-Quiñones (lead author) to compare the overall findings of the study between Course A and B. The bubbles in the middle represent the similarities, while the bubbles at the left of each rectangle represent the differences found in each Course.

The results of this study highlight the promise of the Project-Based Learning Model (PjBL) for multiple purposes: learning the course content and other skills; learning about the model itself; preparing in-service science teachers on how implementation of PjBL looks and feels like, among others. Also, it addresses a research gap in the context of Puerto Rico, a US territory, in which

resources for teacher professional development are limited to one-day workshops mostly. Also, curriculum materials for PjBL design and implementation are limited due to several factors, the language barrier (Spanish) being one of the most cited among in-service science teachers. In the next section, we discuss the implications for practices of the findings of the study.

Discussion of findings

There are many challenges teachers face when deciding to use PjBL to design and implement their curriculum. Lack of time, state-mandated assessment tests, lack of support from principals, science teachers' beliefs about the PjBL model, or having few professional development opportunities represent some of the cited challenges in the research literature (Condliffe et al., 2017; Culclasure et al., 2019; Edmunds et al., 2017; Kurt & Akoglu, 2023; Tamin & Grant, 2013). In the United States of America (USA), the resources and efforts to promote PjBL are widely recognized (Chen et al., 2024; Condliffe et al., 2017; Culclasure et al., 2019; Lee et al., 2014; Virtue & Hinnant-Crawford, 2019). But the geopolitical and cultural context does play a role in how reforms are carried out because it exerts influence on the teaching practices in any society, as reflected in the study on problem-based pedagogies in teacher education programs in Botswana conducted by Major & Muvihill (2018). In the context of Puerto Rico, PjBL is part of the public policy (PRDE, 2022) and is highly recommended, but very few pre-service or in-service teachers have experienced PjBL in their K-12 school years, as was evidenced in our study.

Puerto Rico's geopolitical context is unique in that it is characterized by its territory status to the USA, which means that our educational system emulates that of the USA, but the implementation of educational reforms does not necessarily follow the same path or timeline as in the USA. One way to attend to these challenges is to have a clear understanding of the PjBL model; and the "Gold Standard PBL" framework provides the resources to accomplish this. Nonetheless, many of these resources are in English, and very few are available in Spanish, which is the native tongue language in Puerto Rico.

In some schools in USA, like the schools that are part of the New Tech Network Design (NTN), they use the "Gold Standard PBL Framework" (Culclasure et al., 2019; Virtue et al., 2019) to guide the professional development of their teachers and principals, design the school curriculum across different disciplines, and create a problem/project-based learning environment. Having a clear understanding of the design elements and teaching practices to support student learning and development of skills results in positive opinions and perceptions

among teachers and students (Culclasure et al., 2019). For example, in the study conducted by these researchers, many teachers agreed that PjBL made them more effective teachers. Results from this study indicated that teachers believed that the PjBL model improves student achievement, participation, and the application of information more than any other instructional model (Culclasure et al., 2019). Also, teachers reported that having a clear vision for PjBL in their schools supports the process of implementation. Similar to these findings, our results suggest that using the "Gold Standard PBL" framework provided a clear guide for the design and implementation of the curriculum unit, as well as guiding the learning process of the PjBL for the graduate students of both Course A and B. This led to the overall positive perceptions of the PjBL model.

The cooperative and collaborative structure is not considered as one of the key design elements of the Gold Standard PBL framework, but our findings reflect that this collaborative structure of the PjBL unit was key for their positive experience and learning, even when the cognitive demand of the final products was challenging. Boss & Larmer (2018) state as one key teaching practice, managing activities and some of these activities occur in cooperative or collaborative groups. Even when the collaborative and cooperative structure is included in the types of activities the teacher must manage, it is not considered a key design element of the framework. We suggest that this element should be included in the Gold Standard PBL framework to make teachers and students aware of the importance of collaboration and cooperation in the learning process.

The findings presented in this study suggest that implementing the PjBL model at the graduate level promotes student learning of course content and is perceived as a constructivist learning model by the participants of the study. Understanding how to design and implement PjBL curriculum units is a key component to increase the pedagogical content knowledge (PCK) of in-service science teachers and their self-confidence with constructivist learning models, such as PjBL. Particularly at teacher education programs, teacher educators and researchers must not only talk or lecture about problem- and project-based learning models; they should apply them to their courses and serve as role models of constructivist learning environments. One cannot assume that science teachers will design and implement PjBL based on reading about it; experiential experiences, such as the one described in this paper, are necessary to increase their self-confidence and understanding of the key design elements and teaching practices aligned to the "Gold Standard PBL Framework." It is precisely the use of this theoretical framework in the design of the curriculum unit implemented in both courses, that also served to guide the study is one aspect to take into consideration when conducting future studies. Our findings suggest that a clear understanding of the PjBL model and its underlining

principles is key for its correct implementation at all levels or contexts. Using the "Gold Standard PBL" framework provides a starting point for teachers, teacher educators and researchers to create more constructivist learning environments for their students. Using this framework can guide future research to better understand the educational context in which PjBL is being implemented.

Limitations of the study

We recognize that the results are limited to the context of the study and may not transfer or apply to other contexts or participants. Also, classroom observations were limited due to scheduling conflicts with other collaborating colleagues.

References

Barron, B. J. S., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., Bransford, J. D., & Cognition & Technology Group, Vanderbilt U, Learning Technology Ctr. (1998). Doing with understanding: Lessons from research on problem- and project-based learning. *Journal of the Learning Sciences, 7*(3-4), 271–311. https://doi.org/10.1080/10508406.1998.9672056

Baumgartner, E., & Zabin, C. (2008). A Case Study of Project-Based Instruction in the Ninth Grade: A Semester Long Study of Intertidal Biodiversity. *Environmental Education Research, 14*(2), 97-114. https://doi.org/10.1080/13504620801951640

Bender, W. N. (2012). *Project based learning: differentiating instruction for the 21st century.* Thousand Oaks: California, Corwin.

Bender, W. N. (2017). *20 strategies for STEM Instruction.* Learning Sciences International.

Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajick, J. S., Guzdial, M. & Palincsar, A. (1991). Motivating Project-Based Learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26*(3-4), 369-398. https://doi.org/10.1080/00461520.1991.9653139

Boss, S. & Larmer, J. (2018). *Project Based Teaching: how to create rigorous and engaging learning experiences.* Alexandria, Virginia: ASCD Publications.

Buck Institute for Education (2019). *PBL 101: An introduction to Project Based Learning. (7th ed.)*. Novato, California.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). The BSCS 5E instructional model: Origins and effectiveness. *Colorado Springs, Co: BSCS*, *5*(88-98).

Capraro, R.M., Capraro, M. M., Morgan, J. R. (2013). *STEM project based learning an integrated science, technology, engineering, and mathematics (STEM) approach (2nd. ed.).* Sense Publishers.

Chen, C., Said, T., Sadler, P. M., Perry, A., & Sonnert, G. (2024). The impact of high school science pedagogies on students' STEM career interest and on their ratings of teacher quality. *Journal of Research in Science Teaching, 61*(10),2535–2569. https://doi.org/10.1002/tea.21948

Condliffe, B., Quint, J., Visher, M. G., Bangser, M. R., Drohojowska, S., Saco, L., & Nelson, E. (2017). *Project-Based Learning: A Literature Review. MDRC.* Available at: https://www.scribd.com/document/463376772/Condliffe-et-al-2017-Project-Based-Learning-A-Literature-Review-Working-Paper

Craig T. T., Marshall J. (2019). Effect of project-based learning on high school students' state-mandated, standardized math and science exam performance. *J Res Sci Teach., 56*(10), 1461–1488. https://doi.org/10.1002/tea.21582

Creswell, J. W. (2012). *Research Design: Planning, Conducting, and evaluating quantitative and qualitative research* (4th ed.). SAGE Publications.

Culclasure, B. T., Longest, K. C., & Terry, T. M. (2019). Project-Based Learning (Pjbl) in Three Southeastern Public Schools: Academic, Behavioral, and Social-Emotional Outcomes. *Interdisciplinary Journal of Problem-Based Learning, 13*(2). https://doi.org/10.7771/1541-5015.1842

Dabbagh, N. Dr., & Williams Blijd, C. (2010). Students' Perceptions of Their Learning Experiences in an Authentic Instructional Design Context. *Interdisciplinary Journal of Problem-Based Learning, 4*(1). https://doi.org/10.7771/1541-5015.1092

Díaz Díaz, R. A. (2021). *Teaching strategies in middle school education* [Doctoral dissertation, Ana G. Méndez University]. UAGM Institutional Repository.

Dole, S., Bloom, L., & Kowalske, K. (2016). Transforming Pedagogy: Changing Perspectives from Teacher-Centered to Learner-Centered. *Interdisciplinary Journal of Problem Based Learning, 10*(1). https://doi.org/10.7771/1541-5015.1538

Edmunds, J., Arshavsky, N., Glennie, E., Charles, K., & Rice, O. (2016). The Relationship Between Project-Based Learning and Rigor in STEM-Focused High Schools. *Interdisciplinary Journal of Problem-Based Learning, 11*(1). http://dx.doi.org/10.7771/1541-5015.1618

Jiang, Z., Wei, B., Chen, S. & Tan, L. (2024). Examining the formation of High School Students' science identity: the role of STEM-PBL experiences. *Science & Education, 33*, 135-157. https://doi.org/10.1007/s11191-022-00388-2

Krajcik, J. & Czerniak, C. (2007). *Teaching Science in Elementary and Middle School: A project-based approach. (3rd ed.)* New York, New York: Routledge.

Kurt, G., & Akoglu, K. (2023). Project-based learning in science education: A comprehensive literature review. *Interdisciplinary Journal of Environmental and Science Education, 19*(3), e2311. https://doi.org/10.29333/ijese/13677

Larmer, J., Mergendoller, J. & Boss, S. (2015). *Setting the standard for project-based learning.* Alexandria, Virginia. ASCD Publications

Lee, J. S., Blackwell, S., Drake, J., & Moran, K. A. (2014). Taking a Leap of Faith: Redefining Teaching and Learning in Higher Education Through Project-Based Learning. *Interdisciplinary Journal of Problem-Based Learning, 8*(2). https://doi.org/10.7771/1541-5015.1426

López-Tosado, V. (1996). PROCIC: Un modelo para la enseñanza-aprendizaje de las ciencias naturales con un enfoque constructivista social para la solución de problemas de naturaleza científico-técnica**.** *Veritas: Anuario 97*(14), 113-130.

Merriam, S. B. & Tisdell, E. J. (2016). *Qualitative Research: a guide to design and implementation* (4th ed.). Jossey-Bass: A Wiley Brand.

Major, T., & Mulvihill, T. M. Dr. (2018). Problem-Based Learning Pedagogies in Teacher Education: The Case of Botswana. *Interdisciplinary Journal of Problem-Based Learning, 12*(1). https://doi.org/10.7771/1541-5015.1543

Mitchell, J. & Tilley, E. (2024). The Role of Project Based Learning at the Core of Curriculum Development. *Journal of Problem Based Learning in Higher Education, 12*(1), 1-17. https://doi.org/54.337/ojs.jpblhe.v12i1.9105

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165

NGSS Lead States (2013). *Next Generation Science Standards*: *for states by states.* National Academies Press.

Puerto Rico Department of Education. (2022). *Science Curriculum Framework: Revisions and Updates.* Government of Puerto Rico.

Rivera González, U. (2022). *Service-based learning in instrumental analytical chemistry instruction: A proposal from critical pedagogy for the University of Puerto Rico* [Doctoral dissertation, University of Puerto Rico, Río Piedras Campus]. UPR Repository.

Saldaña, J. (2021). *The Coding Manual for Qualitative Researchers.* SAGE Publications.

Svihla, V., & Reeve, R. (2016). Facilitating Problem Framing in Project-Based Learning. *Interdisciplinary Journal of Problem-Based Learning, 10*(2). https://doi.org/10.7771/1541-5015.1603

Surmani, W., Priatmoko, S, Kurwniawan, C & Prasetya, A. T. (June 16, 2023). Science teacher's perceptions of project-based learning with a STEM

approach (PJBL-STEM). The 8th International Conference on Mathematics, Science and Education 2021. *AIP Conf. Proc. 2614*(1), 030024-1–030024-6; https://doi.org/10.1063/5.0126206

Tamim, S. R., & Grant, M. M. (2013). Definitions and Uses: Case Study of Teachers Implementing Project-based Learning. *Interdisciplinary Journal of Problem-Based Learning, 7*(2). https://doi.org/10.7771/1541-5015.1323

Thomas, J. W. (2000). *A Review of Research on Project-Based Learning.* https://tecfa.unige.ch/proj/eteach-net/Thomas_researchreview_PBL.pdf

Vázquez Alvarado, D. E. (2020). *Project-based learning, video games, and the understanding of Science-Technology-Society* [Doctoral dissertation, University of Puerto Rico, Río Piedras Campus]. ProQuest Dissertations Publishing.

Velázquez Rivera, L. & Figarella García, F. (2018). *La problematización en el aprendizaje: tres estrategias para la creación de un currículo auténtico.* Edición Revisada, Editorial Isla Negra.

Villarini Jusino, Ángel R. (1991). *Manual para la enseñanza de destrezas de pensamiento.* San Juan, Puerto Rico: Proyecto de educación liberal-liberadora.

Virtue, E. E., & Hinnant-Crawford, B. N. (2019). "We're doing things that are meaningful": Student Perspectives of Project-based Learning Across the Disciplines. *Interdisciplinary Journal of Problem Based Learning, 13*(2). https://doi.org/10.7771/1541-5015.1809

Wu, M. L., Li, L., & Zhou, Y. (2023). Enhancing technology leaders' instructional leadership through a project-based learning online course. *STEM Education, 3*(2), 89–102. https://doi.org/10.3934/steme.2023007

Appendix A

Gold Standard PBL Framework: Design Elements

Initial Interviews (October 2022): Deductive Coding – Course A

Participant Number →	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
Key Design Elements ↓	Bachelor degree in Education	Bachelor degree in Biology	Bachelor degree in Education	Bachelor degree in Biology	Bachelor degree in Biology	Bachelor degree in Biology
Challenging problem or driving question	√	√	√	√		√
Sustained inquiry			√			
Authenticity		√	√			
Student voice and choice	√		√	√		√ student centered
Reflection						
Critique and Revision						
Public Product	√	√	√	√	√	√
**Collaborative work Additional element that emerged				√	√	√ Social learning

Participants describe PjBL as a learning model.

Appendix B

Gold Standard PBL Framework: Design Elements

Final Interviews (December 2022): Deductive Coding – Course A

Participant Number →	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
Key Design Elements↓	Bachelor degree in Education	Bachelor degree in Biology	Bachelor degree in Education	Bachelor degree in Biology	Bachelor degree in Biology	Bachelor degree in Biology
Challenging problem or driving question	√	√	√	√	√	√
Sustained inquiry	√	√	√			√
Authenticity	√		√ Context			√
Student voice and choice	√	√	√ The role was different from previous experience	√	√	√
Reflection		√				

Critique and Revision	√ Tuning Protocol Greatest learning experience	√		√ Tuning Protocol Greatest learning experience	√	√ Tuning Protocol Greatest learning experience
Public Product	√	√ Greatest learning experience	√	√	√	√
**Cooperative and collaborative learning	√	√ It was a challenge but was able to manage it	√	√	√ Highlights this element	√ Fishbowl Protocol

- The theme of motivation emerged among the participants as they stated that by working the course with this PjBL model, they felt motivated all the time to attend the classes.
- They also state that many of the activities carried out in class were integrated into their curricular units. This could be evidenced in the curricular units (e.g., Climate Change).
- In the final interviews, the participants expressed that after this experience they feel more confident in implementing the Project-Based Learning model. They also see it as an interdisciplinary model in which various subjects can be integrated.

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 113-140
doi.org/10.54337/ojs.jpblhe.v14i1.10569

The Effectiveness of Problem-Based Learning in Enhancing Learners' English Language Skills

Meta-Analysis and Systematic Review

Alemayehu Assefa | Hawassa University, Ethiopia
Mebratu Mulatu Bachore * | Hawassa University, Ethiopia
Tagesse Daniel | Hawassa University, Ethiopia

Abstract

Problem-Based Learning (PBL) has been widely studied as one of the successful teaching methods in English Language Teaching (ELT) as it enhances learners' motivation, critical thinking, and language acquisition. The purpose of the current systematic review and meta-analysis is to critically evaluate the impact of PBL on reading, writing, and speaking abilities of the learners based on the analysis of 30 published articles from 2016 to 2024. Of the articles, 13 of them were on speaking skills; 10 were on writing and 7 were on reading. Methodologically, the studies were grouped as 14 quantitative, 6 qualitative, and 10 employed mixed methods. Meta-analysis was applied to the quantitative studies to estimate statistical significance (p-values), and the magnitude of the difference (Cohen's d). Heterogeneity of effect sizes was determined by I^2 statistic, and the analysis was also done to explore differences between the effect

* Corresponding author:
Mebratu Mulatu Bachore: mebratumulatu@gmail.com / mebratu@hu.edu.et

Received 3 July 2025 | Accepted 14 January 2026 | Available online in Early View 26 March 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

of PBL in the language skills category (speaking, reading, and writing) and study levels (tertiary and secondary). The findings indicated that PBL significantly improved language skills. It has the highest impact on the writing ability (Cohen's d = 1.2–2.1) whereas speaking ability (d = 0.5–1.5) and reading skill (d = 0.7–1.5) came as runners-up in terms of strength. The outputs of qualitative analysis showed high learner motivation, self-study, and teamwork but were not empirically grounded. The analyses further revealed that students at tertiary level benefited most from PBL intervention than that of the secondary level. In spite of its effectiveness in the area of English language teaching, future studies have to be conducted employing long-term retention measures, relative teaching models and improved standardizations.

Keywords: Problem-Based Learning; Language Learners; English Language Skills

Introduction

Problem-Based Learning (PBL), which was first introduced in medical education in the 1960s at McMaster University in Canada, has changed over the decades to become a popular pedagogical approach in many different fields, from business and engineering to social sciences and more recently to language learning (Barrows & Tamblyn, 1980; Savery, 2006). The basic principle of PBL is encouraging students as they learn best when they actively engage in authentic and contextual problem solving through guided inquiry. This approach has made it wildly popular among education systems interested in promoting active, student-led learning. Over the past two decades, PBL has been implemented more widely in English as a Foreign Language (EFL) and English as a Second Language (ESL) environments due to its potential to promote critical thinking, collaboration, and authentic language use (Lin, 2017; Iskandar et al., 2021). The shift is an important pedagogical change away from traditional teacher-centered instruction to more interactive, participatory, and learner-centered language learning environments.

Philosophical roots of PBL are well rooted in pragmatist and progressive education philosophies. In human life philosophy, PBL aligns with pragmatism in learning by doing and translating knowledge to the real world (Dewey, 1938). Pedagogically, PBL most aligns with progressivism, which advocates experiential learning and the development of problem-solving skills (Barrows, 1986; Dewey, 1938). Further, PBL is guided by critical theory in its approach that allows learners to be more active in their own learning and in societal change. It also aims at fostering critical thinking among the students that

enables them to analyze and question societal norms and injustices (Tavella, 2017).

In addition, it is the base for formation of critical consciousness, and engagement with societal concerns; a way of thinking especially well-suited for multicultural and multilingual environments like EFL settings. In language learning-teaching paradigms, PBL is supported by interactionism and constructivism theories. It puts into perspective the dynamism between learners and their social settings. Interactionism theorizes that the acquisition of language learning is arrived at by a social interaction or negotiation of meaning among learners (Maflah, 2023). This is complemented by the views expressed by Constructivism, stating that active construction of understanding by learners through experience occurs (Tesar et al., 2022). Therefore, both theories perceive language as a social tool jointly built through effective communication, hence making it a perfect paradigm for learning the English language.

Theoretical background of PBL draws from the constructivist theory, more so the works of Jean Piaget and Lev Vygotsky. Knowing this theoretical background helps to establish how these initial viewpoints inform pedagogical mechanism of PBL. Piaget's position is that learners develop knowledge actively from their interactions in the world (Piaget, 2013), while Vygotsky's Social Constructivism puts immense priority on the salient role accorded to the social interaction as well as social tools in cognitively constructivist processes (Vygotsky, 1978). Zone of Proximal Development (ZPD), one of the most Vygotsky's contributions, aligns closely with PBL's scaffolding practical activities, in which the learners are supported by the teacher and peers to solve problems that slightly beyond their immediate abilities. While Zone of Proximal Development (ZPD) is not directly conducted in all of the reviewed studies, the principles of scaffolding learning and collaborative problem solving have conducted and revealed encouraging outcomes in EFL contexts. For example, studies by Berenji et al. (2020) and Sutrisna and Artini (2020) have proven that students have shown significant language ability improvement when engaged in PBL tasks that support group work and contextualized language use.

PBL is now a mainstream teaching methodology all over the world in developing and developed nations. In Asian contexts such as Indonesia, China, and Iran, numerous studies have borne witness to the efficacy of PBL in enhancing learners' language performance and motivation (Syahfutra & Niah, 2019; Jumariati & Sulistyo, 2017; Montafej et al., 2022). In African contexts, PBL has started to gain attention for its potential to be applied in multilingual and resource-poor environments, where traditional rote-based methods are not capable of equipping learners with communicative competence. Its focuses on collaborative learning, real world problem solving, scaffolding, and the use of

locally available materials makes PBL crucial to adapt it in developing countries where technologies and infrastructures are limited. In Ethiopia, English being employed as an instructional language in higher education, the use of PBL in ELT is emerging as a feasible way to develop critical thinking and language capacity (Fekadu et al., 2024). Implementation challenges persist due to infrastructural limitations and inadequate teacher training in learner-centered pedagogies.

Incorporating PBL into ELT resonates with an overarching pedagogical trend toward active, experiential, and inquiry-driven learning. PBL makes students reflective learners while reading class through contextual investigations of themes and their common uses (Arjuna & Jufri, 2016). In speech class, PBL gives the students real interaction through language use for a purpose in discussion and presentation (Kholis, 2021; Fahmi et al., 2021). In writing classes, PBL makes the argumentation and critical thinking process easier as students collaborate to develop solutions to real problems (Dastgeer et al., 2019; Mairani, 2022). These applications demonstrate how PBL is being developed for diverse language abilities and teaching contexts to enable more effective and meaningful learning.

Reading, speaking, and writing are the core of EFL learners' language ability. These skills are needed not only for classroom success but also for communication in daily life, obtaining employment, and participating in world conversation (Nation & Macalister, 2010). In the majority of EFL countries, however, language teaching is still too grammatically and memorization-focused with insufficient focus on communicative competence (Richards, 2006). As PBL is rooted in Interactionism-Constructivism paradigm, it is thus integration of principles about social interaction into constructivist theories of learning with these latter emphasizing meaningful communications in developing language proficiency (Vygotsky, 1978). Thus, PBL comes to plug or fill this gap by enabling learners to employ language as a means of reasoning, expression, and meaning negotiation. Empirical studies across contexts indicate that PBL has a very positive effect on the reading comprehension (Rosyidin et al., 2022), oral expression (Arani et al., 2024), and writing fluency (Alghamdy, 2023) of students.

The applicability of PBL to ELT competencies relies upon its ability to enable active learning, develop intrinsic motivation, which is the internal motivation to learn for personal interest and value, and create contextualized language use. Based upon constructivist and socio-cultural theoretical perspectives (Ryan & Deci, 2000; Vygotsky, 1978), PBL encourages students to engage genuine tasks supportive of autonomy, or independent learning, competence, and relatedness, each essential to long-term language growth. In reading, it enables learners to approach texts as problem-solvers and thereby enhance

comprehension and recall (Berenji et al., 2020). In speaking, it enables spontaneous communication and confidence-building through presentation and discussion in groups (Montafej et al., 2022). In writing, it enables planning, drafting, and critical revision skills needed in academic and professional communication (Jumariati & Elvina, 2024). These findings highlight PBL's potential as an integrating framework for developing all three foundation language skills in a balanced, integrated manner.

Given the importance of PBL in EFL teaching and the enormous extent of empirical studies conducted during the last decade, a meta-analysis and systematic review are necessary as well as in order. Despite early evidence of positive outcomes, existing research is heterogeneous with respect to design, sample size, classroom conditions, and outcome measures. This contradiction has hindered the ability of researchers and teachers to make generalizations or determine best practice. In order for this gap to be closed, this synthesis and overview of 30 peer-reviewed articles derived from diversified nations and methodological inclinations are required to determine the effect of PBL on reading, speaking, and writing proficiency in ELT. Moreover, it also seeks to identify common pedagogical practices, new directions, and gaps in the literature currently, thus providing a common basis for future research and teaching practice.

This Meta-Analysis has implications for teachers, curriculum developers, and policymakers seeking evidence-based practices further to empower ELT. It provides a glimpse of the impact of PBL on language fields and diverse learning environments, even those with inadequate resources. The review also spans primary and tertiary levels, revealing the applicability of PBL at all ages and skill levels. It will inform teaching strategies and the development of PBL-based curricula that are more responsive to 21st-century educational concepts.

The study attempted to answer the following questions:

1. How effective is Problem-Based Learning (PBL) in enhancing reading, speaking, and writing skills in English Language Teaching?
2. What trends and pedagogical approaches characterize the implementation of PBL in ELT across different educational contexts?
3. What methodological patterns, strengths, and gaps are evident in the existing body of PBL-related ELT research?

Methods

This review has critically examined 30 empirical studies which were published from 2016-2024 with the aim to evaluate the effectiveness of Problem-Based

Learning (PBL) in enhancing English language proficiency; that is, speaking, reading, and writing. It employed a systematic review and meta-analysis approach in order to synthesize the peer-reviewed study outputs from diverse educational contexts and methodological backgrounds.

Based on Moher et al.'s (2009) and Petticrew and Roberts's (2006) guidelines, the review applied transparent, reproducible, and systematic methods with the aim of preventing bias and ensuring comprehensive coverage of the literature. Two essential analytic approaches were employed to synthesize evidence in the selected articles. In the first step, meta-analysis was applied in reporting the numerical data, under which quantitative summation of PBL's effect on English language ability was feasible. It entailed computing the effect size and comparing the results by language ability and the nature of study designs. A thematic content analysis was then applied in qualitative data for the identification of trends, concerns, and strengths in pedagogy by PBL enactment in ELT. This consisted of coding text data, packaging themes, and interpreting results through constructivist and socio-cultural theory frameworks. The use of both methods allowed for combined synthesis linking statistical trends and experiential insight. Methodological heterogeneity is referred to as the diversity in methodology used in the 30 studies examined; and not concerning the authors' research design; and speaks to the range of ways of studying PBL with varying contexts and student groups.

Eligibility Criteria

Individual inclusion criteria in the study selection are as follows: only English language-based empirical studies that have been published in the years 2016-2024 were included. The years were chosen in order to adopt the most recent trends in the implementation of PBL in ELT, as they reflect current pedagogic trends as well as current methodological developments. The studies had to imply the implementation of PBL in an explicit way in ELT and include at least a mention of a reference to the three basic language skills, i.e., writing, speaking, or reading. Quantitative, qualitative, and mixed-method studies were allowed, provided they were conducted in an educational setting such as in the primary, secondary, or tertiary learning institutions. Despite their diversity in method and theory, the studies evinced concern about the practicality of PBL's application in the pedagogy of English. Enabling such pedagogic communality, the studies were integrated through discussion of PBL's operation in varying research designs and contexts, while thematic as well as meta-analytic studies provided experiential as well as numerical result integration. Moreover, only that research with measurable outcomes in the form of quantitative, qualitative, or both were included to ensure that the review could systematically assess the impact of PBL on English language proficiency and extract comparable findings across diverse contexts. Non-empirical studies (opinion articles or theory

articles), non-English language, without PBL as the intervention of primary interest, or without measurement of outcome in language skills acquisition were excluded from the selected articles.

Search Strategy

For the purpose of identifying appropriate literature, broad search strategies were employed across several relevant databases, including ERIC, Scopus, Web of Science, ProQuest, and Google Scholar. In addition, institutional repositories were also retrieved. The terms "Problem-Based Learning," "English Language Teaching," "ELT," "reading," "speaking," and "writing" were combined as keywords and implemented using Boolean operators to make the search cover a wider breadth. Truncation and synonym mapping were employed to include variations of keywords. Reference chaining was also conducted to follow other potential studies that were referenced in selected articles.

Study Selection Process

Screening and selection subsequent to the first search were done in accordance with the PRISMA 2020 guidelines (Page et al., 2021). There were 123 articles generated following the initial search. Among these, 34 duplicates were excluded, and the remaining 89 articles became eligible for consideration. The titles and abstracts were screened and 32 articles which were not relevant were excluded. Of the remaining 57 full-text articles, 27 were excluded because they did not meet the inclusion criteria, and thus the final sample consisted of 30 studies. For ensuring objectivity and reliability, the reviewer also conducted two independent screening and selection process.

As a result, 30 empirical PBL effectiveness studies in ELT were selected in this systematic review and meta-analysis. According to the types of research methods used, 14 employed a quantitative method, 6 employed qualitative method, and 10 employed a mixed-methods method.

R. No	Author(s)	Publ. Year	Focus Area/Contribution	Location	Method	Design	Level of Edu.
1	Agustise	2022	Improving Ninth Grade Students' Speaking Skill through PBL	Indonesia	Mixed	Action Research (3 Cycles)	Junior High School
2	Alghamdy	2023	Efficacy of PBL to Enhance Paragraph Writing and Grammar	Saudi Arabia	Mixed	Quasi-experimental	Secondary
3	Arani et al.	2024	Impact of PBL on speaking proficiency features in EFL learners	Iran	Quantitative	Experimental	Pre-intermediate
4	Arjuna & Jufri	2016	Use of PBL in teaching reading comprehension	Indonesia	Qualitative	Descriptive-Analytical	Junior High School
5	Aulia et al.	2023	PBL to improve reading comprehension in senior high school EFL students	Indonesia	Mixed	Two-cycle CAR	Senior High School
6	Berenji et al.	2020	Impact of PBL on EFL learners' engagement and reading comprehension	Iran	Quantitative	Quasi-experimental	Undergraduate
7	Cahyaningrum et al.	2024	Improving writing ability of vocational students through PBL	Indonesia	Mixed	Classroom Action Research (3 cycles)	Vocational High School (Grade 11)
8	Dastgeer et al.	2019	Transforming English Writing via PBL	Pakistan	Quantitative	Experimental	Secondary (Grade 9)
9	Dwiyamtini	2022	Application of PBL to Improve English Speaking Skills	Indonesia	Mixed	Two-cycle CAR	Senior High School
10	Fahmi et al.	2021	Using PBL to enhance students' speaking ability	Indonesia	Quantitative	Experimental	Senior High School

11	Hamsia & Erydani	2022	Implementation of PBL Model in Improving Speaking Skills	Indonesia	Qualitative	Descriptive Qualitative	Higher Ed
12	Iskandar et al.	2021	PBL for enhancing critical thinking and reading skills in vocational EFL learners	Indonesia	Mixed	Mixed	Vocational School
13	Iswandari et al.	2017	Environmental PBL and Vocabulary/Writing Ability	Indonesia	Quantitative	Quasi-experimental	Senior High School
14	Janitra & Dewi	2024	Vocational students' perceptions of PBL in speaking English	Indonesia	Quantitative	Survey	Vocational High School
15	Jeldu et al.	2024	PBL's effect on oral vocabulary as part of speaking performance	Ethiopia	Quantitative	Quasi-Experimental	Secondary
16	Jumariati & Arapah	2024	Effects of PBL on Writing Across Personality Types	Indonesia	Quantitative	Quasi-experimental	University (English Dept.)
17	Jumariati & Sulistyo	2017	Effect of PBL on argumentative writing skills	Indonesia	Quantitative	Quasi-Experimental	Undergraduate
18	Kholis	2021	Teaching Speaking Using PBL in vocational EFL students	Indonesia	Qualitative	Observation-based	Vocational HS
19	Lestari et al.	2023	PBL Implementation for Students' Speaking Achievement	Indonesia	Qualitative	Comparative analysis	(Jr High, High School
20	Lin	2017	Impact of PBL on reading comprehension, strategy use, and learning attitudes	Taiwan	Quantitative	Quasi-experimental	Undergraduate
21	Mairani	2022	Improving Students' Writing Skill Using PBL	Indonesia	Mixed	Classroom AR	Senior High School

22	Montafej et al.	2022	Effects of hybrid and pure PBL on speaking and self-confidence in Iranian EFL learners	Iran	Quantitative	Quasi-experimental	Undergraduate
23	Mubarak et al.	2023	PBL in Teaching Students' Speaking Skill	Indonesia	Qualitative	Descriptive Analytical	Secondary
24	Oktadela & Elida	2022	PBL to improve speaking skills in EFL learners	Indonesia	Qualitative	ADDIE Model	Higher Ed
25	Qadryanti et al.	2022	PBL Approach to Improve Writing Skills for Post Graduate Students	Indonesia	Quantitative	Pre-experimental (one-group pre-post)	Postgraduate (3rd semester)
26	Rosyidin et al.	2022	Effect of PBL on reading comprehension in EFL learners	Indonesia	Quantitative	Experimental (2×2 factorial)	Tertiary
27	Setlight et al.	2023	PBL as a method for improving EFL students' writing	Indonesia	Mixed	Classroom Action Research (2 cycles)	Senior High School
28	Sutrisna & Artini	2020	Impact of PBL on speaking skills and learner attitudes	Indonesia	Mixed	One-group pre-post + qualitative	Secondary
29	Sutrisna & Juliari	2019	Promoting writing skills in EFL through PBL	Indonesia	Mixed	Pre-experimental (embedded)	Secondary (Grade 7)
30	Syahfutra & Niah	2019	Strategic reading development through PBL	Indonesia	Quantitative	Quasi-Experimental	Junior High School

Table 1. Selected studies.

Quantitative studies employed experimental or quasi-experimental methods in an attempt to quantify the effect of PBL with statistical measures. The research presented robust quantitative data on the effect of PBL on the reading, speaking, and writing ability of the students. The qualitative research examined students' attitude, experience, and engagement towards PBL in the actual classrooms. The studies gave rich descriptive data about implementation of PBL in improving students' confidence, cooperation, and autonomy.

The mixed-methods studies combined both qualitative and quantitative approaches in providing thorough analysis on the effectiveness of PBL. Employing multiple sources of data, test scores, classroom observation, students' reflection, and teachers' interview allowed the studies to assess process and outcome of PBL. This three-dimensional metric allowed researchers to measure not only gains in language proficiency but also shifts in learner participation, autonomy, and collaborative action, thus further illuminating the pedagogical effectiveness of PBL in ELT environments.

Data Extraction

A systematic process of data extraction was conducted. A data sheet was prepared so that data can be collected in the studies in a consistent manner. The data used included authorship, year, study title, purpose, linguistic competence addressed, design and methodology, participant education level, number of participants, data collection instruments, sampling technique, data analysis method, quantitative findings, findings of significance, and gap filled. Statistical information gathered through the quantitative research was group means, p-values, and effect sizes. The principal findings, research gaps, and authors' conclusions were recorded in all cases to inform the synthesis.

Quality Assessment

To ensure methodological consistency and homogeneity in assessing the quality of the included studies, the relevant appraisal tools were chosen in accordance with the study design. Quantitative studies were assessed employing the Joanna Briggs Institute (JBI) checklist, most appropriate for assessing quasi-experimental and randomized studies in an educational setting. In case of qualitative studies, the Critical Appraisal Skills Programme (CASP) checklist was employed, which is most renowned for addressing credibility, relevance, and transparency in qualitative research. Mixed-methods studies were assessed using the Mixed Methods Appraisal Tool (MMAT) by Hong et al. (2018), which supports overall assessment of qualitative and quantitative aspects. Instruments were selected considering popularity, robustness, and correspondence with the varied methodological approach documented in reviewed literature. Although studies were not excluded purely according to

quality scores, the result of appraisals guided interpretative weighting at synthesis. More robust studies, according to the JBI, CASP, and MMAT tools, held increased dominance in informing conclusions, where findings agreed across several robust designs. Methodologically flawed studies were, in contrast, approached with caution and entered into thematic patterns rather than underpin key assertions. This practice maintained the synthesis inclusively but critical.

Methods of Analysis

The data analysis was carried out in two-pronged approach. For qualitative data, thematic content analysis was applied to determine common patterns, pedagogical benefits, and challenges in implementing PBL in ELT. This method involved technically coding textual data from the chosen research, grouping related codes into themes, and interpreting those themes in relation to the research questions and theoretical framework. The thematic analysis was adopted due to its flexibility and appropriateness in summarizing heterogeneous qualitative outcomes to document a subtle comprehension of experience and implementation of PBL in different learning settings.

For quantitative studies, a meta-analysis was applied in the studies with sufficient numerical data. Analysis involved computing standardized mean difference (Cohen's d), calculation of statistical significance from p-values, and calculation of confidence intervals. Heterogeneity of effect sizes was assessed using the I^2 statistic, and subgroup analyses by language ability and educational level were performed to investigate variation in the effect of PBL. This intensive, multi-level methodological approach ensured that the review was systematic and integrative, mirroring the breadth and depth of the effect of PBL in English language classrooms across a variety of educational settings.

Results and discussion

Language Skill	Total Studies	Quantitative	Qualitative	Mixed-Method
Speaking	13	5	5	3
Reading	7	4	1	2
Writing	10	5	0	5
Total	30	14	6	10

Table 2. Overview of studies on PBL and English Language Skills.

Of the total studies, 14 employed quantitative methods, 6 qualitative methods, and 10 mixed-method studies. The most studied language skill was speaking, with 13 studies, of which 5 were quantitative, 5 qualitative, and 3 mixed-method studies. Reading was explored in 7 studies of which 4 were quantitative, 1 qualitative and 2 mixed-method. Writing was explored in 10 studies, half and half between 5 quantitative and 5 mixed-methods research.

Research methods employed in language skills

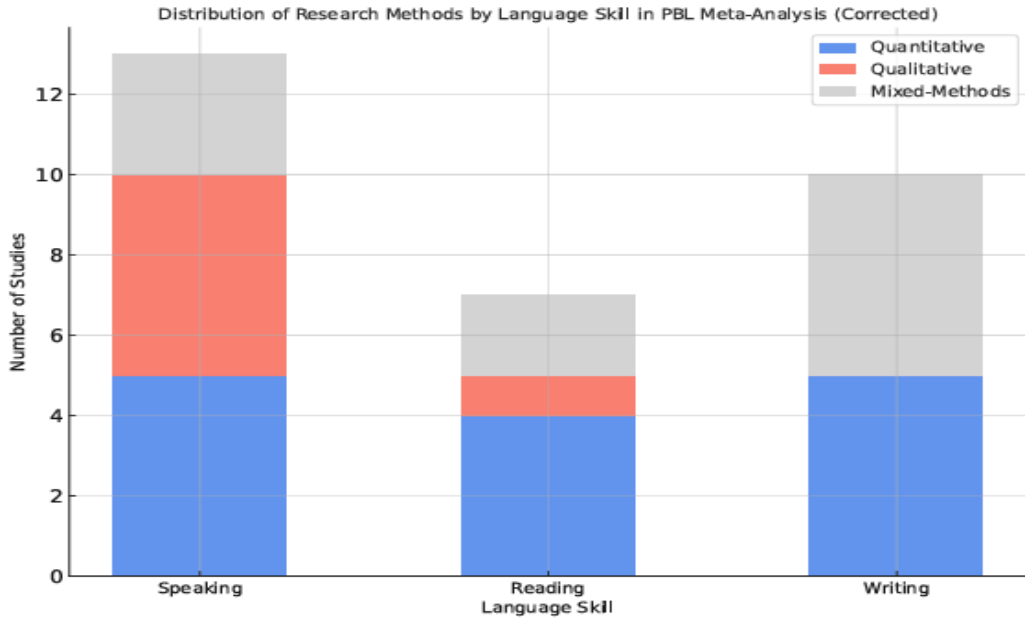


Figure 1. Distribution of research methods by language skills in PBL meta-analysis.

The bar chart illustrates the spread of research approaches: quantitative, qualitative, and mixed-methods, among the three key English language skills: speaking, reading, and writing, as explored in the 30 empirical studies included in this systematic review and meta-analysis. The results reveal that speaking skills were the most researched, appearing in 13 studies. Five of them employed quantitative research methods, five qualitative, and the remaining three mixed-method approaches. This suggests a relatively balanced methodological concern with the development of speaking skills through Problem-Based Learning (PBL), though variations in study design and context warrant cautious interpretation.

By way of contrast, reading skills were the focus of only seven studies. Four of these used quantitative research approaches, one used a qualitative approach, and two were mixed-method studies. The relative under-representation of qualitative studies of reading suggests a remarkable gap in the literature that could be explored through more descriptive and exploratory approaches and

closer engagement with learner perceptions and process of reading activity. More studies can utilize ethnographic approaches, discourse analysis, or narrative studies to attempt discovering how learners build meaning, traverse across texts, and react to PBL-infused activities in reading. This study can clarify the socio-cognitive aspects of reading in ELT and inform theory building with learner autonomy, scaffolding, and meaning negotiation between constructivist and socio-cultural orientations.

Writing skills were examined in ten studies, of which five were each quantitative and mixed-methods. Furthermore, there was not a single qualitative review on writing skills in the literature examined. This shortage of qualitative research opens the window of possibilities for an engaging field of future studies, i.e., cognitive and affective dimensions of writing development in PBL systems. Think-aloud protocols, learner diaries, classroom ethnographies, or case studies are some of the means by which more light could be shed on how the students themselves understand writing tasks, manage their feelings, and acquire metacognitive abilities. This type of research has the potential to shed light on scaffolding, feedback, and peer work that facilitate writing capacity and make theoretical contributions to self-regulated learning, socio-cognitive engagement, and identity formation in ELT.

Overall, the distribution reveals that while all three language skills have been studied through various methodological frameworks, qualitative inquiry remains underrepresented in both reading skill and writing skill studies. The prevalence of quantitative and mixed-method designs is a reflection of the field's commitment to continuing to emphasize measuring the efficacy of PBL through empirical and in most instances experimental methods. These findings underscore the need for a more balanced methodological terrain, especially where learner experience and teaching procedures: such as classroom dynamics, feedback practices, scaffolding techniques, and learner motivation, may be more effectively handled via qualitative research. Reflective diary, interview, and classroom observation are some of the instruments that can yield data-rich insights into the ways PBL is realized and experienced in ELT classrooms.

Effect of PBL on Reading Skill

Seven studies in the dataset focused on the use of PBL for reading skills development, of which 4 were quantitative, 1 qualitative and 2 mixed methods. Lin (2017), Syahfutra and Niah (2019), Berenji et al. (2020), and Rosyidin et al. (2022) demonstrated that there was noteworthy improvement in reading comprehension test scores and vocabulary of the students following the application of PBL approaches. The qualitative research of Arjuna and Jufri (2016) established that learners utilizing PBL were more likely to comprehend

texts and employ critical thinking strategies in reading classes. Two employed mixed-methods in assessing the reading performance. Iskandar et al. (2021) and Aulia et al. (2023) found that, apart from the students improving the level of comprehension, they also had more positive attitudes towards reading. These two research studies were highly observant of how PBL was capable of facilitating more profound investigation of the text, inferencing, and communal interpretation on the part of the students.

PBL was observed to improve motivation, increased understanding, and strategic reading behavior, which led to a significant improvement in comprehension skills. In the four quantitative studies, the meta-analysis approximated the average effect size to vary between Cohen's d = 0.7 to 1.5 with moderate heterogeneity (I^2 = 51.2%) and evidenced consistency in the positive effect of PBL with methodological variation.

Lin (2017) conducted a quasi-experiment among 56 undergraduate students (Exp = 26, Ctrl = 30) and concluded that PBL had a significant effect on reading comprehension improvement. The research indicated a high effect size (d = 0.81, $p < 0.05$, CI: 0.62–0.99), finding that students who were subjected to PBL demonstrated improved reading strategies and comprehension activities when compared to students in normal learning settings. Similarly, Syahfutra & Niah (2019) tested 48 junior high school students (Exp = 24, Ctrl = 24) and determined that PBL promoted significantly recall of facts information (d = 0.73), identification of main ideas (d = 1.78), acquisition of vocabulary (d = 1.35), citation (d = 1.30), and inferencing ability (d = 1.58) significantly, with significant comprehension gain.

The enhancements were also verified by Berenji et al. (2020) using a greater sample size of 80 undergraduate students (Exp = 40, Ctrl = 40). There were differences in their ANCOVA test ($F = 91.28$, $p < 0.001$, $\eta^2 = 0.54$), verifying the effectiveness of PBL. The students also were shown to be more active and more involved with PBL, where in Wilks' Lambda = 0.02, $F = 261.42$, $p < 0.001$, high levels of student motivation and activity existed.

The qualitative research also shows improvement of student participation, motivation, and understanding due to PBL. Arjuna & Jufri (2016) documented a positive change in the level of student engagement, i.e., PBL encouraged independent learning and more interaction with texts. Their observation was not tested empirically, however, and statistical comparison was not possible. Iskandar et al. (2021) carried out their study among vocational high school students and reported improved critical thinking as verified by expert judgment. Their research shows that PBL encourages analytical reading ability more than generic reading comprehension.

Aulia et al. (2023) carried out PBL using the Gallery Walk method of a two-cycle classroom action research. The process involved the students hanging their work along the class and walking around in groups to view, discuss, and provide comments about each other's work. The process allowed for active engagement, learning from each other, and reflective thinking; all of which just so happen to be very much in line with the collaborative and inquiry-based approach of PBL. Findings indicated that student engagement had an improved high percentage in Cycle 2, in which group dynamics problems that inhibited performance in Cycle 1 were resolved. The most robust evidence recorded by the research was enhanced students' cooperation in PBL. In spite of that, the research failed to construct statistical proof to establish the general success of the strategy, negating its findings.

Despite the sheer preponderance of evidence in favor of PBL's impact on reading comprehension, there are certain lacunae. Firstly, there are barely any long-term retention studies, and one doesn't know if gains attributable to PBL are long term. Secondly, nearly all the research focuses on short-term interventions, which tell very little about the long-term influence of PBL on comprehension. Future research will be required to employ controlled longitudinal designs to determine ways in which PBL sustains reading ability many years after it has been learned. These studies might establish trends in students' reading proficiency, reveal long-term cognitive and motivational effects of PBL, and inform teaching practice for supporting extended literacy development. Longitudinal evidence may also further sharpen theory-development on learner autonomy, learning transfer, and constructivist teaching stability in ELT.

Effect of PBL on Speaking Skill

Speaking skill garnered the greatest number of responses to the area concerned, with 13 papers, of which 5 were quantitative, 5 qualitative, and 3 mixed-method studies, discussing the measurement of PBL's impact on the speaking skill, fluency, pronunciation, and usage of the students. In the quantitative studies, Fahmi et al. (2021), Montafej et al. (2022), Janitra and Dewi (2023), Jeldu et al. (2024), and Arani et al. (2024) indicated statistically significant development in the speaking accuracy, fluency, and oral vocabulary of the students with PBL-interventions. The qualitative studies, for instance, Kholis (2021), Hamsia and Erydani (2022), Oktadela and Elida (2022), Mubarak et al. (2023), and Lestari et al. (2023), highlighted PBL in facilitating real-life and authentic speaking practice, reducing language anxiety, and enhancing confidence among the learners.

Apart from this, mixed-methods studies provided an overall view of how PBL impacts speaking. Sutrisna and Artini (2020), Agustise (2021), and Dwiyamtini

(2022) considered not only measurable improvement in speaking ability only, but also qualitative outcome of more learner autonomy among students and peer collaboration in communicative activities. In combination, these studies lend early support to the potential of PBL to facilitate active communication for language learners, particularly through greater autonomy and peer collaboration. On the other hand, with restricted sample size and setting variability, assertions for large-scale efficacy should remain cautious.

The effectiveness of PBL to enhance speaking ability has been supported by various experimental and quasi-experimental studies. The findings indicate that PBL facilitates enhancement in fluency, vocabulary, and confidence in speaking with medium to large effect sizes (Cohen's $d = 0.5$ to 1.5, $I^2 = 57.9\%$).

For example, Arani et al. (2024) did an experiment with 90 EFL pre-intermediate students by dividing them into three groups (Online PBL = 30, Face-to-Face PBL = 30, Control = 30). They reached the conclusion that there is an extremely high effect of PBL on speaking skill, with best effect when online ($d = 1.5$, $p < 0.005$, CI: 1.30–1.75). Results show that facilitated problem-solving elicits more interaction and spoken communication.

Another example is provided by Fahmi et al. (2021), who applied senior high school students using pre-post experimental study. Gains of confidence and fluency ($d = 0.95$, $p < 0.05$, CI: 0.70–1.15) were shown, confirming PBL's effectiveness. In addition, Jeldu et al. (2024) applied oral vocabulary acquisition for Grade 11 students, and the findings indicated significant vocabulary gains ($d = 0.5$, $p < 0.05$, CI: 0.35–0.65), validating language accuracy's application of PBL.

Some qualitative studies also agree with participation, fluency, and motivational gains with PBL. Kholis (2021) achieved greater fluency and use of grammar among vocational high school students but not statistically backed. Hamsia and Erydani (2022) experimented with part-time university students and found greater levels of participation and engagement, vouching for the effectiveness of PBL in motivating language learners in non-traditional settings. Agustise (2022) conducted three cycles of classroom action research using junior high school students, observing incremental gains in fluency without statistical p-values. Similarly, Mubarak et al. (2023) conducted tests of vocabulary and speaking performance with positive oral communication gains but in the absence of empirical baselines.

Some of the knowledge gaps in speaking-related PBL research are the difficulties of transposing traditional instruction procedures into online environments, where real-time interaction, group dynamics, and feedback mechanisms may be disrupted or diluted relative to face-to-face conditions.

There are also no controlled longitudinal studies that directly seek to establish the degree to which PBL interventions facilitate long-term retention of fluency. The future research will require methodological and contextualization adjustments to facilitate comparative research in different learning environments, i.e., urban vs. rural schools, online vs. in-person learning, multilingual vs. monolingual classrooms. These modifications can involve the adjustment of intervention duration, the calibration of test measures for oral proficiency, and the use of culturally responsive pedagogies to facilitate a more accurate measurement of long-term improvement in speaking ability following long-term PBL enactment.

Effected of PBL Writing Skill

Writing was explored in 10 studies, half and half between 5 quantitative and 5 mixed-methods research, with analytical, argumentative, procedural, descriptive, and explanatory writing tasks were included. Among quantitative research, Iswandari et al. (2017), Jumariati and Sulistyo (2017), Dastgeer et al. (2019), Qadryanti et al. (2022), and Jumariati and Arapah (2024) confirmed that PBL improved the students' grammatical accuracy, organization, and coherence of writing. The same studies highlighted how writing in problem-solving scenarios built the students' capacity to organize arguments and express complex ideas.

The mixed-methods studies of Alghamdy (2023), Sutrisna and Juliari (2019), Mairani (2022), Setlight et al. (2023), and Cahyaningrum et al. (2024) revealed that PBL yielded measurable writing performance improvement when coupled with positive learner attitudes. The studies determined that teamwork on real problems pushed the students to write and rewrite more critically and led to better writing quality. Use of classroom action research (CAR) in a series of studies also allowed for following up progress and implementing innovations in teaching.

It is evidence for the effect on writing development that is found with strongest influence, large to extremely large effects ($d = 1.2$ to 2.1), though with considerable heterogeneity ($I^2 = 65.4\%$) due to methodological variation.

Dastgeer et al. (2019) performed an experiment on 831 secondary school students and demonstrated the greatest effect ($d = 2.1$, $p < 0.001$, CI: 1.95–2.30) with a significant improvement in writing structure. Alghamdy (2023) demonstrated improvement in grammar accuracy ($d = 1.3$, $p < 0.01$, CI: 1.00–1.50), and Qadryanti et al. (2022) demonstrated improvement in postgraduate level writing competence ($d = 1.2$, $p = 0.002$, CI: 1.00–1.40).

Though empirically well established, the following are issues of concern: lack of long-term studies of writing retention comparisons; lack of explicit contrast between PBL and guided writing approaches. Long-term writing ability by age group and contrast limited to enhanced creative writing under conditions of PBL need to be assessed by future research. In focus, the research should be conducted on integration of AI with PBL to enhance writing skills and learners' autonomy. Results of such research could be utilized to guide the creation of adaptive learning environments, advance personalized feedback mechanisms, and promote self-regulated learning habits; it realizes the effect of PBL. On the other hand, it can minimize the workload of teachers. Moreover, the integration can render PBL a more powerful pedagogical theory by demonstrating that it is compatible with emerging technologies and resilient enough to meet the needs of the digital age.

Differences between the Effects of PBL in Variation of Language Skills

Language Skills	**Number of Studies**	**Avg Cohen's d**	**I^2 (%)**	**Interpretation**
Reading	5	0.7 – 1.5	51.2%	Moderate Heterogeneity
Speaking	7	0.5 – 1.5	57.9%	Moderate-High Heterogeneity
Writing	9	1.2 – 2.1	65.4%	High Heterogeneity

Table 3. Differences of PBL impact in language skills.

The analysis presents critical evaluation of the effects of Problem-Based Learning (PBL) on multilingual competencies and varying education levels. By looking at effect sizes and the level of heterogeneity; i.e., the heterogeneity in study results because of differences in learner groups, instructional environments, and delivery approaches, the evidence points towards flexible and well-designed PBL approaches capable of yielding replicable outcomes for a range of learner populations. Apart from that, the combination of AI and digital technology in PBL is an understudied topic because there were few studies that examined their separate influence on the learning achievements of EFL learners.

There is heterogeneity among reading, speaking, and writing skills regarding PBL, and writing is identified to be the strongest having the largest effect size and highest heterogeneity. Reading comprehension enhances moderately due to PBL since a moderate effect size varies from Cohen's d = 0.7 to 1.5 indicating that steady enhancement is uncovered across the studies despite

methodological variations. The degree of heterogeneity (I^2 = 51.2%) indicates moderate practice variations in instruction, implying reading-based PBL intervention is formal and systematic in nature with consequent predictable gains in learning.

Speaking skill has comparatively smaller effect sizes (Cohen's d = 0.5–1.5) but larger heterogeneity (I^2 = 57.9%), implying greater variability in application practice. Face-to-face PBL interventions have uniformly indicated improvement in fluency, vocabulary, and confidence, whereas online PBL interventions have had inconsistent effectiveness, and the degree of effectiveness significantly depended on student engagement and access to digital resources. The timeliness of discussion-based PBL facilitates immediate verbal feedback, peer discussion, and mutual support, generating immediate involvement and collaborative learning. However, heterogeneity in delivery mode; i.e., synchronous and asynchronous presentation, online and face-to-face learning, and levels of teacher facilitation, can lead to variation in learner interaction, quality of feedback, and overall communicative development.

Writing, however, produces the highest effect size (Cohen's d = 1.2–2.1), reaffirming the strong impact of PBL on written capacity for communication. However, heterogeneity levels (I^2 = 65.4%) are also high, indicating high heterogeneity in practice of instruction between studies. Some employ collaborative writing formats, but others employ individual scaffolded writing tasks, with the success rates being mixed. The results affirm that PBL is very potent in developing clear writing skill, but task complexity character, peer criticism format, and guided instruction impact overall consistency.

Differences between the effects of PBL in Variation of Educational Level

Educational Level	**Number of Studies**	**Avg Cohen's d**	**I^2 (%)**	**Interpretation**
Secondary (Middle & High School)	10	0.6 – 1.4	54.8%	Moderate Heterogeneity
Higher Education (University & Postgraduate)	11	1.0 – 2.1	62.1%	Moderate-High Heterogeneity

Table 4. Differences of PBL impact in educational level.

The strength of the effect of PBL also varies by education level, with university students showing greater gains compared to secondary level students. Effect sizes for secondary students range between Cohen's d = 0.6 to d = 1.4, and are moderately heterogeneous (I^2 = 54.8%), and suggest that PBL may be making a

contribution to the development of language at this level. However, variation in teaching strategies appears to influence learning. For more supported and explicit instruction frequently needed by younger learners, benefits from PBL will be maximized when mediated by teachers and facilitated through structured problem-solving frameworks.

Postgraduate and university students demonstrate larger effect sizes (Cohen's d = 1.0–2.1) with larger heterogeneity (I^2 = 62.1%), a fact which can be justified by the fact that at more advanced levels of expertise, PBL affects more because students already have prior knowledge, independent learning ability, and more linguistic involvement to be able to take advantage of interactive, problem-based learning to the maximum. The results indicate that PBL performs optimally in situations of advanced education, where students are able to employ sophisticated problem-solving methods for solving complex language problems to facilitate self-directed skill development and long-term memory.

Conclusions

The findings of this systematic review and meta-analysis are strong empirical evidence that Problem-Based Learning (PBL) significantly contributes to English language ability in reading, speaking, and writing. Both qualitative and quantitative research confirm that PBL results in deep engagement, cognitive development, and language acquisition for use, and hence a pedagogical practice well worth investing in ELT. The meta-analysis reinforced significant effect sizes across all language abilities, writing having the biggest gain (Cohen's d = 1.2–2.1), followed by speaking (d = 0.5–1.5) and reaing (d = 0.7–1.5). Statistical significance was reported in all studies ($p < 0.05$ to $p < 0.001$), reinforcing PBL's advantage over traditional techniques. Furthermore, moderate heterogeneity (I^2 = 58.7%) shows consistency of PBL's positive effect across different teaching techniques.

Qualitative studies supported these results with empirical data of enhanced motivation, collaboration, and critical thinking among the students. Classroom observation data of increased fluency, vocabulary gains, and formal writing skill were observed; however, some studies were not empirically grounded and employed non-standard designs, limiting the generalizability and statistical stability of findings. Thus, although there were encouraging trends, conclusions based on these studies need to be taken with caution. The analyses also revealed important differences with writing skills having the largest effect sizes but also heterogeneity, since variability in PBL implementation was observed. Comparisons at the school level also identified that the students of universities

gained more from PBL than secondary students, and this indicated that PBL encourages higher language skills and independent study.

Although designed to be effective, the existing strategy is still lacking in sufficiently addressing the existing implementation gaps and learning outcomes. Very little work on long-term skill retention with PBL has been done, particularly for writing and speaking. Comparative PBL analysis to other learning models such as task-based learning, guided writing processes, and direct instruction requires more studies to be performed. Lastly, there must be standardized PBL processes in every form of education to reduce variance in outcomes. This article points out that PBL is a student-centered, creative pedagogy that not only enhances language abilities but also problem-solving, collaboration, and motivation. As teachers and researchers continue to search for effective language teaching methods, PBL provides a well-supported alternative that can transform the way students learn and acquire English. Long-term retention studies, comparative approaches, and standardization of PBL techniques must be researched in future studies to further tap their potential in different learning settings. Emerging studies also need to investigate how the use of AI-based tools impacts PBL in problem-solving solutions, student self-determination, and peers help in EFL settings.

References

Agustise, P. (2022). Improving ninth-grade students' speaking skill through the application of problem-based learning (PBL) method at SMPN 3 Tungkal Jaya Muba. *Esteem Journal of English Education Study Programme*, *5*(1), 154–160. https://www.academia.edu/103219564

Alghamdy, R. Z. (2023). Efficacy of problem-based learning strategy to enhance EFL learners' paragraph writing and grammar skills. *Arab World English Journal (AWEJ), 14*(1). https://doi.org/10.2139/ssrn.4431211

Arani, S. M. N., Zarei, A. A., & Sarani, A. (2024). Problem-based learning affecting features of speaking proficiency. *Journal of Research in Applied Linguistics, 15*(1), 75-91. https://doi.org/10.22055/RALS.2023.41996.2888

Arjuna, G., & Jufri, J. (2016). The use of problem-based learning method in teaching reading comprehension. *Journal of English Language Teaching, 5*(1), 306–312. Retrieved from https://ejournal.unp.ac.id/index.php/jelt/article/view/7317

Aulia, H. R., Laeli, A. F., & Ulwiyah, S. (2023). Problem-based learning as a method to improve senior high school students' reading comprehension in English. *ELTR Journal, 7*(2), 77–85. https://doi.org/10.37147/eltr.v7i2.171

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education*, *20*(6), 481–486. https://doi.org/10.1111/j.1365-2923.1986.tb01386.x

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education*. Springer Publishing.

Berenji, S., Saeidi, M., & Ghafoori, N. (2020). Problem-based Learning and its Impact on EFL Learners' Engagement and Reading Comprehension. *Journal of Language Horizons*, *4*(1), 149-174.

Cahyaningrum, C. D., Firdaus, M., & Mulyadi. (2024). Improving the eleventh-grade students' writing ability through problem-based learning at SMKN 1 Penukal. *Esteem Journal of English Education Study Programme, 7*(1), 266–275. https://www.researchgate.net/publication/377956155

Dastgeer, G., Afzal, M. T., & Atta, N. (2019). Transforming English Language Writing Skill Employing Problem Based Learning. *Journal of Research in Social Sciences, 7*(2), 99-116. https://www.researchgate.net/publication/334898046

Dewey, J. (1938). *Experience and education*. Macmillan.

Dwiyamtini, M. R. (2023). Application of problem-based learning (PBL) to improve English speaking skills. *Applied Research in English Education, 1*(2), 80–91. https://doi.org/10.26714/aree.1.2.2023.80-91

Fahmi, R., Muslem, A., & Usman, B. (2021). The use of problem-based learning to improve students' speaking ability. *English Education Journal, 12*(2), 260–281. https://doi.org/10.24815/eej.v12i2.17920

Hamsia, W., & Erydani, V. A. C. (2022). Implementation of Problem-Based Learning Model in Improving Speaking Skills for Part-Time Students at A Higher Education Institution in Semarang. *Journal of English Teaching and Learning Issues, 5*(2), 135. https://doi.org/10.21043/jetli.v5i2.17087

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information*, *34*(4), 285-291. https://doi.org/10.3233/EFI-180221

Iskandar N., Mustaji, Miftakhul J., & Soetam Rizky Wicaksono. (2021). The Problem Based Learning in Enhancing Students' Critical Thinking for Reading Skills in English Teaching at Vocational School. *IJORER: International Journal of Recent Educational Research, 2*(2), 237–249. https://doi.org/10.46245/ijorer.v2i2.93

Iswandari, D. C., Prayogo, J. A., & Cahyono, B. Y. (2017). Effect of environmental problem-based learning on the indonesian EFL students' environment-related vocabulary mastery and writing ability. *Theory and Practice in Language Studies, 7*(8), 608–616. https://doi.org/10.17507/tpls.0708.02

Janitra, N. C., & Dewi, D. N. (2023). Vocational Students' Perception of The Use Problem-Based Learning in Speaking English. *IDEAS: Journal on English Language Teaching and Learning, Linguistics and Literature, 11*(1), 205–217. https://doi.org/10.24256/ideas.v11i1.3750

Jeldu, F. A., Lucha, Z. T., & Feyisa, J. J. (2024). Effects of Applying Problem Based Learning (PBL) Strategy Use on Students' Oral Vocabulary as One Aspect of Speaking Performance. *English Language, Literature & Culture, 9*(1), 16–28. https://doi.org/10.11648/j.ellc.20240901.13

Jumariati J., & Arapah, E. (2024). The Effects of Problem-Based Learning on the Writing Skills of Students Across Various Personality Types. *Journal of Language Teaching and Research, 15*(5), 1730-1740. https://doi.org/10.17507/jltr.1505.34

Jumariati, J., & Sulistyo, G. (2017). *Problem-based writing instruction: Its effect on students' skills in argumentative writing.* Arab World English Journal, 8(2), 87–100. https://doi.org/10.24093/awej/vol8no2.6

Kholis, M. N. (2021). Oral communication in teaching speaking using problem based learning on vocational school students. *RETAIN: Journal of Research on English Language Teaching in Indonesia*, *9*(3), 184–191. Retrieved from https://ejournal.unesa.ac.id/index.php/retain/article/view/44036

Lestari, Y., Hartono, R. Yuliasri, I, & Pratama, H. (2023). Problem-based learning implementation for students' speaking achievement. *Proceedings of International Conference on Science, Education, and Technology, 9*(1), 886–891. Retrieved from https://proceeding.unnes.ac.id/ISET/article/view/2526

Lin, L. (2017). Impacts of the Problem-based Learning Pedagogy on English Learners' Reading Comprehension, Strategy Use, and Active Learning Attitudes. *Journal of Education and Training Studies, 5*(6). https://doi.org/10.11114/jets.v5i6.2320

Maflah, A. J. (2023). Insight into the Role of Interaction in Language Acquisition: Vygotsky's Interactionist Theory of Language. *Arab World English Journal, 14*(2), 281–294. https://doi.org/10.24093/awej/vol14no2.20

Mairani, R. (2022). Improving Students' Writing Skill Using Problem-Based Learning. *Dialectical Literature and Educational Journal, 7*(2), 71–81. https://doi.org/10.51714/dlejpancasakti.v7i2.89.pp.71-81

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Montafej, J., Lotfi, A. R., & Chalak, A. (2021). Implementation of Hybrid and Pure Problem-based Learning in EFL Context: The case of speaking skill and self-confidence of Iranian undergraduate participants. *International Journal of Foreign Language Teaching & Research, 9*(35).

Mubarak, F., Charisma, D., & Nurcholish, H. (2023). Problem Based Learning in Teaching Students' Speaking Skill: The Implementation. *National Conference on Language, Education, and Technology Proceeding, 3*(1), 30-42. https://e-journal.umc.ac.id/index.php/PBI/en/article/view/4765

Nation, I. S. P., & Macalister, J. (2010). *Language curriculum design*. Routledge. https://doi.org/10.4324/9780203870730

Oktadela, R., & Elida, Y. (2022). The Use of Problem Based Learning in Improving Students' Speaking Skill. *Journal of English Language and Education, 7*(2), 132–138. https://doi.org/10.31004/jele.v7i2.309

Page, M. J., McKenzie, J. E., Bossuyt, P. M., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide*. Blackwell Publishing. https://doi.org/10.1002/9780470754887

Piaget, J. (2013). *Origin of Intelligence in the Child*. Routledge. https://doi.org/10.4324/9781315006260

Qadryanti, N., Kurnia, F. D., & Fadilah, E. (2022). Problem-Based Learning Approach to Improve Writing Skills for Post Graduate Students. *Budapest International Research and Critics Institute (BIRCI-Journal), 5*(1). https://doi.org/10.33258/birci.v5i1.4270

Richards, J. (2006). *Communicative Language Teaching Today.* Cambridge University Press.

Rosyidin, I., Nurrudin, N., & Dewanti, R. (2022). The effect of problem-based learning model towards students' comprehension of the English reading text. *English Review: Journal of English Education, 10*(2), 565–578. https://doi.org/10.25134/erjee.v10i2.6259

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning, 1*(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Setlight, K. C. M. S., Betaubun, M., & Kartika, V. (2023). Involving problem-based learning as an alternative for EFL students' writing improvement: A method for teaching writing. *Journal of English Culture, Language, Literature and Education, 11*(2), 210–235. https://doi.org/10.53682/eclue.v11i2.6625

Sumartini, S. A. (2019). Effectiveness of the problem-based learning approach in improving skills in writing exposition text. *Alinea: Jurnal Bahasa, Sastra, dan Pengajaran, 2*(1), 53. https://doi.org/10.35194/alinea.v2i1.427

Sutrisna, G., & Artini, L. P. (2020). Does problem-based learning affect students' speaking skill and attitude toward ELL? *RETORIKA: Jurnal Ilmu Bahasa, 6*(2), 131–138. https://doi.org/10.22225/jr.6.2.2315.131-138

Sutrisna, G., & Juliari, I. G. A. I. T. (2019). *Using "Problems" to Promote Students' Writing Skills in EFL*. Conference Paper, Seminar Nasional INOBALI 2019, (December 2019), 590–596.

Syahfutra, W., & Niah, S. (2019). Improving Students' Reading Comprehension by Using Problem-based Learning Strategy. *Journal of Education Informatic Technology and Science (JeITS), 1*(1), 125–136. https://www.researchgate.net/publication/335060407

Tavella, G. (2017). Approaches and Methods in Language Teaching (third edition). *ELT Journal, 71*(1), 122–124. https://doi.org/10.1093/elt/ccw083

Tesar, M., Hytten, K., Hoskins, T. K., Rosiek, J., Jackson, A. Y., Hand, M., … Jackson, L. (2022). Philosophy of education in a new key: Future of philosophy of education. *Educational Philosophy and Theory, 54*(8), 1234–1255. https://doi.org/10.1080/00131857.2021.1946792

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Appendix

Appendix 1: A Meta-Analysis of PBL's Impact on Language Skills

Study	Skill	Sample Size (Exp/Ctrl)	Group Means (Post-Test)	Standardized Mean Difference (Cohen's d)	p-value	95% Confidence Interval
Lin (2017)	Reading	26/30	Exp = Higher, Ctrl = Lower	**0.81**	**< 0.05**	**0.62 – 0.99**
Syahfutra & Niah (2019)	Reading	24/24	Multiple RC Components	**0.73 – 1.78**	**< 0.05**	**0.65 – 1.90**
Berenji et al. (2020)	Reading	40/40	Exp = 16.02, Ctrl = 11.37	**1.2**	**< 0.001**	**1.00 – 1.45**
Rosyidin et al. (2022)	Reading	22/22	PBL = 33.82, TBL = 31.27	**0.55**	**0.039**	**0.30 – 0.75**
Sutrisna & Artini (2023-24)	Speaking	41	Pre: 57.61; Post: 77.27	**1.3**	**< 0.001**	**1.10 – 1.55**
Fahmi et al. (2021)	Speaking	~30/~30	Pre: 53.33; Post: 64.13	**0.95**	**< 0.05**	**0.70 – 1.15**
Montafej et al. (2022)	Speaking	18/20	HPBL = 6.50, PPBL = 7.00, Ctrl = 6.00	**0.85**	**< 0.001**	**0.60 – 1.00**
Dwiyamtini (2022)	Speaking	36	Pre: 70.67; Cycle II: 82.11	**0.68**	**Not Reported**	**0.50 – 0.80**
Jeldu et al. (2024)	Oral Vocabulary	48/48	Exp = 1.615, Ctrl = 1.688	**0.5**	**< 0.05**	**0.35 – 0.65**
Arani et al. (2024)	Speaking	30/30/30	Online = 12.805, F2F = 10.813, Ctrl = 10.156	**1.5**	**< 0.005**	**1.30 – 1.75**
Alghamdy (2023)	Writing & Grammar	18/20	Writing Exp = 14.89, Ctrl = 10.05	**1.3**	**< 0.01**	**1.00 – 1.50**
Iswandari et al. (2017)	Vocabulary/ Writing	30/30	Vocab Exp = 68.93, Ctrl = 49.03	**1.45**	**< 0.001**	**1.20 – 1.60**
Jumariati & Sulistyo (2017)	Argumentative Writing	~60/~60	Exp = Higher, Ctrl = Lower	**0.75**	**0.041**	**0.50 – 0.90**
Dastgeer et al. (2019)	Writing	416/415	Exp = 6.25 → 10.41, Ctrl = 6.43 → 6.64	**2.1**	**< 0.001**	**1.95 – 2.30**

Sutrisna & Juliari (Unknown Year)	Writing	41	Pre: 58.05 → Post: 78.34	**1.25**	**< 0.001**	**1.10 – 1.45**
Mairani (2022)	Writing (Descriptive)	26	Pre = 63.1, Cycle 2 = 84.19	**1.05**	**Not Reported**	**0.90 – 1.25**
Qadryanti et al. (2022)	Postgraduate Writing	20	Pre = 76.8, Post = 89.6	**1.2**	**0.002**	**1.00 – 1.40**
Setlight et al. (2023)	Writing (Explanation)	18	Cycle I = 63.33%, Cycle II = 81%	**1.1**	**Not Reported**	**0.95 – 1.25**
Cahyaningrum et al. (2024)	Procedural Writing	34	C1 = 63.82%, C2 = 74.5%, C3 = 89.71%	**1.3**	**Not Reported**	**1.10 – 1.50**
Jumariati & Arapah (2024)	Personality & Writing	28/28	PBL Group > Guided Writing	**0.85**	**0.013**	**0.60 – 1.00**

Vol 14, No. 1, Page 141-162
doi.org/10.54337/ojs.jpblhe.v14i1.10704

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Project-Based Learning to Promote EFL Students' Self-oriented and Collaborative Skills Within Education for Sustainable Development

Ridho Praja Dinata | Universitas Negeri Malang, Indonesia
Utami Widiati * | Universitas Negeri Malang, Indonesia
Efa Silfia | Universitas Batanghari, Indonesia
Mutia Hasymi | Universitas Negeri Malang, Indonesia
Mala Rovikasari | Universitas Negeri Malang, Indonesia
Trishna Nanda Barianti | Universitas Negeri Malang, Indonesia

Abstract

This study aims to explore the integration of Project-based Learning (PjBL) in English as a Foreign Language (EFL) classrooms to promote self-oriented and collaborative skills while aligning with the principles of Education for Sustainable Development (ESD). This study employed a phenomenological approach, focusing on the experiences of students who participated in a PjBL. The participants included four EFL students from a state university in Indonesia who experienced the PjBL in promoting ESD during their learning process. The data collection method included semi-structured interviews, which were analysed using thematic analysis to identify key skills and their relevance to ESD. The findings indicate that PjBL effectively promotes self-

* Corresponding author:
Utami Widiati, Email: utami.widiati.fs@um.ac.id

Received 27 August 2025 | Accepted 10 January 2026 | Available online in Early View 13 March 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

oriented skills including self-regulation, reflective thinking, adaptability, and digital literacy, thereby developing collaborative skills including communication, interpersonal problem-solving, and responsibility. This study suggests that PjBL be considered as an alternative effective pedagogical approach for integrating ESD into EFL instruction through meaningful, contextually grounded learning activities in higher education.

Keywords: Project-based Learning; Self-oriented skills; Collaborative skills, Education for sustainable development

Introduction

One of the Sustainable Development Goals (SDGs) is quality education, which delivers an agenda for global educational changes and mobilises the world's educational resources to assist a more sustainable future (UNESCO, 2020). To enhance the quality of education globally, UNESCO introduced Education for Sustainable Development (ESD) with the aim of equipping learners with the competencies to think and act sustainably (Araneo, 2024; Caputo et al., 2021). To address this issue, it is suggested that students be provided with the opportunity to enhance their life skills, such as self-oriented and collaborative skills (Dias-Oliveira et al., 2024; Wu, 2024). One of the significant strategies to realise the suggestion is project-based learning (PjBL). Self-oriented and collaborative skills are crucial in preparing students to address complex global challenges. In particular, PjBL has been linked to ESD, equipping students with the competencies necessary to contribute to achieving the SDGs (Yu et al., 2024). PjBL is increasingly recognised as an instructional approach that aligns with ESD goals, particularly within the contexts of English as a Foreign Language (EFL) (Almulla, 2020; Mitchell & Tilley, 2024).

Over the past decade, a growing body of research has highlighted the effectiveness of PjBL as an instructional approach for enhancing student engagement, critical thinking, and real-world application of knowledge across educational settings (Aisyah & Novita, 2025; Sun & Zhu, 2023). In EFL classrooms, PjBL has been linked to improvements in language acquisition, learner autonomy, and task-based communication skills, demonstrating its value beyond traditional rote learning (Al-Busaidi & Al-Seyabi, 2021; Chimwayange, 2024; Suwannaphima & Vibulphol, 2023). Recent studies have explored how PjBL can support life skills development, including self-management and reflective learning, essential competencies in the 21st century (Fortune et al., 2018; Guo et al., 2020; Shi et al., 2024). At the same time, global educational priorities have increasingly emphasised the integration of ESD into curricula, promoting competencies such as critical thinking, problem-solving,

and active citizenship (Arslan & Curle, 2021; González-Salamanca et al., 2020; Hays & Reinders, 2020).

The convergence between PjBL and ESD highlights the potential for project-based tasks to promote student engagement with sustainability-related content and real-world problem-solving (Wahbeh et al., 2021; Wróblewska & Okraszewska, 2020). These studies underscore that PjBL can serve as a platform for fostering language and life skills within sustainability education. However, despite the evident potential, limited empirical studies have examined how PjBL promotes self-oriented and collaborative life skills within the framework of ESD in EFL contexts. While existing studies support the general value of PjBL in building life skills, there remains limited attention on how these competencies develop in tandem with ESD principles in language learning environments. Moreover, research on unpacking students' lived experiences in PjBL purposefully designed to meet ESD goals is still scarce.

This study focuses on the integration of PjBL with ESD principles to promote students' skills in EFL settings. By exploring how PjBL can be integrated with ESD principles to support the development of self-oriented skills such as self-regulated learning, adaptability, and reflective thinking, and that of collaborative skills including communication, interpersonal sensitivity, and shared responsibility. Furthermore, this study seeks to provide insights into how teachers can implement PjBL to support language achievement by assisting students' self-orientation and collaborative skills to become proactive contributors to sustainable development. In other words, this study aims to explore the PjBL initiatives and the institutional context of quality education, hence providing essential skills and experience-based activities in sustainability programs elsewhere. In short, this study was led by these research questions:

1. How does project-based learning promote EFL students' self-oriented skills for education for sustainable development?
2. How does project-based learning promote EFL students' collaborative skills for education for sustainable development?

Project-based learning (PjBL)

Dewey (1987), with his works focusing on learning by doing, is considered by certain scholars to be the pioneer of PjBL (Wahbeh et al., 2021). His educational theories promoted a lifelong learning perspective, emphasising that learning occurs through student interactions during authentic activities. Further, PjBL is a collection of significant learning activities in a social context that concentrates on a particular subject matter or a theme (Aisyah & Novita, 2025; Al-Busaidi & Al-Seyabi, 2021; Fortune et al., 2018). Consequently, PjBL emphasises learning through action, experimentation, problem-solving, and collaboration. These

insights support that Dewey significantly transformed education. Nevertheless, this does not deny the role of Vygotsky's (in Akpan et al., 2020) contribution as the founder of social constructivist theory in promoting PjBL within educational institutions. The social constructivist theory posits that engaging in educational initiatives allows students to collaborate with their peers and share ideas, assisting them in enhancing their skills and acquiring new knowledge.

PjBL is an essential approach that reflects key principles of social constructivist theory, particularly collaborative learning and the support provided by teachers. PjBL engages students in real-world projects to develop deeper skills, emphasising student-centred inquiry, critical thinking, and problem-solving over rote memorisation (Mitchell & Tilley, 2024; Shi et al., 2024). Key characteristics of PjBL include a strong connection to real-world problems, which enhances the relevance and applicability of learning. It fosters student autonomy by allowing learners to exercise choice and control over their projects, boosting engagement and motivation (Suwannaphima & Vibulphol, 2023). Furthermore, the literature identifies three factors that contribute to students' learning, particularly their independence and freedom to learn, plan their education, and explore the content. Therefore, this present study focuses on how these three elements highlight project-based learning as a component of sustainable education since they contribute to the enhancement of students' self-oriented and collaborative skills.

PjBL as a facilitating factor of self-oriented and collaborative skills

PjBL extends beyond the acquisition of academic knowledge by fostering the development of critical self-oriented and collaborative skills. Rooted in constructivist theory, PjBL emphasises that students actively construct knowledge through guided inquiry and social interaction. Educators play a facilitative role, creating learning environments where learners assume responsibility for their learning. These settings empower them to engage in projects that cultivate self-oriented and collaborative skills crucial for personal and professional growth (Almulla, 2020).

The collaborative nature of PjBL encourages students to work in teams, promoting social interaction as they communicate and collaborate to solve complex problems. This process not only promotes teamwork but also develops essential life skills, including interpersonal communication, critical thinking, and adaptability (Wróblewska & Okraszewska, 2020**).** Collaborative skills flourish in these dynamic social contexts, where students take full ownership of their educational journeys and bridge the gap between theoretical knowledge and practical competencies (Kemaloglu-Er & Sahin, 2022). This transformative learning approach aligns with the principles of sustainable education,

preparing students to actively contribute to democratic societies through continuous self-improvement and engagement.

Moreover, PjBL promotes self-oriented skills by encouraging students to take ownership of their learning processes, engage in self-reflection, and set personal goals. Through project execution, students develop numerous essential metacognitive abilities, such as planning, monitoring, and evaluating their progress, crucial for independent problem-solving and decision-making (Chen & Yang, 2019). These activities require students to manage their time effectively, adapt to challenges, and take initiative in exploring solutions, enhancing their autonomy and self-regulation (Gras-Velázquez, 2020). By accommodating diverse learning styles, PjBL enables students to build self-oriented skills while engaging collaboratively in both academic and real-world contexts. Through learning practices and team-based problem-solving, students learn to take initiative, improve their creativity, and develop the interpersonal skills necessary for success in an interconnected world (Saenz et al., 2018). These attributes are connected to transformative education, underscoring PjBL's role in preparing students for lifelong learning.

The intersection of PjBL, self-oriented and collaborative skills, and ESD

The integration of PjBL with the development of self-oriented and collaborative skills represents a critical dimension of ESD. As Arbeiter and Bučar (2021) emphasise, access to transformative education is vital for addressing inequities and expanding opportunities for marginalised learners. Importantly, PjBL provides a dynamic environment for transformative learning, enabling students to articulate ideas, devise and implement plans, and engage in reflective practice to refine outcomes. This is aligned with the study by Sun and Zhu (2023), which highlights the value of interdisciplinary approaches in fostering sustainability education and ESD. PjBL, through its integrative nature, provides a robust platform for interdisciplinary learning, positioning it as a potent tool for advancing ESD. Öhman and Sund (2021) propose a comprehensive model of sustainability commitment that addresses intellectual and practical dimensions. PjBL aligns with this model by engaging students holistically, further linking it to sustainability commitment. Therefore, Fortune et al. (2018) demonstrate that PjBL creates opportunities for transformative learning among students in the educational context, enabling them to navigate learning experiences and gain new perspectives on their own and others' worldviews.

Beyond facilitating transformative education, PjBL also serves as a medium for cultivating essential life skills. Holdo (2023) identifies transformative learning as a driver of lifelong learning, which inherently intertwines with the development of core life competencies. Life-long learning fosters adaptability

and resilience, equipping individuals to navigate complex societal dynamics. González-Salamanca et al. (2020) emphasise that life skills education enhances individuals' ability to adopt behaviours that promote healthy societal functioning. Additionally, these studies underscore the critical role of PjBL in integrating self-oriented and collaborative skills into ESD. This approach is particularly impactful in education settings, where interdisciplinary and reflective practices enhance students' engagement with ESD themes while fostering significant competencies for personal and societal development.

Methodology

Research design and participants

This study employs a qualitative research design with a phenomenological approach to investigate how PjBL promotes the development of EFL students' self-oriented and collaborative skills in the context of ESD. A phenomenological approach allows for an in-depth investigation of participants' experiences (Creswell, 2012), understanding their subjective realities and interpretations of PjBL that promote self-oriented and collaborative skills in ESD.

This study involved four English education students from a state university in Indonesia. The participants were selected using a purposive sampling technique based on their experiences of PjBL. This sampling technique ensures that insights are drawn from students with the most relevant experiences (Nyimbili & Nyimbili, 2024). This study received ethical approval and consent forms; participants were given information regarding the purpose of the study, the privacy of their responses, and their willingness to share detailed experiences through interviews.

Research instruments

The research instrument for collecting data was semi-structured interviews. Semi-structured interviews collected the students' perceptions and challenges in experiencing PjBL in relation to self-oriented and collaborative skills that were adapted from Wahbeh et al. (2021). Semi-structured interviews permit participants to elaborate on their perspectives while allowing the study to delve deeper into emerging themes.

Data collection

The data were collected through semi-structured interviews to explore how PjBL can be used to promote skills development. The interview was conducted for 30 to 50 minutes and was recorded using the Zoom application. The students

shared their experiences and perspectives on skill development and ESD. Further, all interviews were audio-recorded with permission, transcribed verbatim, and anonymised using participant codes.

Data analysis

The data were analysed using thematic analysis following Braun and Clarke's (2006) phases. Thematic analysis involves systematically identifying as well as interpreting patterns and themes to understand how PjBL promotes skills development for ESD.

The analysis began with familiarisation, reviewing interview transcripts and becoming immersed in the data. In the second phase, generating initial codes, significant insights of data were highlighted and labelled according to their relevance to the research questions. This coding process involved identifying explicit ideas as well as implicit meanings derived from the context. For instance, statements related to planning, time management, and independent learning were coded as self-regulated. The data were coded iteratively across all transcripts, with codes being repeatedly reviewed and refined to maintain consistency. Emerging codes and themes were also discussed through peer debriefing to check the alignment between data extracts, codes, and themes. During the third phase, these codes were clustered and organised into broader themes. These categories were then refined during the reviewing themes phase, to ensure that each theme accurately represented the dataset and demonstrated internal coherence. In the defining and naming themes phase, related codes were consolidated into clearly articulated themes. The last phase is reflected in the presentation of findings, where themes are woven into an interpretation that synthesises how PjBL promotes self-oriented and collaborative skills and their implications for ESD.

This study emphasised trustworthiness, including credibility, transferability, dependability, and confirmability (Ary et al., 2018). To improve credibility, debriefing was conducted with an ELT professor, who reviewed selected data segments for thematic consistency. Member checking also validated themes with participants. Transferability is enhanced by providing a detailed description of the research context, participants, and processes. Dependability is maintained through a thorough documentation of the research design, data collection, and analysis procedures. Confirmability is ensured by maintaining reflexivity throughout the study, where the researcher acknowledges potential biases and ensures that interpretations are grounded in the data rather than personal assumptions.

Skills	Themes	Concise definition
Self-oriented	Self-regulated	The ability to plan, monitor, and evaluate learning.
	Adaptability	The ability to be flexible and resilient in changing circumstances
	Reflective thinking	The ability to assess personal strengths, weaknesses, and learning approaches
	Digital literacy	The ability to use digital tools to access and create content
Collaborative	Communication	The ability to use verbal strategies to convey ideas appropriately in diverse settings
	Interpersonal	The ability to build and maintain positive relationships
	Problem-solving	The ability to analyse situations, evaluate options, and collaboratively find solutions
	Responsibility	The ability to reliably manage tasks, commitments, and take ownership of actions

Table 1. Theme on self-oriented and collaborative skills.

Findings

This study demonstrates that the students experienced PjBL as supporting the development of self-oriented skills and collaborative skills among EFL students while fostering their understanding of ESD. These findings highlight PjBL's transformative potential as an instructional approach for equipping students with crucial life skills relevant to sustainability challenges.

Development of self-oriented skills

PjBL served as an effective approach for developing self-oriented skills, particularly self-regulated, adaptability, reflective thinking, and digital literacy. Students reported for becoming more proactive in planning and organising their learning processes. Self-regulation skills emerged as a critical skill, with students taking ownership of their schedules and tasks to meet project deadlines. For instance, students outlined detailed strategies for communicating with teachers, planning contingencies, and managing unexpected disruptions in project timelines. Below is the demonstration:

> From the beginning, I was definitely planning and organising the project. A bit more self-reflective, like how we manage our time, make our schedule, how my friend and I manage our time well, and how we evaluate our progress and work. (S1)

> I needed to manage my time, plan the tasks that needed to be done, and work independently to complete the assignments given to me by my team members. This made me more disciplined in organising my schedule and staying focused. (S2)

Reflective thinking skills were evident as students assessed their strengths and weaknesses, and delegated tasks based on individual competencies. Such self-awareness not only improved individual performance but also strengthened team dynamics. These are the demonstrations:

> It involves assessing my strengths and weaknesses, as well as my friends. We discussed our assigned roles related to the project, like my friend will cover my weaknesses. (S1)

> In the project, each member was assigned tasks based on their strengths to ensure effective collaboration. I learned to evaluate my progress to achieve my goals in a more organised way. (S2)

Adaptability was another essential skill, as students demonstrated adjusting to diverse stakeholders, unexpected schedule changes, and interpersonal challenges, demonstrating flexibility in navigating real-world complexities. These experiences underscored the importance of flexibility and problem-solving in completing the project. Below is the demonstration:

> Adapting to teachers, students, and company staff was a valuable experience gained through the implementation of PjBL. Adapting to new challenges during the project's completion process was a significant aspect for my learning experience. (S4)

> We have that experience, including adjusting to unexpected schedule changes, rescheduling meetings, or handling uncooperative group members. (S1)

PjBL also strengthened students' digital literacy skills. Students gained proficiency in using and teaching technological tools essential for project completion, deepened their understanding of various ICT platforms, and explored the use of AI-based applications like Scribo to enhance writing activities. Here is the demonstration:

> We developed the skills to use and teach the Scribo application for the writing activities required in the project. (S1)

> Digital literacy skills were enhanced through this PjBL. I learned to understand the characteristics of the various ICT platforms, the strengths and weaknesses. (S3)

Development of collaborative skills

The findings highlight that PjBL significantly enhances students' ability to collaborate effectively. Students reported improvements in communication, interpersonal relations, problem-solving, and responsibility, which are critical for effective collaboration. Communication skills emerged as a foundational competency, as students frequently interacted with teachers, students, and teammates to coordinate project tasks and clarify expectations. This process strengthened their ability to articulate ideas, listen actively, and maintain productive dialogue. This process further fostered self-initiative and strengthened students' ability to collaborate and achieve project goals. Here is the demonstration:

> We have to contact the teacher, which requires communication skills. It's very influential for the completion of the project. Because we need to communicate with other people, the teacher as well as the students. (S1)

> I learned several things, including how to communicate effectively. Through PjBL experience, I learned to clearly express my opinions and ideas while also listening to my teammates' points of view. (S2)

Moreover, interpersonal skills were developed as students navigated diverse perspectives within group settings. Students identified the significance of maintaining positive relationships with peers, teachers, and external stakeholders involved in the project. Here is the demonstration:

> Then, interpersonal skills also include communication skills to maintain a positive relationship. (S1)

> It is essential to maintain good relationships with various parties, such as teachers, students, lecturers, and everyone involved in the PjBL activities. (S4)

At the same time, problem-solving skills are particularly significant when students address real-world challenges by thinking critically, making informed decisions, and finding effective solutions. Whether navigating scheduling conflicts, resolving issues collaboratively, or overcoming unexpected obstacles, these experiences highlighted the importance of problem-solving in achieving project success. As stated by the participants:

> We are forced to solve real problems through the project, including arranging meetings via Zoom during holidays and figuring out how to make it work. (S1)

> When I encountered problems, I thought critically and made the right decision to solve them. (S2)

Responsibility was another key competency cultivated through the project. Students learned to manage deadlines, fulfil assigned tasks, and contribute reliably to group outcomes. These experiences illustrate how PjBL reinforces accountability and ownership of work within collaborative settings. As the student described:

> After dividing tasks between teams and setting a deadline, I had to be responsible for the task given to me. (S2)

> Through this project, as a coordinator, I was responsible for summarising and reporting the progress of my peers' work to the lecturer. (S4)

Alignment with ESD

The findings demonstrate the strong alignment between PjBL and the principles of ESD. Students demonstrated that PjBL deepened their understanding of ESD by allowing them to engage directly with real-world environmental and social issues. They reported that authentic tasks made sustainability concepts more meaningful and helped them develop key competencies such as teamwork, problem-solving, and critical thinking. Students also became more aware of equity concerns, particularly the unequal access to technology among Indonesian teachers, which they viewed as an important aspect of sustainable education. Here is the demonstration:

> PjBL provides learning activities with real-world issues, helping me understand ESD better. It allows me to work on projects related to environmental and social challenges. (S1)

> PjBL shows how to build skills like teamwork and problem-solving. We can think critically and creatively, which will be useful for our future. (S2)

> This experience helped me realise the importance of integrating ESD and technological advancement to bridge the gap. (S3)

Beyond sustainability awareness, the skills developed through PjBL were viewed as transferable to academic and professional contexts. Students noted communication, teamwork, adaptability, and problem-solving as essential

competencies they could apply beyond the classroom. The findings demonstrate that skills developed through PjBL equip students for future academic and professional pursuits while simultaneously promoting the principles of ESD, preparing them to contribute meaningfully to a sustainable and inclusive future. Below are the demonstrations:

> The skills I gained, including communication, teamwork, and time management, will be beneficial outside the classroom or in the workplace. (S1)

> The problem-solving skills I have practised during PjBL will help me solve problems effectively in various situations, whether at work or in daily life. (S2)

> Communication skills are essential and highly applicable in the professional world. Thus, adaptability is also important, ensuring I am not overwhelmed when working with individuals from different backgrounds and fostering mutual respect. (S3)

Discussion

This study elucidates the significance of PjBL in developing self-oriented and collaborative skills while aligning with ESD principles. The findings underscore PjBL's transformative potential as an approach for equipping students with critical life skills and promoting their capacity to address sustainability challenges in educational and professional contexts (Wu, 2024; Yu et al., 2024). This study contributes to PjBL-ESD scholarship in EFL by examining a technology-mediated project in which students were engaged in pedagogical supports for in-service teachers across diverse Indonesian contexts through the adoption of the Scribo digital writing tool. This hands-on involvement provided invaluable experiences in providing feedback to teachers, assisting with the integration of new technology, and monitoring the progress of students' writing.

Moreover, the findings advance current understandings of how PjBL aligns with ESD by explicating the experiential mechanisms through which sustainability-related competencies are developed. This study highlights the development of self-oriented and collaborative skills enhanced through structured planning and sustained collaboration. By situating these processes within the ESD competency framework, this study offers a more conceptually grounded account of PjBL as a sustainability-oriented pedagogy, rather than merely a task-based instructional approach. Ultimately, it contributes to theoretical discussions by clarifying how PjBL supports the development of

specific life-skill competencies associated with sustainable learning in higher education. Drawing on curriculum-oriented perspectives, these competencies such as self-regulation, adaptability, collaboration, and problem-solving are widely recognised as foundational skills for sustainable learning and lifelong functioning (Mitchell & Tilley, 2024; Sun & Zhu, 2023).

To clarify the relationship, Figure 1 illustrates a proposed conceptual model presenting how PjBL in this study potentially promotes the development of self-oriented and collaborative skills, which eventually contribute to the attainment of ESD competencies.

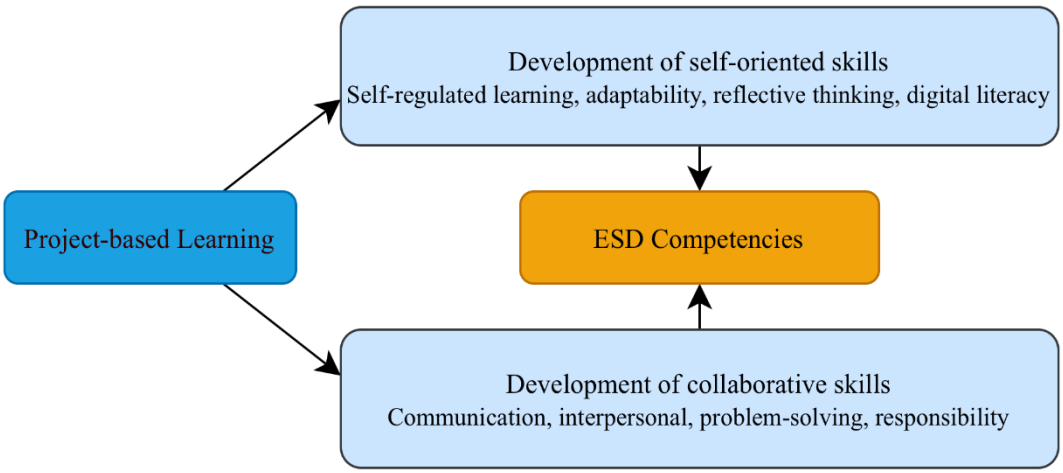


Figure 1. Conceptual alignment of PjBL, self-oriented and collaborative skills, and ESD.

Development of self-oriented skills

PjBL has emerged as a powerful pedagogical approach for fostering self-oriented skills such as self-regulation, adaptability, reflective thinking, and digital literacy. The students in this study demonstrated improved self-regulation capabilities by actively managing their learning activities, organising their schedules, and developing contingency plans to meet project deadlines. These findings align with self-regulated learning theory (Wu, 2024; Zimmerman, 1989), which emphasises students' active control over planning, monitoring, and evaluating their learning, suggesting that the structured and goal-oriented nature of PjBL creates conditions that support these regulatory processes. Similarly, self-regulated learning is significant for autonomous task completion and self-management, particularly in dynamic learning environments (Gras-Velázquez, 2020; Guo et al., 2020). Additionally, PjBL creates learning environments where student responsibility and collective engagement are mutually reinforced, thereby extending its impact beyond immediate academic achievement.

Furthermore, adaptability skills emerged as a critical skill developed through PjBL, enabling students to navigate the dynamic challenges inherent in project implementation. The participants adjusted to diverse stakeholders, such as teachers and company staff, and managed unexpected changes, including rescheduling meetings and resolving uncooperative team dynamics. These findings highlight students' capacity for responding constructively to challenges, adjusting strategies, and sustained improvement in learning practices over time. In line with this, Chen and Yang (2019) demonstrated that PjBL enhances students' ability to cope with unpredictable contexts. From an ESD perspective, adaptability reflects students' capacity to respond to uncertainty and complexity, a core sustainability competency developed through engagement with authentic and unpredictable project contexts. By addressing real-world complexities, students improve their adaptive skills when engaged in project-based language teaching, underscoring its relevance for sustainability-oriented education (Sun & Zhu, 2023).

Reflective thinking further enhanced the development of self-oriented skills as the participants assessed personal strengths and weaknesses while delegating tasks effectively within their teams. This critical self-awareness not only enhanced individual performance but also optimised team dynamics, reflecting Fischer et al.'s (2022) assertion that reflective practice is integral to achieving sustainable education outcomes. By intentionally reflecting on competencies, the students aligned their contributions with their strengths, ensuring a more organised and productive workflow. Fortune et al. (2018) show that PjBL experiences stimulate transformative reflection, illustrating how project-based tasks encourage students to critically evaluate their strengths and weaknesses and apply these insights to improve both individual and team outcomes. This reflective process resonates with Dewey's (1987) notion of learning through experience, where reflection enables students to make meaning from action and refine future decisions.

Likewise, this study revealed that PjBL significantly enhanced digital literacy, equipping the students with practical ICT skills for academic and professional contexts. They became more proficient in using and teaching technological tools, such as the AI-based application Scribo, which played a pivotal role in writing activities. These findings corroborate Nanni and Pusey's (2022) highlights of the necessity of digital literacy as a core competency in the 21st-century education context. By engaging with ICT platforms and understanding their functionality, the students bridged the gap between technological tools and pedagogical applications, thereby aligning with ESD's emphasis on integrating innovation into learning environments. These results align with Hays and Reinders (2020), who point out that sustainable learning is most effective when digital integration is embedded in practice. The responsibility of

higher education is to foster digital literacy as part of its contribution to achieving the SDGs (Caputo et al., 2021). Within ESD-oriented education, digital literacy functions not only as a technical skill but also as an enabler of participation, collaboration, and equitable access to learning opportunities.

Development of collaborative skills

The collaborative skills of PjBL have been proven to significantly contribute to fostering students' interpersonal, communication, and problem-solving skills which are essential for effective teamwork in educational and professional settings. This study shows that communication skills were notably highlighted as the students interacted with their teachers, peers, and other stakeholders, necessitating them to express ideas clearly and listen actively. From a social constructivist perspective (Vygotsky, 1978), communication operates as a mediating tool through which students co-construct knowledge, negotiate meaning, and coordinate shared action in socially situated tasks. These experiences align with Dias-Oliveira et al. (2024), underscoring the importance of communication in fostering collaborative efficacy. In addition, PjBL enhances communication as a fundamental life skill, equipping students with the ability to articulate ideas effectively in diverse contexts (Wahbeh et al. 2021).

Interpersonal skills were also developed in this study as the students navigated diverse perspectives within team settings and maintained positive relationships with stakeholders. This finding supports the assertion by Sun and Zhu (2023) that fostering interpersonal competencies in PjBL enhances collaborative learning outcomes. The students emphasised relationship management, conflict resolution, and adaptability as critical to achieving success in group projects. This aligns with Almulla (2020), who demonstrated that PjBL fosters stronger social interaction and teamwork in higher education by improving empathy and relationship management in EFL contexts. Within ESD-oriented education, interpersonal skills are crucial for promoting cooperation and inclusiveness in addressing complex social challenges.

Moreover, problem-solving skills were equally significant as students confronted real-world challenges that required informed decision-making and innovative solutions. The students applied theoretical knowledge to practical scenarios by engaging with authentic tasks, fostering critical competencies as suggested by Chimwayange (2024). Similarly, Bekteshi and Xhaferi (2020) found that integrating SDGs into ELT projects enhances students' problem-solving competencies. PjBL further creates learning environment in which problem-solving skills develop through engagement with complexity, requiring students to apply existing knowledge and adapt their responses as situations evolve. These processes align with ESD's focus on cultivating critical

judgement and responsible decision-making in addressing sustainability-related issues (Arslan & Curle, 2021).

Responsibility also notably developed in this study as the students were held accountable for their tasks and outcomes. They demonstrated learning to manage deadlines, fulfil commitments, and take ownership of their contributions. These findings align with Fischer et al. (2022), who conceptualise transformative pedagogy as fostering responsibility through shared, relational learning process. Further, PjBL has been shown to cultivate accountability by positioning learners as active contributors rather than passive recipients of instruction (Aghayani & Hajmohammadi, 2019; Uggla & Soneryd, 2022). Within an ESD framework, responsibility functions as both an individual and collective competency that supports sustainable and ethical participation in learning and professional communities.

Alignment with ESD principles

This study underscores a strong alignment between PjBL and ESD principles, particularly in fostering the self-oriented and collaborative skills essential for addressing global sustainability challenges. By integrating real-world issues into project tasks, PjBL appears to bridge theoretical learning with practical actions, enabling students to engage meaningfully in sustainability challenges. These outcomes align with Araneo (2024) and Yu et al. (2024), who emphasise the importance of empowering students to address the SDGs through innovative and practical educational practices. The integration of technological tools, such as Scribo, has highlighted the synergy between innovations and sustainable education practices. The students in this study became more aware of the inequities in technological access among educators, particularly in the Indonesian context, which underscores the relevance of PjBL in addressing systemic disparities. By fostering awareness and practical solutions, PjBL supports ESD's aim of cultivating critical, creative, and socially responsible students equipped for global citizenship (Caputo et al., 2021).

A broader look at PjBL research in other higher-education contexts reinforces this study. Studies from Oman (Al-Busaidi & Al-Seyabi, 2021), Turkey (Kemaloglu-Er & Şahin, 2022), and China (Sun & Zhu, 2023) have shown that PjBL is effective in supporting collaboration and language development. However, these studies have rarely explored PjBL through an ESD lens or examined students' lived experiences with sustainability-focused tasks. The present study adds this perspective by showing how PjBL in the Indonesian EFL context nurtures both life skills and sustainability awareness. These outcomes may be shaped by institutional expectations, cultural practices, and differences in access to technology. This comparison highlights how

educational settings influence the way students internalise self-oriented and collaborative skills when project activities are intentionally aligned with ESD.

Furthermore, PjBL serves as a robust approach promoting significant skills for academic and professional success, while also advancing the goals of ESD. PjBL fosters the development of critical skills such as communication, teamwork, and time management, as evidenced in multiple studies (Aghayani & Hajmohammadi, 2019; Aisyah & Novita, 2025). PjBL enhances problem-solving capabilities by encouraging students to engage with real-world problems, aligning with frameworks outlined by Bekteshi and Xhaferi (2020). PjBL nurtures adaptability and digital literacy, equipping students with the tools to navigate the complexities of modern, technologically driven environments. These skills are crucial to addressing global sustainability challenges, emphasising informed decision-making and collaborative problem-solving. Consistent with the principles of ESD, PjBL equips students for professional endeavours by cultivating a sense of responsibility toward sustainability (Uggla & Soneryd, 2022). This underscores the importance of expanding PjBL implementation within higher education to support the broader goals of sustainable development.

This study highlights significant contributions to the growing body of PjBL-ESD research in EFL settings. One meaningful addition lies in its Indonesian higher-education context, which remains largely overlooked in sustainability-oriented language learning research. By examining a project utilizing the Scribo digital writing tool, the study provides a concrete example of how technology-mediated PjBL can cultivate sustainability-aligned competencies. Importantly, the findings move beyond the outcome-focused discussions that dominate the literature by showing how skills such as self-regulation, reflective thinking, adaptability, and collaboration develop through students' day-to-day engagement in planning, negotiation, and problem-solving. By foregrounding students' lived experiences, the study offers a more grounded explanation of the processes that activate ESD-related life skills within authentic EFL learning environments, an aspect that has received limited attention in previous work.

Conclusions and recommendations

This study has shown that PjBL is an effective pedagogical approach for developing self-oriented and collaborative skills that are crucial for students' academic success, professional readiness, and capacity to address sustainability challenges. Through real-world projects, students are able to enhance crucial life skills such as critical thinking, problem-solving abilities, and adaptability, which are essential for the dynamic and evolving demands of the 21st century

(Fortune et al., 2018; Sun & Zhu, 2023; Yu et al., 2024). Therefore, PjBL aligns closely with the principles of ESD, which emphasise the cultivation of collaboration and responsible decision-making (Uggla & Soneryd, 2022; Wahbeh et al., 2021). Through technology integration and real-world engagement, PjBL has enabled students to develop crucial life skills while gaining insights into the complexities of sustainable education. This comprehensive approach encourages students to take ownership of their learning to become responsible global citizens. Ultimately, this study advances current PjBL scholarship by offering a mechanism-based explanation of how project work stimulates ESD-aligned competencies in EFL contexts. These contributions underscore the relevance of PjBL not only as a language-learning approach but also as a transformative model that strengthens ESD implementation in diverse educational systems.

This study highlights the need for deeper integration of PjBL in EFL education, as it effectively fosters self-oriented and collaborative skills. To maximise its impact, teachers can strengthen self-oriented and collaborative skills through PjBL by organising projects around clear stages such as planning, research, collaboration, and reflection. Deciding project topics that relate to local ESD issues can make learning more meaningful and help students develop linguistic competencies and the life skills needed for sustainable development. At the curriculum level, higher institutions should embed PjBL across programmes to ensure continuity and coherence in developing students' competencies. Policy makers and institutions should further support equal access to digital tools and provide sustained professional development so that teachers can facilitate PjBL effectively, enabling students to connect theoretical knowledge with sustainable practices for meaningful learning outcomes.

Limitations and ethical considerations

This study underscores several limitations that should be acknowledged. First, the findings arise from a single institutional context involving EFL students who experienced one PjBL project. This narrow setting limits the extent to which the results can be transferred to other institutions, regions, or disciplines. Second, this study involved a small sample of four participants, which restricts the breadth of perspectives represented and therefore limits generalisability. Third, the reliance on qualitative data, such as interviews, may have introduced subjective biases as the participants' responses were partly shaped by their perceptions and experiences.

These constraints highlight the need for future research that expands larger and diverse participant groups across multiple educational contexts to provide

broader insights into how PjBL supports ESD-related skill development. Further, incorporating broader comparative or longitudinal studies would help clarify how PjBL supports ESD-related skills in different EFL environments and strengthen the overall evidence base. Ethical considerations were carefully addressed throughout the study. The participants were informed of the study's purpose, and their consent was obtained before participation. Confidentiality and anonymity were ensured by assigning codes to participants and securely storing data. These procedures aimed to uphold the ethical standards of respect, fairness, and transparency in educational research.

Acknowledgements

The AI language tool (ChatGPT) was used to support language editing and improve clarity. It did not generate any conceptual, methodological, analytical, or interpretive content. All substantive ideas and scholarly contributions are the sole work of the authors.

References

Aghayani, B. & Hajmohammadi, E. (2019). Project-based learning: Promoting EFL learners' writing skills. *A Journal on Language and Language Teaching, 22*(1), 78-85. Retrieved from https://e-journal.usd.ac.id/index.php/LLT/article/view/1727/1436

Aisyah, S. & Novita, D. (2025). Teachers' perception of the implementation of project-based learning in early childhood education in Indonesia. *Cogent Education, 12*(1). https://doi.org/10.1080/2331186X.2025.2458663

Akpan, V. I., Igwe, U. A., Mpamah, I. B. I., & Okoro, C. O. (2020). Social constructivism: Implications on teaching and learning. *British Journal of Education, 8(*8), 49-56.

Al-Busaidi, A. & Al-Seyabi, F. (2021). Project-based learning as a tool for student teachers' professional development: A study in an Omani EFL teacher education program. *International Journal of Learning, Teaching and Educational Research, 20*(4), 116-136. https://doi.org/10.26803/ijlter.20.4.7

Almulla, M. A. (2020). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *Sage Open*, *10*(3). https://doi.org/10.1177/2158244020938702

Amin, M. A., & Greenwood, J. (2018). The UN sustainable development goals and teacher development for effective English teaching in Bangladesh: A gap that needs bridging. *Journal of Teacher Education for Sustainability, 20*(2), 118-138. https://doi.org/10.2478/jtes-2018-0019

Araneo, P. (2024). Exploring education for sustainable development (ESD) course content in higher education: A multiple case study including what students say they like. *Environmental Education Research, 30*(4), 631-660. https://doi.org/10.1080/13504622.2023.2280438

Arbeiter, J., & Bučar, M. (2021). *Transformative education: Bridging education for change*. Bridge 47.

Arslan, S., & Curle. (2021). Sustainable development goals in the English language high school curriculum in Turkey. *European Journal of Education, 56*(4), 681-695. https://doi.org/10.1111/ejed.12473

Ary, D., Jacobs, L. C., Irvine, C. K. S., & Walker, D. (2018). *Introduction to research in education* (10th ed.). Cengage Learning.

Bekteshi, E., & Xhaferi, B. (2020). Learning about sustainable development goals through English language teaching. *Research in Social Sciences and Technology, 5*(3), 78-94. https://doi.org/10.46303/ressat.05.03.4

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Caputo, F., Ligorio, L., & Pizzi, S. (2021). The contribution of higher education institutions to the SDGs - an evaluation of sustainability reporting practices. *Administrative Sciences, 11*(3). https://doi.org/10.3390/admsci11030097

Chen, C. & Yang, Y. (2019). Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators. *Educational Research Review, 26*, 71-81. https://doi.org/10.1016/j.edurev.2018.11.001

Chimwayange, C. (2024). Promoting student engagement using project based learning as service-based skills development. *International Journal of Technology and Design Education, 35*, 1429-1446. https://doi.org/10.1007/s10798-024-09947-w

Creswell, J. W. (2012). *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (4th ed.). Pearson.

Dewey, J. (1897). *My pedagogic creed. The School Journal*, 54, 77-80.

Dias-Oliveira, E., Pasion, R., Cunha, R. V., & Coelho, S. L. (2024). The development of critical thinking, team working, and communication skills in a business school-A project-based learning approach. *Thinking Skills and Creativity, 54*. https://doi.org/10.1016/j.tsc.2024.101680

Fischer, D., King, J., Rieckmann, M., Barth, M., Bussing, A., Hemmer, I., & Lindau-Bank, D. (2022). Teacher education for sustainable development: A review of an emerging research field. *Journal of Teacher Education, 73*(5), 509-524. https://doi.org/10.1177/00224871221105784

Fortune, T., Borkovic, S., Bhopti, A., Somoza, R., Nhan, H.C., Rangwala, S. (2018). Transformative learning through international project-based learning in the global south: Applying a students-as-partners lens to a

"high-impact" capstone. *Journal of Studies in International Education, 23(1)*, 49-65. https://doi.org/10.1177/1028315318814571

González-Salamanca, J. C., Agudelo, O. L., & Salinas, J. (2020). Key competences, education for sustainable development and strategies for the development of 21st century skills. A systematic literature review. *Sustainability, 12*(24). https://doi.org/10.3390/su122410366

Gras-Velázquez, A. (2020). *Project-based learning in second language education: Building communities of practice in higher education*. Routledge. https://doi.org/10.4324/9780429457432

Guo, P., Saab, N., Post, L. S., & Admiraal W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research, 102*, 1-13. https://doi.org/10.1016/j.ijer.2020.101586

Hays, J., & Reinders, H. (2020). Sustainable learning and education: A curriculum for the future. *International Review of Education, 66*, 29-52. https://doi.org/10.1007/s11159-020-09820-7

Holdo, M. (2023). Critical reflection: John Dewey's relational view of transformative learning. *Journal of Transformative Education, 21*(1), 9-25. https://doi.org/10.1177/15413446221086727

Kemaloglu-Er, E., & Sahin, M. T. (2022). Project-based learning in English language teaching at a rural school: A case study from Turkey. *Novitas-ROYAL (Research on Youth and Language), 16*(1), 34-55.

Mitchell, J. & Tilley, E. (2024). The role of project based learning at the core of curriculum development. *Journal of Problem Based Learning in Higher Education, 12*(1). https://doi.org/10.54337/ojs.jpblhe.v12i1.9105

Nanni, A. & Pusey, K. (2020). Leveraging students' digital literacy through project-based learning. *The Asian EFL Journal, 24*(1), 141-164.

Nyimbili, F., & Nyimbili, L. (2024). Types of purposive sampling techniques with their examples and application in qualitative research studies. *British Journal of Multidisciplinary and Advanced Studies, 5*(1), 90-99. https://doi.org/10.37745/bjmas.2022.0419

Öhman, J., & Sund, L. (2021). A didactic model of sustainability commitment. *Sustainability, 13*(6). https://doi.org/10.3390/su13063083

Saenz, B. F., Florez, K., Gomez, T., Acevedo, M. R., & Suarez, S. T. (2018). Implementing a community-based project in an EFL rural classroom. *Colombian Applied Linguistics Journal, 20*(2), 274-289. https://doi.org./10.14483/22487085.13735

Shi, C., Kassim, A., Radzuan, N. R. M. (2024). Improving EFL learners' English public speaking performance through project-based learning strategy at tertiary level. *Language Teaching Research Quarterly, 42*, 126-144, https://doi.org/10.32038/ltrq.2024.42.08

Shi, J., Sitthiworachart, J. & Hong, J-C. (2024). Supporting project-based learning for students' oral English skill and engagement with immersive

virtual reality. *Education and Information Technologies, 29*, 14127-14150. https://doi.org/10.1007/s10639-023-12433-w

Sun, X. & Zhu, P. (2023). Implementing project-based language teaching to develop EFL high school students' key competences. *Sustainability, 15*(2). https://doi.org/10.3390/su15021658

Suwannaphima, S., & Vibulphol, J. (2023). Fostering learner autonomy of Thai lower secondary school students in project-based English instruction. *LEARN Journal: Language Education and Acquisition Research Network, 16*(2), 259-272.

Uggla, Y. & Soneryd, L. (2022). Possibilities and challenges in education for sustainable development: the case of higher education. *Journal of Education for Sustainable Development, 17*(1), 63-77. https://doi.org/10.1177/09734082231183345

UNESCO (2020). *Education for sustainable development: A roadmap.* UNESCO. https://doi.org/10.54675/YFRE1448

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wahbeh, D. G., Najjar, E. A., Sartawi, A. F., Abuzant, M., & Daher, W. (2021). The role of project-based language learning in developing students' life skills. *Sustainability, 13*(12). https://doi.org/10.3390/su13126518

Wróblewska, D., & Okraszewska, R. (2020). Project-based learning as a method for interdisciplinary adaptation to climate change – Reda Valley case study. *Sustainability, 12*(11). https://doi.org/10.3390/su12114360

Wu, X. (2024). Unveiling the dynamics of self-regulated learning in project-based learning environments. *Heliyon, 10*(5). https://doi.org/10.1016/j.heliyon.2024.e27335

Yu, B., Guo, W. Y., & Fu, H. (2024). Sustainability in English language teaching: Strategies for empowering students to achieve the sustainable development goals. *Sustainability, 16(*8). https://doi.org/10.3390/su16083325

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*, 329-339. https://doi.org/10.1037/0022-0663.81.3.329

Vol 14, No. 1, Page 163-188
doi.org/10.54337/ojs.jpblhe.v14i1.9783

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Conflict Resolution in Project-Based Learning

A Mediation Approach

Safia Bendjebar * | University 8 May 1945 Guelma, Algeria
Yacine Lafifi | University 8 May 1945 Guelma, Algeria
Sevinç Gülseçen | Istanbul University, Turkey
Zohra Mehenaoui | University 8 May 1945 Guelma, Algeria
Aymen Boukeskes | University 8 May 1945 Guelma, Algeria

Abstract

In Project-Based Learning (PBL), the learners collaborate to create projects to adjust and improve their cognitive levels. When learners work on the same project, conflict can arise and may impact their knowledge and relationships, as they often have different skills and backgrounds. This study aims at resolving conflicts among learners within PBL using a mediation approach. The proposed approach involves calculating the similarity between learners to select the proper rescuer based on specific criteria. A set of functions has been used to calculate each criterion. A system called CORE-PBL (For Conflict Resolution in Project-Based Learning) has been implemented to validate the proposed approach. Furthermore, an experimental study had been conducted in the Social Department of Guelma University (Algeria) to address potential conflicts among learners in their projects. The obtained results were satisfactory, as they demonstrated that the cognitive profiles of most students had been improved.

* Corresponding author:
Safia Bendjebar: bendjebar.safia@univ-guelma.dz

Received 10 December 2024 | Accepted 26 June 2026 | Available online in Early View 31 August 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

Keywords: Conflict resolution; Project-Based Learning (PBL); Mediation; Cognitive profile; Educational technology

Introduction and motivation

The integration of Virtual Learning Environments (VLEs) has established a transformative discipline that significantly enhances human learning and knowledge acquisition. This new approach facilitates the learning process for both learners and teachers. This learning model has largely been used during the COVID-19 pandemic, which has disrupted people's global livelihoods since late 2019. Currently, asynchronous learning is utilized to ensure learners' safety at home (Wulandari et al., 2022). Within this context, Project-Based Learning (PBL) has emerged as an effective instructional strategy that encourages students to solve real-world problems, collaborate, and develop creative solutions (Chen et al., 2017). Furthermore, it is carried out through authentic questions and problems within real-world practices (Al-Balushi &Al-Aamri, 2014).

Moreover, PBL implies an approach that serves as a guide for carrying out a project and learning. Helle et al. (2006) identified various reasons to justify the use of PBL. One of these reasons is that each student has a different understanding of the topic and can contribute in different ways.

Learners in PBL environments collaborate to create projects that reflect their knowledge (Bell, 2010). Social interaction involves a struggle over claims to resources, power and status, beliefs, and other preferences and desires. Conflicts can arise among learners in PBL, as they may hold different opinions, perspectives, and contribute varying ideas, or have differing decision-making styles.

In other words, where there are human interactions, there is a likelihood of personal likes and dislikes. These agreements and disagreements among individuals and groups lead to conflict (Crawford & Bodine, 1996; Kapusuzoglu, 2010). The latter is a natural occurrence that can occur in various areas, including business, education, health, and military. Choosing the most appropriate strategy to manage or resolve a conflict depends on several variables, including goals, situational context, interests, and personal skills.

There are numerous benefits to managing conflict resolution, including increased productivity among team members, fostering a deeper understanding of situations, strengthening relationships between users, and developing conflict resolution skills. (Thakore, 2013; Oni-Ojo et al., 2014). For this purpose, we have focused on resolving conflicts among learners in PBL

environments. This resolution positively impacts learners' skills and motivates them to work in groups. There are many ways to resolve or avoid conflict. In this work, the objective is to resolve conflicts through "mediation". The selection of the mediator helps the learners clarify ideas for solving their projects. It is a process designed to improve relationships while resolving specific problems (Oni-Ojo et al., 2014). This mode of conflict resolution is defined as an autonomous approach to resolving interpersonal conflicts (Milburn, 2002). Mediation in education can improve conflict resolution and teacher training, fostering new competencies and enhancing conflict management skills (Yuferova et al., 2021).

For that purpose, we propose a comprehensive method for resolving conflicts among learners in PBL through a peer mediation strategy based on the selection of a learner referred to as the rescuer who intervenes constructively in a dispute. In contrast to previous studies and research, our approach is pedagogically motivated, whereas the rescuer selection criteria are based on educational factors that take into account learners' past interactions, collaborative preferences, and knowledge. A key innovation is that the tool is not just a computational mechanism but a pedagogical aid for supporting collaboration, fairness, and knowledge construction in PBL contexts. The approach is explicitly designed to manage both cognitive and social conflicts, thereby aligning with the collaborative and problem-oriented nature of PBL pedagogy. The selection of the rescuer is based on multiple weighted criteria, including:

- The cognitive profile of the learner (it is calculated using performance on targeted multiple-choice questions aligned with key concepts in the specific domain),
- The social relationship between the rescuer and the conflicting learners (the degree to which a learner interacts with, and prefers to collaborate with, another learner),
- The conflict-of-interest level reflects whether a learner has previously mediated conflicts between the same peers. If the prior resolution was unsuccessful, that learner is added to a blacklist and excluded from a future mediation between those individuals.
- And the history of any successful conflict resolution (whether the learner has previously resolved conflicts effectively).

Several research questions motivated our contribution:

1. How can a conflict between learners in PBL be effectively resolved?
2. How do we identify the relevant rescuer of a problem?
3. How do we identify the nature of the conflict resolution?

To answer these questions, a new approach is proposed to select a rescuer to resolve a conflict between learners by using a set of relevant criteria to identify the most suitable one.

The present work is organized as follows: Section 1 introduces the work. Section 2 deals with some studies related to conflict resolution and PBL. Section 3 describes the structure of the proposed conflict model and the different formulas used for selecting a rescuer. Section 4 presents an example demonstrating how to select the relevant rescuer. Section 5 presents the results of the experiment conducted at an Algerian University, concluding the work and outlining future research directions.

Literature review

Conflict resolution encompasses various areas, including education, business, social sciences, and the medical sector. The literature contains many studies on this topic. This section summarises some works on conflict resolution and Project-Based Learning (PBL).

In PBL environments, learners can create more original projects that enhance their academic results. These projects involve a significant period during which students reflect and improve their knowledge. This reflection can be done individually or in groups (Hanifah, 2022). Research studies have consistently shown that students' skills improve significantly when they apply them in educational settings (Markula & Aksela, 2022).

Zhang and Ma (2023) conducted a meta-analysis of 66 empirical research papers published between 2003 and 2023 on the effects of project-based instruction. They analyse how different moderating variables influence the impact of project-based learning, including subject area, course type, academic period, group size, class size, and experiment duration. They suggested that PBL significantly improves students' learning outcomes compared to traditional teaching models, with a moderate positive effect (SMD = 0.441).

Kortam and his colleagues (2018) studied the influence of PBL on learners' attitudes and motivation. This work is evaluated among biology students, and the authors found that PBL has a positive impact on learners' lives.

To understand how PBL can enhance writing skills and provide valuable insights for educators, Alemneh and Gebrie (2024) employed an experiment on 10th-grade Amharic-speaking students. They compared the effectiveness of PBL with traditional teaching methods and suggested that project-based

learning plays a significant role in improving students' overall and sub-skills in writing.

Within PBL, learners have diverse opinions and levels that can hinder their productivity and impact their interactions and other key performance indicators. Additionally, a lack of knowledge on how to work in a team can lead to conflict between learners, which must be resolved promptly. Project team conflict is a significant obstacle that can hinder the success of inter-firm projects (Von Danwitz, 2018).

There are many definitions of the term "conflict"; each is used according to the application field. For example, in healthcare, Sigut (2013) defined a conflict as "The lack of communication between co-workers, which in turn can be the impetus for medical errors and adverse health outcomes. In conjunction with physical harm, conflict can also cause emotional harm in the form of increased stress on patients, physicians, and managers" (Sigut, 2013). Lists of factors that cause conflicts have been identified through interviews with team members. For example, Chan and Chen (2010) have cited various factors, including poor task management, unfair work allocation, and poor communication.

The phenomena relating to conflicts have been systematically treated by authors in philosophy, biology, sociology, and many other subjects (Abiodun, 2014). For example, in philosophy, Dewey (1998) observed that when obstacles or conflicts interrupt the relationship between human beings and their environment, individuals must use their intelligence to adapt by changing their accustomed modes of thought.

In the context of online education, existing studies addressing conflict resolution problems are relatively underdeveloped compared to the rapid growth of online education (Perry & Pilati, 2011; Schroeder, 2014). Furthermore, resolving such conflicts between students is essential to improving their skills (Payne et al., 2005; Borg et al., 2011; Chan & Chen, 2010). For this purpose, the researchers have conducted various interviews to analyze the causes and solutions that can be implemented to prevent conflict among students. Group conflicts should be addressed because they can lead to destructive behavior and division within the group (Hadad & Reed, 2007). Effective management strategies, including open communication, mediation, and negotiation, facilitate successful conflict resolution in educational settings, resulting in enhanced collaboration, increased student engagement, and a more harmonious environment (Chaudhary, 2023).

In cooperative innovation projects, task conflict indirectly improves success by mediating the effects of tacit and ambiguous knowledge acquired from partners

and knowledge base compatibility (Mu et al., 2021). The following table outlines some related works on PBL. The order of the presented works is chronological.

Authors	Difficulties of the project	Type of the project	Framework/ Project name	Participants
Tiwari et al. (2017)	The difficulty for the students working face to face.	Medicine	N/A	99 students
Aldabbus (2018)	The projects took more than the expected time and students lacked the skills of collaborative work.	Bahraini Primary Schools		24 teachers
Kortam et al. (2018)	Students feel tired when they respond to the questionnaire.	Middle-school biology	N/A	178 students
Alves et al. (2019)	The lack of overall knowledge about the different applications.	Industrial Engineering and Management	N/A	54 students
Santhi et al. (2019)	The system was not developed, and learners are not motivated to work in groups.	English learning	N/A	35 students
Eckardt et al. (2020)	Some students have negative past experiences working in groups	Education	Course EDU 3600	44 students
Alemneh & Gebrie (2024)	Teachers need training and curriculum adaptation to apply PBL in a classroom	Writing abilities of Amharic-speaking	PBL conceptual framework described by Melin et al. (2006)	10 students

Table 1. Summary of difficulties encountered in PBL.

These studies have shown that when the PBL method is implemented, learners improve their knowledge level and evaluate their collective work. In PBL environments, learners develop their attitudes and skills more positively than in traditional learning environments. Most of these studies are evaluated by interviews and questionnaires. The use of this kind of evaluation induces the

learner to answer automatically without reflection. In addition, these works show that learners have different opinions and levels that can lead to decreased productivity, as well as impact their interactions and other key performance indicators. In this situation, the conflict produced between learners must be resolved expeditiously. However, none of these studies took into account the resolution of conflicts in PBL.

The present study highlights the possibility of setting expectations, causes, and consequences before transferring primary responsibility for conflict resolution to learners. Thus, we try to resolve conflicts to produce a better learning experience. Therefore, our work aims to present a new approach to resolving disputes in project-based learning, where learners can serve as conflict rescuers themselves and effectively assist their peers in conflicts.

Our approach differs from those shown in the table above by using formulas and algorithms that take into account various features. The detailed description of the approach is presented in the following sections of the article.

Design of conflict resolution approach in PBL environments

Selecting the rescuer is a crucial task in resolving conflicts between learners. This work suggests a novel approach to resolving potential conflicts between learners with varying profiles and skill sets who need to work together on tasks associated with a shared project. The selection of the appropriate rescuer is guided by specific criteria that take into account cognitive and social features. Once identified, the rescuer can intervene with the learners directly through the system in a digital manner.

At the same time, the teacher plays an important supervisory role by monitoring the process, validating the fairness of the mediation, and ensuring that the conflict is effectively resolved. This ensures that the conflict resolution process remains aligned with the pedagogical objectives of PBL, where collaboration, negotiation, and peer regulation are central learning outcomes.
The main process of our proposition can be summarized as follows:

a. The learning group:

1. The teacher proposes a project for two learners randomly selected from each group. These learners may have different profiles but must work together on this project.

b. Automatic conflict detection:

1. When they encounter a conflict during the project resolving task, they should activate the conflict notification option in the system.
2. Construct the initial conflict model. In this step, they must define its type, causes (reasons), status, etc. (see Table 2).

c. Intelligent selection of a conflict rescuer:

1. Select the relevant rescuers who can resolve this conflict based on some criteria.
2. Sort the rescuers from the previously obtained list.

d. Conflict resolution

1. Select from the list of potential rescuers the first one who can resolve this conflict.
2. Inform the chosen rescuer by sending him a notification to resolve the conflict.
3. Verify if the conflict has been resolved or not.
   3.1. If the conflict has not been resolved, remove this rescuer from potential rescuers and update the base of conflict interests.
   3.2. Repeat from step d.1 with the following rescuer.

e. Updates

- If the conflict is resolved, update the learners' model database and the conflict model database.

Figure 1 below presents the different steps of the proposed approach.

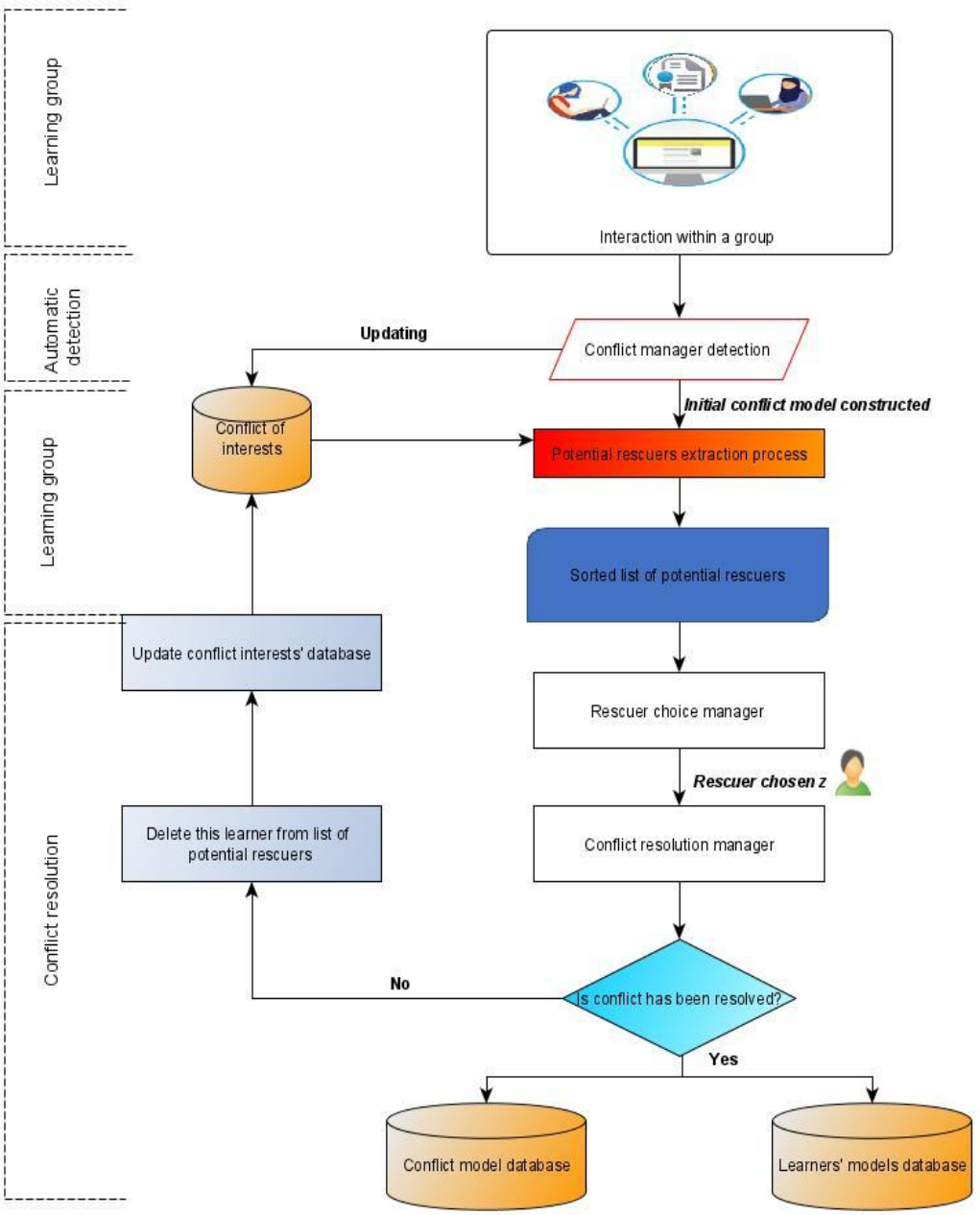


Figure 1. The process of conflict resolution between two learners.

The structure of the proposed conflict model

A conflict exists where there is an interaction between two or more learners with different viewpoints on answering or carrying out a common task. To better understand this conflict, it has to be modeled. To our knowledge, no work has proposed a conflict model. In our proposition, it is defined by its type and causes. In addition, it is characterised by the rescuer and the dedicated time used for resolving it (see Table 2).

As a result, the final conflict model Cf is presented as follows:

$$C_f = \{D, P, T, I, A, D, S, O\} \quad \textbf{(1)}$$

The final conflict model	The initial conflict model	The attribute	The designation
		D : The identifier of the conflict	Presents the identifier of the conflict.
		P : The learners in conflict	Presents a couple of learners (example: (l_1, l_2)) who are in conflict.
		T : The type	The type of conflict: social, technical, etc.
		I: The reasons	Reasons for a conflict: communication, structure, or behavior.
		A : Status	The status of the conflict (Resolved / Not Resolved)
		D : The duration	The duration of a conflict resolution
		S : The rescuer	The rescuer of the conflict
		O : The solution	The solution to the conflict.

Table 2. The description of the conflict model.

The main issue is how to select the relevant rescuer for a conflict. Our vision is presented in the next section.

The selection of the relevant rescuer

In humanitarian action, a peacemaker is "a person who helps in a conflict between two or more individuals on a voluntary basis, without formal authority, by acting impartially and working with one or more parties to resolve the conflict constructively (Radice, 2019)".

Furthermore, according to Nowbahari and Hollis (2010), "a rescuer is a person who helps another individual in a harmful difficult situation".

This rescuer's job is to explore and engage in mediation activities, making an effort to attain peaceful solutions to conflicts.

In our case, to select a relevant rescuer $R(l_z)$ for resolving the conflicts between two learners l_x and l_y, we proposed using four criteria: the cognitive profiles of learners (Mehenaoui et al., 2014), the social relationships of potential partners (Tadjer et al., 2018), the excluded rescuers, and the previous resolution of conflicts (Tadjer et al., 2018; Smith et al., 2002). Then, we calculated the degree of similarity among learners using these criteria. Finally, we established a function to sort the list for recommending the right rescuers according to the learners who needed conflict resolution. Therefore, the rescuer selection was conducted according to the formula outlined in Appendix A.

When the intersection is empty according to the proposed formula (Appendix A), all the learners who have already resolved conflicts are recommended and classified according to their degree of resolution.

Description of criteria for rescuer selection

Similarity concerning the cognitive profile

The learner's cognitive profile (*Cp*) is defined as his level of knowledge according to each learning object, which is assessed through a set of targeted Multiple-Choice Questions (MCQ). In this paper, a learning object is defined as a specific theoretical concept relevant to the course taught (in our case, computer science). A certain number of MCQs (for example, ten) were developed based on the course syllabus and project requirements. To calculate the value of the cognitive profile Cp, we consider the number of proposed questions (n) and the number of correct answers (b_answer), which reflect the understanding of the learner l_z of the specific learning object relevant to the project. The formula used to calculate this profile was validated in our previous work (Mehenaoui et al., 2014; Tadjer et al., 2018) (for more explanation, see Appendix B).

While soft skills such as conflict management and collaboration are important in PBL environments, our model does not directly assess them as learning objects. In this work, learning objects are limited to domain-specific knowledge components. In the selection of a learner l_z , the rescuer of l_x and l_y $learners$ (who are in conflict), the learner l_z must have a cognitive profile higher than that of the learners in conflict l_x and l_y, and also be the most cognitively similar (closest) to them among those with better scores (Mehenaoui et al., 2016) (see Appendix C). Whereas the mediator (or the rescuer in our case) demonstrated high levels of competence in mediation and cognitive flexibility (Gecikli & Yazici, 2026), and he plays a role in cognitive scaffolding (Wood et al., 1976).

Social relationships of the potential partner

The social relationship of the potential partner for a learner refers to how much a learner interacts and prefers to work with his partner. This will later help the

learners to become good conflict rescuers. This factor describes if this partner ($\boldsymbol{l_z}$) is active or inactive with the learner ($\boldsymbol{l_x}$). To calculate this criterion, we have used three activities.

1. The number of views done by the learner $\boldsymbol{l_x}$ on the other learner's profile, noted $\boldsymbol{V(l_x, l_z)}$.
2. The number of communication messages sent by the learner $\boldsymbol{l_x}$ to the other learner, noted $\boldsymbol{M(l_x, l_z)}$.
3. The carried-out communication using the e-mail tool sent by the learner $\boldsymbol{l_x}$ to the other learner, noted $\boldsymbol{E(l_x, l_z)}$.

While these indicators are widely utilized in the literature (Dawson, 2008), we acknowledge that they do not capture the qualitative valence of the exchanges, these metrics serve as an objective proxy for social tie strength, providing a non-intrusive digital footprint of learner engagement that is essential for real-time system recommendations.

To give a final score (see Appendix D), we calculated the average Rel of the previous three scores ($\boldsymbol{V(l_x, l_z)}$, $\boldsymbol{M(l_x, l_z)}$, $\boldsymbol{E(l_x, l_z)}$).

To calculate each action, we have adapted the formula proposed by Tadjer and her colleagues to our problem (Tadjer et al., 2018). For example, to calculate the number of views of a profile, we used the formula found in Appendix E with an example.

Excluded rescuers list

To ensure the long-term effectiveness of the mediation process, the system incorporates a feedback loop based on the success of prior interventions. If the learners $\boldsymbol{l_x}$ or $\boldsymbol{l_y}$ do not prefer the resolution of the learner (rescuer) $\boldsymbol{l_p}$, and they don't want him to resolve another conflict, the next time when there is a conflict between the learner $\boldsymbol{l_x}$ and $\boldsymbol{l_y}$, the learner $\boldsymbol{l_p}$ is added to the excluded rescuers list for those specific learners.

The algorithm used for the detection of excluded rescuers list is presented in Appendix F.

Previous resolution of conflicts

A learner can resolve several conflicts at the same time for different learners. Indeed, to make a final decision on the selection of a learner to solve a problem (i.e. rescuer), we take into account their history of conflict resolution, specifically focusing on previous successful resolutions with the learners involved in the present conflict.

In other words, we look for rescuers who have already solved conflicts r_z with the concerned learners and classify them to assign them based on the degree of effectiveness calculated with the formula found in Appendix G.

The selection of the relevant rescuer

To select the relevant rescuer from a list of learners, we have focused on the above criteria: the potential partner's cognitive profile, social relationship, excluded rescuers, and previous conflict resolution. Based on these criteria, there are qualitative and quantitative values. The quantitative values are the potential partner's cognitive profile, social relationships, and previous conflict resolutions.

We represent each rescuer $\boldsymbol{l_z}$ with three quantitative values (Sim_cp, Rel, dg) in Three-dimensional space(x, y, z) (see Figure 2). This rescuer $\boldsymbol{l_z}$ is the result of his relation between $\boldsymbol{l}_{\mathrm{x}}$ and $\boldsymbol{l}_{\mathrm{y}}$, so we have two different values of the cognitive profile similarity (i.e. $Sim_cp(l_x, l_z)$ and $Sim_cp(l_y, l_z)$), the social relationship of the potential partner (i.e. $Rel(l_x, l_z)$ and $Rel(l_y, l_z)$) and the degree of previous resolution (i.e. $dg(l_x, l_z)$ and $dg(l_y, l_z)$). According to Pythagoras theorem, we obtain the formula found in Appendix H.

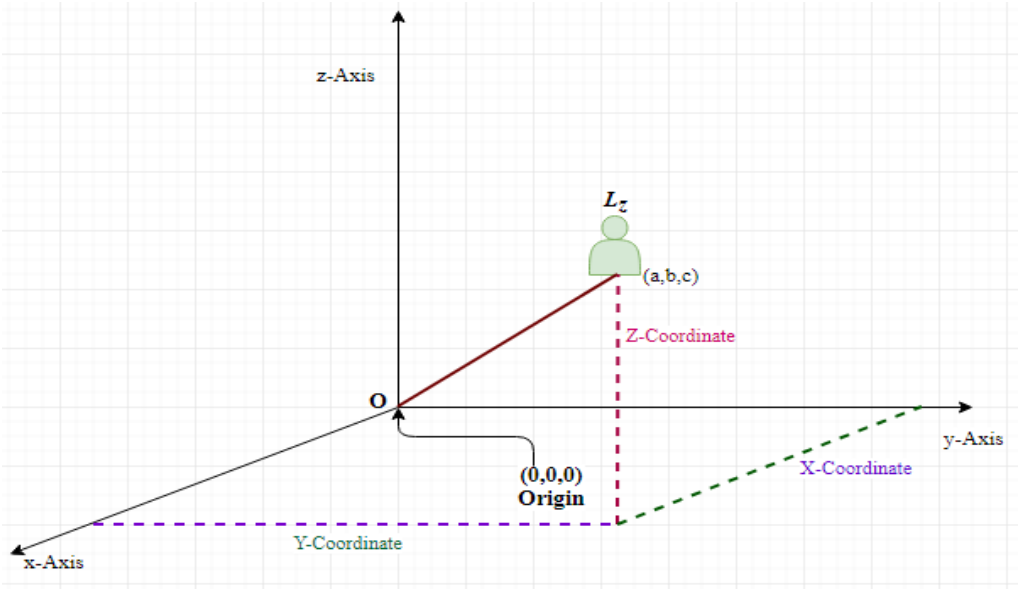


Figure 2. The representation of the rescuer in 3D space.

The above equation is the general form of the distance formula in 3D space. A particular case is when there is no previous resolution of conflict between $\boldsymbol{l}_{\mathrm{x}}$ and $\boldsymbol{l}_{\mathrm{y}}$, so the value of $dg = 0$. In this case, we represent the rescuer $\boldsymbol{l_z}$ in two-dimensional space (2D), and the formula becomes as indicated in Appendix I. A detailed example of recommendation is presented in Appendix J.

Experiment: results and discussion

To validate the idea of conflict resolution, we have tested the prototype utility for sociology students at Guelma University (Algeria). These students can use *CORE-PBL* (For **C**Onflict **R**Esolution in **P**roject-**B**ased **L**earning) at http://www.prdlearn.com/CORE-PBL/ from any internet navigator.

Figure 3 shows an interface from the CORE-PBL system, which presents an example of each learner's project resolution.



Figure 3. Interface from CORE-PBL system.

Participants

A sample of 40 first-year students from the Department of Sociology was selected randomly for the experiment. Students solved projects about Excel software during the period of the experiment. The students were asked to solve some projects, such as calculating the students' average, establishing an invoice, etc. The selected students have been divided into two groups randomly: a control group and an experimental group, with 20 students in each one. *CORE-PBL* environment offers all the necessary resources and communication tools that allow learners to collaborate on a given project.

Methodology

The experiment was conducted (before-after situation) with the students who were selected randomly. As mentioned previously, these students were divided into two groups using a random assignment process without any prior selection criteria (such as gender or academic level). The 'control group' worked without the system (in other words, they don't use the feature of conflict resolution proposed by our system CORE-PBL), while the 'experimental group', worked with the suggested system (with all its proposed features, especially conflict resolution approach). During the project work, some conflicts naturally

emerged among learners due to differences in opinions, task distribution, or understanding of the project requirements. In the experimental group, students used the system to identify a suitable rescuer based on the proposed criteria.

After that, to see the effect of the proposed approach, we compared the results of the experimental group members to those of the group that did not use the developed system (i.e., the control group).

During the experimental period, the students learned to use the Excel software. Then, two members in each group were assigned to resolve a joint Excel software project. Two questionnaires were proposed by the teacher:

- Pre-test Questionnaire: In the first phase, this tool evaluated the initial cognitive profiles and Excel proficiency of all learners to ensure baseline comparability between the two groups.
- Post-test Questionnaire: In the second stage, this questionnaire measured the perceived usefulness of the rescuer recommended by the system. It specifically tested whether the intervention positively influenced the learners' cognitive performance.

In this system, the learners could visualize their cognitive and behavior profiles. In addition, they could interact with each other using different tools (shared space, instant messaging, etc.).

Results and Discussion

To validate our contributions, we proposed to verify the following hypothesis: The null hypothesis is:

> H0: Using the proposed approach does not improve the cognitive profiles of the learners.

The research hypothesis is:

> H1: Using the proposed approach helps learners improve their cognitive profiles.

To verify these hypotheses, we used XLSTAT, which is the leading data analysis and statistical solution for Microsoft Excel.

Before using the t-test, we had to ensure the data was normally distributed. To do this, we used the Shapiro-Wilk test. The obtained results showed that the data was distributed normally because the P-value was greater than the chosen alpha level (α=0.05) for the two groups. Then, the null hypothesis that the data came from a normally distributed population could not be rejected. These results are expressed in Table 7.

Experimental group		Control group	
W	P-value	W	P-value
0,963	0,399	0,920	0,198

Table 7. Test for normality – Shapiro-Wilk.

To verify our hypothesis, we calculated the difference in the students' cognitive profiles. For that, we used a paired unilateral t-test because the sample size was less than 30. The results obtained are presented in Table 8.

The results showed a significant difference between the experimental group mean (Mean=0.350; SD=0,233) and the control group (Mean=0.210; SD=0. 171). A paired unilateral t-test was conducted to assess the progression of each group. The cognitive level of the experimental group improved significantly (t(19)= 6.054; P-value < 0,.0001), while the cognitive level of the control group did not improve significantly (t(19)= 5.480; P-value= 0.102). Therefore, the null hypothesis H0 is rejected. So, the alternative hypothesis is proved, and it demonstrates that selecting rescuer learners based on their profiles significantly enhances knowledge acquisition within PBL environments. Based on the experimental group, the cognitive profile indicates that peer mediation effectively resolves learning conflicts.

	N	df	Mean	SD	tscore	P-value
Experimental group	20	19	0.350	0.233	6.054	$1.23.10^{-8}$
Control group	20	19	0.210	0.171	5.480	0.102

Table 8. Results of experimentation with the t-test.

Conclusion and future work

In education, conflict resolution between group members involves channeling the expertise, energies, and resources of the conflicting groups to find solutions to their common problems. In our context, common projects include accommodating each other's needs, compromising, or working together toward a shared goal in PBL. Therefore, this strategy of learning improves creativity and teamwork competencies.

This paper proposes an approach for resolving conflicts that may arise between learners when they collaborate on a common project. To respond to the first main question, resolving conflict in PBL is crucial. It is essential to select a learner who can help their teammates solve problems within a circle of trust.

To do this, all data about the learners involved in the conflict and their previous conflicts (if they exist) are used. To validate this contribution, the proposed approach was implemented using a system called Conflict Resolution in Project-Based Learning (CORE-PBL), which incorporates various tools. This proposition can be adapted to resolve conflicts in another research.

In response to the questions asked in the introduction section, to effectively resolve a conflict between learners in PBL, it is crucial to know who the most skilled mediator will be to redress the situation. This method will reduce the need to avoid, compete with, or attempt to defeat the opponent. To achieve this, we propose selecting a rescuer from the list of learners who have already successfully resolved conflicts. To identify him, we have used a set of relevant criteria and a set of functions. These are mentioned in the second part of this paper. Regarding the question of identifying the nature of the conflict, we proposed a model that can accommodate various types of projects and have applied it to several domains beyond education. The answer is presented in the last part of this paper.

The experimental results confirmed that the proposed approach enhances learners' cognitive profiles. Furthermore, they demonstrated its effectiveness in promoting knowledge acquisition and conflict management. While the results are promising, this study has some limitations. The cognitive profile assessment was exclusively composed of multiple-choice questions; it may not have provided a comprehensive measure of the deeper or applied knowledge acquired by learners. Another significant limitation of this work concerns the assessment of social relationships. Our three quantitative indicators do not take into account the semantic content of the exchanged messages. Consequently, a high volume of interactions characterized by a negative qualitative valence could indicate that the relationships are not as good as expected, so the mediator could not be the best rescuer or cannot deal with effective mediation.

For future work, the objective is to propose a measure of the amount of conflict between two in-group specific members and how to handle conflict between in-group members and out-group members. In other words, the diagnosis of intragroup conflict should indicate the gravity of the conflict compared to the out-group members. Gravity is defined by the extent of conflict, whether it is too little, too much, or moderate, and how efficiently group members can handle it. Consequently, we propose extending the model to directly address complex multi-learner dynamics. In this case, we deal with multi-learner scenarios by decomposing group tensions into pairwise conflicts, and we acknowledge the need for a more holistic approach. In addition, another future research is to study case-based conflict resolution, which can facilitate the resolution process.

Data Availability

Data generation is available at: https://github.com/Bendjebar/CORE-PBL.git

References

Abiodun, A. R. 2014. Organizational conflicts: causes, effects and remedies. *International Journal of Academic Research in Economics and Management Sciences, 3*(6), 118. http://dx.doi.org/10.6007/IJAREMS/v3-i6/1351

Al-Balushi, S. M., & Al-Aamri, S. S. 2014. The effect of environmental science projects on students' environmental knowledge and science attitudes. *International Research in Geographical & Environmental Education, 23*(3), 213-227. https://doi.org/10.1080/10382046.2014.927167

Alemneh, S., & Gebrie, G. 2024. The role of project-based learning in improving the writing ability and sub-writing abilities of 10th grade Amharic speaking students. *Social Sciences & Humanities Open, 9*, 100843. https://doi.org/10.2139/ssrn.4596147

Bell, S. 2010. Project-based learning for the 21st century: Skills for the future. *The Clearing House, 83*(2), 39-43. http://www.jstor.org/stable/20697896.

Borg, M., Kembro, J., Notander, J., Petersson, C., & Ohlsson, L.2011. Conflict management in student groups-a teacher's perspective in higher education. *Högre utbildning, 1*(2), 111-124. https://doi.org/10.23865/hu.v1.860

Chan, L., & Chen, C. 2010.Conflict from teamwork in project-based collaborative learning. *Performance Improvement. 49*(2), 23–28. https://doi.org/10.1002/pfi.20123

Chaudhary, R. P. 2023. Effective Management Style for Resolving Academic and Non-Academic Conflicts in University Colleges in Kathmandu. *Nepal Journal of Multidisciplinary Research (NJMR), 6*(2), 114-123. https://doi.org/10.3126/njmr.v6i2.57477

Chen, J. J., Li, H., & Wang, J. Y.2017. Implementing the project approach: A case study of hybrid pedagogy in a Hong Kong kindergarten. *Journal of Research in Childhood Education, 31*(3), 324-341. https://doi.org/10.1080/02568543.2017.1309479

Crawford, D., & Bodine, R.1996. *Conflict resolution education. A guide to implementing programs in schools, youth-serving organizations, and community and juvenile justice settings.* US Department of Justice & US Department of Education. https://doi.org/10.1037/e511932006-001

Dawson, S. (2008). A study of the relationship between student social networks and sense of community. *Journal of educational technology & society, 11*(3), 224-238.

Dewey, J. 1988. Human nature and conduct, (Vol. 14, pp. 1899-1924). Carbondale, IL: Southern Illinois University Press.

Eckardt, P. N., Craig, M., & Kraemer, L. (2020). The impact of project-based learning on student content knowledge in an undergraduate, teacher preparation, foundations of education course. *Journal for Leadership and Instruction, 19*(1), 38-42. http://dx.doi.org/10.54691/bcpep.v9i.4603

Gecikli, E., & Yazici, B. (2026). Cognitive flexibility as a predictor of mediating competence. *International Journal of Conflict Management, 37*(2), 446-467. https://doi.org/10.1108/IJCMA-05-2025-0148

Hadad, M., & Reed. J. 2007. The Post-Secondary Learning Experience, Nelson Education Limited. 300 pages.

Hanifah, N. N. 2022. Implementasi pembelajaran project based learning dalam program life skill di homeschooling taman sekar bandung (Doctoral dissertation, Universitas Pendidikan Indonesia). *Indonesian Journal of Adult and Community Education, 4*(2), 55-59. https://doi.org/10.17509/ijace.v4i2.53619

Helle, L., Tynjälä, P., & Olkinuora, E.2006. Project-based learning in post-secondary education: theory, practice and rubber sling shots. *Higher Education, 51*(2), 287-314. https://doi.org/10.1007/s10734-004-6386-5

Kapusuzoglu, S. 2010. An investigation of conflict resolution in educational organizations. *African Journal of Business Management, 4*(1), 96-102.

Kortam N, Basheer A, Hofstein A, Hugerat M. 2018. How Project-Based Learning promotes 7th grade students' motivation and attitudes towards studying biology. *Action Research and Innovation in Science Education, 1*(2), 9-17. https://doi.org/10.51724/arise.10

Markula, A., & Aksela, M. 2022. The key characteristics of project-based learning: how teachers implement projects in K-12 science education. *Disciplinary and Interdisciplinary Science Education Research, 4*(1), 1-17. https://doi.org/10.1186/s43031-021-00042-x

Mehenaoui, Z., Lafifi, Y., & Seridi-Bouchelaghem, H. 2016. A new approach for the recommendation of relevant learners in CSCL systems. *International Journal of Technology Enhanced Learning, 8*(3-4), 234-252. https://doi.org/10.1504/ijtel.2016.082311

Mehenaoui, Z., Lafifi, Y., Seridi, H., Merzoug, M. & Abassi, A. 2014. Recommandation des apprenants pertinents dans un environnement d'apprentissage collaboratif. Paper presented at 9ème Conférence sur les Technologies de l'Information et de la Communication pour l'Enseignement (TICE'2014), Béziers, France, 18–20 November 2014.

Melin, U., Axelsson, K., & Wedlund, T. (2006). In Project-based learning: An emergent Framework for designing courses. The information systems education conference 2006. Linkoping University, Sweden: Linkoping University Electronic Press.

Milburn, P. 2002. La médiation : expériences et compétences. La Découverte-Syros, coll. Alternatives sociales, 171 pages. https://doi.org/10.4000/questionsdecommunication.7565

Mu, T., Yang, J., Zhang, F., Lyu, C., & Deng, C. 2021. The role of task conflict in cooperative innovation projects: An organizational learning theory perspective. *International Journal of Project Management*, *39*(3), 236-248. https://doi.org/10.1016/j.ijproman.2020.12.005

Nowbahari, E., & Hollis, K. L. (2010). Rescue behavior: Distinguishing between rescue, cooperation and other forms of altruistic behavior. *Communicative & Integrative Biology*, *3*(2), 77-79. https://doi.org/10.4161/cib.3.2.10018

Oni-Ojo, E. E., Iyiola, O. O., Osibanjo, A. O., & IGBINOBA, E. E. 2014. Managing Workplace Conflicts in Business Environment: The Role of Alternative Dispute Resolution (ADR). *European Journal of Business and Management*, *6*(36), 74-82. https://doi.org/10.7176/rjfa/10-1-01

Payne, B. K., Sumter, M., & Monk-Turner, E. 2005. Conflict resolution and group work. *Academic Exchange Quarterly*, *9*(2), 22-27.

Perry, E. H., & Pilati, M. L. 2011. Online learning. *New Directions for Teaching and Learning*, (128), 95-104. http://dx.doi.org/10.1002/tl.472

Radice, H. (2019). Saving ourselves? On rescue and humanitarian action. *Review of International Studies*, *45*, 431 - 448. https://doi.org/10.1017/s0260210518000554

Schroeder, J. 2014. Literature Review: Conflict Resolution in Post-Secondary Online Education. Liberty University Graduate School Research Symposium, Lynchburg VA. https://digitalcommons.liberty.edu/cgi/viewcontent.cgi?article=1005_grad

Sigut, B. 2013. Conflict Resolution Management Between Healthcare Managers and Physicians (Doctoral dissertation, University of Pittsburgh).

Smith, S. W., Daunic, A. P., Miller, M. D., & Robinson, T. R. (2002). Conflict resolution and peer mediation in middle schools: Extending the process and outcome knowledge base. *The Journal of social psychology*, *142*(5), 567-586. https://doi.org/10.1080/00224540209603919

Tadjer, H., Lafifi, Y., & Seridi-Bouchelaghem, H. 2018. A New Approach for Assessing Learners in an Online Problem Based Learning Environment. *International Journal of Information and Communication Technology Education (IJICTE)*, *14*(4), 18-33. http://dx.doi.org/10.4018/IJICTE.2018100102

Thakore, D. 2013. Conflict and Conflict Management. *IOSR Journal of Business and Management (IOSR-JBM)*, *8*(6). https://doi.org/10.9790/487x-0860716

Von Danwitz, S. 2018. Managing inter-firm projects: A systematic review and directions for future research. *International Journal of Project Management*, *36*(3), 525–541. https://doi.org/10.1016/j.ijproman.2017.11.004

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of child psychology and psychiatry*, *17*(2), 89-100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x

Wulandari, Y. O., Khasanah, F., & Octavianti, C. T. 2022. Project-based learning as an alternative solution for learning computer basics during the Covid-19 pandemic. *International Journal for Educational and Vocational Studies, 4*(2), 125-129. http://dx.doi.org/10.29103/ijevs.v0i0.5645

Yuferova, M., Koryakovtseva, O., & Bugaichuk, T. 2021. Mediation in education and development of conflictological competence of the teacher. in society. integration. education. Proceedings of the International Scientific Conference (Vol. 2, pp. 646-655). https://doi.org/10.17770/sie2021vol2.6481

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in psychology, 14*, 1202728. https://doi.org/10.3389/fpsyg.2023.1202728

Appendix

Appendix A

$$\boldsymbol{Rescuer}\ (\boldsymbol{l_x}, \boldsymbol{l_y}) = \begin{cases} = [\left(list_{sim_{cp(l_x)}} \cup list_{sim_{cp(l_y)}}\right) \cap \left(list_{rel(l_x)} \cup list_{rel(l_y)}\right)] - [list_conf_interest(l_x) \cup \\ list_conf_interst(l_y)] \cup \left[list_{Rs(l_x)} \cap list_{Rs(l_y)}\right] \textbf{ If there was a conflict between } \boldsymbol{l_x} \textbf{and } \boldsymbol{l_y} \\ = \left[\left(list_{sim_{cp(l_x)}} \cup list_{sim_{cp(l_y)}}\right) \cap \left(list_{rel(l_x)} \cup list_{rel(l_y)}\right)\right] - [list_conf_interst(l_x) \cup \\ list_conf_interst(l_y)] \textbf{ Otherwise} \end{cases} \quad (2)$$

Such as:

- $\boldsymbol{Rescuer}\ (\boldsymbol{l_x}, \boldsymbol{l_y})$: List of the learners who can be a rescuer of the conflict,
- $\boldsymbol{list_{sim_{cp(l_x)}}}$ And $\boldsymbol{list_{sim_{cp(l_y)}}}$: List of learners who have a similar cognitive profile as l_x and l_y,
- $\boldsymbol{list_{rel(l_x)}}$ And $\boldsymbol{list_{rel(l_y)}}$: List of the learners who have a social relationship with the potential partner with l_x and l_y,
- $\boldsymbol{list_conf_interst(l_x)}$ And $\boldsymbol{list_conf_interst(l_y)}$: List of the learners who had already resolved conflicts for l_x and l_y (respectively), but these latter don't desire these learners to solve another conflict,
- $\boldsymbol{list_{Rs(l_x)}}$ and $\boldsymbol{list_{Rs(l_y)}}$: List of the learners who had already resolved a conflict between l_x and l_y.

Appendix B

$$Cp\ (\boldsymbol{l_z}) = \frac{\sum_{i=1}^{n} b_answer_i}{\sum_{i=1}^{n} Q_i} \quad (3)$$

Appendix C

$$Sim_Cp(l_x, l_z) = 1 - (Cp(l_z) - Cp(l_x)) \quad (4)$$

All the similarities $sim_cp(l_x, l_z)$ are numbered in [0,1]. Furthermore, If $Cp(l_z) < Cp(l_x)$ then $Sim_Cp(l_x, l_z) = 0$

We apply this formula to all the learners. Then, we order them according to the obtained results.

$$list_{sim_{cp(l_x)}} = \{l_z, l_w, \dots, l_i\}\ i\ is\ the\ number\ of\ learners\ who\ are\ similar\ to\ l_x \quad (5)$$

Example:

For example, the cognitive profile of the learner l_x is: $Cp(l_x) = 0.4$.
If there are ten questions (n=10) and a learner (l_z) has answered six questions (b_answer=6); in this case $Cp\ (\boldsymbol{l_z}) = 0.6$.
So, the similarity between the two profiles is: $Sim_Cp(l_x, l_z) = 0.8$

Appendix D

$$Rel(l_x, l_z) = \frac{V(l_x, l_z) + M(l_x, l_z) + E(l_x, l_z)}{3} \quad (6)$$

Appendix E

$$V(l_x, l_z) = \frac{number\ of\ view\ l_x\ of\ l_y}{Total\ number\ of\ view\ l_x\ for\ all\ learners\ profiles} \quad (7)$$

Example:

For example, we suppose that there are eight learners in the system, and we want to extract the potential partner of the first learner l_1 by using the previous formulas. Table 3 presents the obtained results.

Learner	The views	The messages	The emails	The potential partner
l_1	$l_3 = 4$ $l_6 = 2$ $l_8 = 2$	$l_3 = 1$ $l_4 = 2$ $l_6 = 1$	$l_3 = 1$ $l_6 = 2$ $l_7 = 5$	$l_3 = 0.291$ $l_4 = 0.166$ $l_6 = 0.25$ $l_8 = 0.083$ $l_7 = 0.208$
Number of total actions	8	4	8	

Table 3. Example of the extraction of the potential partner.

According to this table, the learner l_3 is the potential partner of the learner l_1.

Appendix F

Algorithm extract excluded rescuers *(x: learner)*

Input: L: a set of learners

Output: IR(x): a set of irrelevant rescuers

Begin

For each learner **l∈L** and **l <> x** do

If x does not prefer the resolution of **l then**

Example:

A learner l_1 is in conflict with another learner, and we select the learner l_4 to resolve his conflict; if l_1 does not accept any relationship with the learner l_4 then this latter will belong to the list of irrelevant rescuers.

Appendix G

$$dg(l_x, r_z) = \frac{\sum_{i=1}^{k} W_{ri}}{\sum_{j=1}^{k} W_j} \qquad (8)$$

Where:

W_{ri} : the weighting of the conflict resolved by the rescuer r_z,

W_j : the weights assigned for each conflict has been resolved,

k : is the total number of resolved conflicts.

Example:

The learner l_1 has already encountered three different conflicts, and three different learners have resolved them. By using the previous formulas, we obtain the results mentioned in the Table 4:

The previous rescuer	The weighting of the conflict resolution	The degree of conflict resolution
r_3 r_4 r_5	$W_{r3} = 1$ $W_{r4} = 3$ $W_{r5} = 2$	$dg(l_1, r_3) = 0.16$ $dg(l_1, r_4) = 0.5$ $dg(l_1, r_5) = 0.33$
Number total of weights	6	

Table 4. Example of the extraction of the previous rescuers.

Appendix H

$$Dist\ Ol_z = \sqrt{\left(Sim_{cp(l_x,l_z)} - Sim_{cp(l_y,l_z)}\right)^2 + \left(Rel(l_x,l_z) - Rel(l_y,l_z)\right)^2 + \left(dg(l_x,l_z) - dg(l_y,l_z)\right)^2} \quad (9)$$

		x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
Sim_Cp	x_1	X	0	0,57	0,76	0,25	0,83	0,64	0,34	0	0
	x_2	0,12	X	0,75	0,35	0,72	0,53	0,87	0	0,95	0
	x_3	0,67	0,13	X	0,41	0	0	0,82	0,97	0,76	0,34
	x_4	0,72	0,83	0,17	X	0,56	0,89	0	0	0,55	0,68
	x_5	0,5	0,25	0	0,53	X	0,95	0,68	0,87	0,19	0,72
	x_6	0,85	0,78	0	0,83	0,35	X	0,57	0,41	0	0,88
	x_7	0,75	0,45	0,17	0,67	0,76	0,22	X	0,12	0,43	0,83
	x_8	0,15	0	0,55	0	0,38	0,72	0,68	X	0,38	0,64
	x_9	0	0,25	0,73	0	0,85	0	0,25	0,56	X	0,15
	x_{10}	0	0	0,27	0,93	0,5	0,45	0,12	0,87	0,34	X
Rel	x_1	X	0,75	0	0,95	0	0,34	0,78	0,5	0,93	0
	x_2	0,41	X	0,56	0	0,19	0,75	0	0,68	0	0
	x_3	0,76	0	X	0	0	0,93	0	0,72	0	0,67
	x_4	0,97	0,5	0,64	X	0	0	0,88	0	0	0,25
	x_5	0,88	0,23	0,35	0,74	X	0	0	0,93	0	0
	x_6	0,95	0,15	0,85	0,5	0,67	X	0	0	0,38	0
	x_7	0,38	0,72	0	0,19	0,87	0,76	X	0,74	0,82	0,76
	x_8	0	0,87	0,39	0	0,56	0,45	0,23	X	0,78	0,95
	x_9	0,25	0,68	0,82	0,36	0,75	0	0,88	0	X	0,35
	x_{10}	0	0	0	0,22	0,48	0,64	0	0,35	0,25	X
dg	x_1	X	0,12	0,5	0	0	0	0	0	0,41	0,5
	x_2	0	X	0,87	0	0,38	0,56	0,25	0	0	0
	x_3	0,41	0,5	X	0	0	0,25	0,75	0	0	0
	x_4	0	0	0,25	X	0	0,72	0,95	0	0	0,75
	x_5	0,5	0,25	0		X	0	0	0	0, 25	0
	x_6	0,5	0,83	0,95		0, 25	X	0	0, 35	0	0, 75
	x_7	0	0	0,15	0	0	0,65	X	0	0	0
	x_8	0,25	0,95	0,75	0,19	0	0,5	0	X	0	0,5
	x_9	0,87	0,67	0	0,25	0	0,75	0	0	X	0
	x_{10}	0	0,25	0	0	0	0,88	0,95	0	0,5	X

Table 5. An explaining example of the proposed approach.

Appendix I

$$Dist\ Ol_z = \sqrt{\left(Sim_{cp(l_x,l_z)} - Sim_{cp(l_y,l_z)}\right)^2 + \left(Rel(l_x,l_z) - Rel(l_y,l_z)\right)^2}$$

Appendix J

EXAMPLE OF RECOMMENDING RELEVANT RESCUER

The following table shows an example of ten learners to whom the proposed approach is applied. We extract the similarity between the learner $\boldsymbol{x_i}$ and the other learners in the system.

N.B. In the last parameter, we identify the learners in the same conflict with the same color. For example, the learner $x_{\uparrow 1}$ solves the conflict between x_2 and x_3 (blue color).

In this example, we try to find the rescuer to resolve a conflict between x_1 and x_2. Using the general formula (2), firstly, we extract the list of the learners who are similar to the cognitive profile($list_sim_{cp}$) of x_1 and x_2, and the values of this similarity.

$list_{sim_{cp(x_1)}} \cup list_{sim_{cp(x_2)}} = \{x_3, x_4, x_5, x_6, x_7, x_8\} \cup \{x_3, x_4, x_5, x_6, x_7, x_9\} = \{x_3, x_4, x_5, x_6, x_7, x_8, x_9\}$

The same goes for the potential partners($list_rel$) of x_1 and x_2.

$list_{rel(x_1)} \cup list_{rel(x_2)} = \{x_3, x_4, x_5, x_6, x_7, x_9\} \cup \{x_4, x_5, x_7, x_8, x_9\} = \{x_3, x_4, x_5, x_6, x_7, x_8, x_9\}$

Secondly, we extract the list of learners who had already resolved conflicts between x_1 and x_2.

$list_{Rs(x_1)} \cap list_{Rs(x_2)} = \{x_3, x_5, x_6, x_8, x_9\} \cap \{x_3, x_5, x_6, x_8, x_9, x_{10}\}$
$= \{x_3, x_5, x_6, x_8, x_9\}$

Thirdly, we extract the list excluded rescuers (see Table 6).

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
list_conf_interst	x_3, x_7, x_{10}	x_8, x_{10}	x_2, x_6, x_8	**X**	x_7, x_{10}	x_3, x_7,	x_5	**X**	x_3, x_8,	x_6, x_8

Table 6. The results of excluded rescuers.

According to the above table, we extract $list_{conf_{interst}}$ of x_1 and x_2, we obtain:
$list_conf_interest(x_1) \cup list_conf_interest(x_2) = \{x_3, x_7, x_8, x_{10}\}$
$list_{Rs(x_1)} \cap list_{Rs(x_2)} = \{x_3, x_5, x_6, x_8, x_9\}$

As a result to the general formula (2), we obtain this list:
$Rescuer\ (x_1, x_2) =$
$[\{x_3, x_4, x_5, x_6, x_7, x_8, x_9\} \cap \{x_3, x_4, x_5, x_6, x_7, x_8, x_9\}] - \{x_3, x_7, x_8, x_{10}\} \cap \{x_3, x_5, x_6, x_8, x_9\}$
$= \{x_5, x_6, x_9\}$

Finally, we classify the learners according to the formula (9)

$$Dist\ Ox_5 = \sqrt{\left(Sim_{cp(x_1,x_5)} - Sim_{cp(x_2,x_5)}\right)^2 + \left(Rel(x_1,x_5) - Rel(x_2,x_5)\right)^2 + \left(dg(x_1,x_5) - dg(x_2,x_5)\right)^2}$$
$$= \sqrt{(0{,}5 - 0{,}25)^2 + (0{,}88 - 0{,}23)^2 + (0{,}5 - 0{,}25)^2} = 0{,}739$$

The same way for x_6, x_9
$Dist\ Ox_6 = 0{,}868$
$Dist\ Ox_9 = 0{,}536$

According to these results, we recommend the first rescuer, who is the learner x_6.

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 189-210
doi.org/10.54337/ojs.jpblhe.v14i1.11019

"What is in it for me?"

Student Perspectives on Interdisciplinary Learning Activities

Kirsten Jæger * | Aalborg University, Denmark
Jette Egelund Højgaard | Aalborg University, Denmark
Mia Thyrre Sørensen | Aalborg University, Denmark
Maria Hvid Stenalt | Aalborg University, Denmark
Thomas Ryberg | Aalborg University, Denmark
Katrine Lohmann Bjerg | Aalborg University, Denmark

Abstract

This paper reports on a study of interdisciplinary student collaboration conducted at a PBL university. It reports on a range of university-wide study activities, initiated for the purpose of strengthening interdisciplinary collaboration across study programs. The majority of projects investigated were organized as problem-based project work. In some projects, students formed groups with fellow students from their own program but collaborated with student groups from other programs. In other projects, individual students from different programs and institutions formed groups. The study has a specific focus on students' experiences of these activities, particularly how they experience cognitive, social, and epistemic gains from participating in interdisciplinary collaboration. The study finds that students acquire

* Corresponding author:
Kirsten Jæger, Email: kirstenj@ikk.aau.dk

Received 11 November 2025 | Accepted 22 September 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

knowledge from 'foreign disciplines' to complete the interdisciplinary project but also that they appreciate disciplinary boundaries and differences as well as the contribution that other disciplines can make towards realizing the goals of the group. The participants also realize how interdisciplinary collaboration constitutes valuable preparation for future job contexts. Concluding that the interviewed students experienced interdisciplinary collaboration as both highly rewarding and more challenging than project work within the framework of their own program or discipline, the paper suggests that the concept of 'hard fun' (Barrett, 2012) may be a relevant point of departure for future research.

Keywords: Interdisciplinarity; Student collaboration; Problem-Based Learning

Introduction

Most universities encourage interdisciplinary collaboration but refrain from in-depth restructuring of departments and programs along interdisciplinary lines (Lindvig, 2022). Instead, universities host several interdisciplinary research centers, groups, and projects and offer interdisciplinary programs, often with the experience that realizing interdisciplinarity in education is associated with practical obstacles, ranging from incompatible timetables (Lyall et al., 2015) to assessment criteria that differ across disciplines. Often institutions and individual teachers go to great lengths to offer students interdisciplinary learning opportunities. Such opportunities require an extra effort on the part of academic and administrative staff (Holgaard et al., 2025) and may also require new curricular frameworks. Given these efforts, investigating students' experience of and perspectives on interdisciplinary activities is important. The purpose of this paper is to focus on the value of interdisciplinary study activities seen from a student perspective. Thus, based on an interview study involving student participants in interdisciplinary study activities, the research question that we intend to answer is:

Which cognitive, social, and epistemic gains do students experience when participating in interdisciplinary study activities?

The ambition is to listen to student voices across different interdisciplinary activities to understand what students find attractive about these projects, which value they ascribe to them, and how they relate their experience to the ways in which the activities were organized. The intention is to generate knowledge that is useful to researchers interested in interdisciplinary learning, to organizers of interdisciplinary study activities, and to students who consider including such activities in their academic careers.

The setting

This study reports on three different interdisciplinary study activities organized within a university-wide initiative to promote interdisciplinary collaboration among students. Interviews were conducted with members of six student groups participating in these activities. The study was conducted at a Danish PBL university. Consequently, two of the investigated activities (involving four student groups) were arranged as problem-based project work. Project work takes the form of group-organized, semester-long projects, researching a student-defined problem. With some variation across semesters and programs, the semester projects take up a half or a third of the students' workload. One of the investigated activities was arranged as an extracurricular activity. In all cases, the students actively selected the interdisciplinary activity. Where the interdisciplinary activity, in the form of an interdisciplinary project, constituted a credit-bearing, integral part of their program, the students had the option of choosing an ordinary project or an internship, in other words a project that did not require them to engage knowledge beyond their own discipline.

Theoretical framework: Cognitive, social, and epistemic gains

This study assumes that understanding interdisciplinary student collaboration requires an interdisciplinary theoretical approach. Firstly, we draw on contributions from cognitive psychology and social learning theory (Vygotsky, 1978; Wertsch and Tulviste, 1992) to understand what individual participants learned from the collaboration. Secondly, we draw on theories on leadership and coordination in groups and organizations to identify how participants develop their collaboration skills in these socially demanding activities. Thirdly, we include epistemological theory to identify how various forms of disciplinary knowledge and differing epistemic practices influence collaboration and the creation of a shared product. The inclusion of an epistemic perspective considers gains beyond individual learning and enables an appreciation of the knowledge developed in the projects, including innovative ideas resulting from interdisciplinary collaboration.

As will be illustrated in the following brief review of existing literature, empirical studies of interdisciplinary student collaboration often draw on similar theoretical approaches. It is, however, rare that these theoretical approaches are combined to serve as a framework for subsequent analysis as is the case in this study.

Amelink et al. (2024) focus on development of 'complex thinking skills' and agree with Routhe et al. (2023) that students through interdisciplinary project work reach an advanced understanding of how different disciplines can complement each other. Thomassen & Stentoft (2020) emphasize the promotion of 'metacognitive competences' (p. 5). Braβler and Dettmers (2017) as well as Klaassen (2018) conceive of interdisciplinary groups as social learning environments where the 'meeting of different perspectives' enables 'co-construction of learning' (Klaassen 2018, p. 843). Some studies investigate how students manage the complex social task of coordinating interdisciplinary projects and find that participants learn to overcome stereotypical thinking about "others" and to appreciate contributions across disciplinary boundaries (Ellingsen et al. 2021; Routhe et al. 2023). Studies with an epistemic focus pay attention to how disciplines differ in their epistemic practices and knowledge structures, creating challenges in interdisciplinary collaboration, illustrated by Arthar et al.'s (2024) study on an interdisciplinary group's laborious process of arriving at a shared understanding of the very problem they intended to solve. Often, however, the solution of complex problems requires the integration of widely different knowledge areas as illustrated in Kirsop-Taylor et al.'s study on PBL in a political ecology program (2021).

In this paper, we understand the cognitive dimensions of learning in interdisciplinary contexts based on sociocultural theories of learning (e.g. Vygotsky, 1978; Wertsch & Tulviste, 1992; Lattuca, 2002; McMurtry, 2024). Thus, while learning is viewed as involving individual cognitive processes, it originates in social relations and interactions with the socio-material context (Wertsch & Tulviste, 1992). The latter point is reflected in the Vygotskyan concept of mediation, which Lattuca (2002) connects to the context of interdisciplinary learning. Lattuca defines mediational means as 'the products of sociocultural evolution' appropriated by individuals so that they 'may participate in the particular social practices of [their] culture' (715). She further categorizes disciplines as mediational means that 'frame the thinking and the intellectual activity of individuals who use them' (715).

Consequently, interdisciplinary learning contexts require adaption to the mediational means represented by the participating disciplines. Sociocultural learning theory helps us understand that this endeavor not only involves familiarizing oneself with different types of knowledge and epistemic practices, but also the ways in which individuals have adapted cognitively to these practices. Following sociocultural approaches, learning in disciplinary communities requires the internalization of ways of talking, writing, and thinking typical of the discipline. As participants in interdisciplinary activities have adapted to different *disciplinary* social and material contexts, instances of cognitive development are likely to emerge as accounts of experiences of

cognitive dissonance (disruption of existing understandings) and cognitive adaptation to new environments (characterized by gaining familiarity with unfamiliar theories, methods, technologies etc.).

Furthermore, interdisciplinary learning environments foster complex social dynamics. Sociological accounts of disciplines conceptualize them as relatively stable social orders in which the status of the individual member is defined by academic accomplishments in the field. Academic titles and degrees, grades, and consensus around quality standards indicate a well-ordered social system into which individuals are socialized. Disciplinary social orders are, for example, reified in curricula, syllabi, and exam requirements but, at the same time, dynamic and subject to ongoing negotiation in the university's everyday practices, not least at universities that adopt student-centered and project-organized learning forms. Such learning forms are generally seen as conducive to students' development of collaboration and project management skills (Routhe et al., 2023).

Among the potential *social gains* from interdisciplinary collaboration, we focus on leadership and coordination skills. Alvesson & Spicer (2012) view leadership as social practices contributing to the steering of organizational processes towards a goal. These processes are distributed among several individuals located in various positions in the organization. Similarly, Gronn (2002) and Harris & Spillane (2006) apply the term 'distributed leadership'. In principle, leadership may be enacted without designated leader figures (Sutherland et al., 2013). 'Leaderless leadership' involves understanding leadership as a 'relational, socially constructed phenomenon' concerned with the 'management of meaning' (Sutherland et al., 2013, 760), resembling Gioia & Chittipeddi's view of leadership as sense-giving and sense-making processes (1991). Such conceptualizations of leadership processes will help understanding leadership and coordination processes in student groups. Particularly, we take an interest in how students, when leading and coordinating interdisciplinary projects, manage responsibility and decision-making in the diverse and complex settings that these projects constitute.

The students in this study participate in activities that require extensive planning on the part of the teaching staff to create well-functioning frameworks for student learning (Holgaard et al., 2025). Despite these efforts, students may still find themselves in an academic grey zone because (some of) the scaffolding disciplinary structures are disabled or at least relativized to accommodate the interdisciplinary activity. To understand what students gain from navigating in such an environment, we draw on Akkerman and Bakker's concept of *coordination* that includes 'establishing communicative connections', 'translation between different worlds', 'enhancing boundary permeability', and

'routinization' (Akkerman & Bakker, 2011). These concepts involve identifying patterns of communication between the participating students and exploring the extent to which the participants develop mutual understanding across disciplinary boundaries.

Finally, the study seeks to identify *epistemic gains* achieved in interdisciplinary study activities. Arthars et al. (2024) define interdisciplinarity as 'knowledge work that includes different kinds of engagement with knowledge beyond a single discipline' (p. 409). Thus, interdisciplinarity is understood as an epistemic accomplishment, involving 'integration of disciplinary ideas and tools, such as concepts, theories, and methods' (p. 408). Goodyear and Zenios (2007) distinguish between *learning* as a personal matter and *knowledge building* as a public one. Bereiter (2002) explains the distinction in the following way 'In producing [...] theory I have created knowledge, whereas in the other cases I may be said to have acquired knowledge (possibly through some internal constructive process) and created ways of instilling similar knowledge in others. Thus, creating a knowledge object is one thing and helping others to know is another. The first I call knowledge building; the second learning' (Bereiter, 2002, p. 68). Knowledge building implies using and producing epistemic products, 'conceptual artifacts' (Bereiter, 2002), which are 'discussable ideas, ranging from theories, designs, and plans down to concepts' (p. 68). Within disciplines and sub-disciplines, knowledge building takes place through different forms of 'progressive discourses', through which knowledge is advanced in a particular knowledge community.

In interdisciplinary collaboration projects, participants draw on different conceptual artifacts and master different knowledge-progressing discourses (Arthars et al., 2024). In interdisciplinary collaboration, the point is not necessarily to reach agreement but to advance the state of knowledge through discussions of disagreements, which requires common understanding (Bereiter, 2002). Existing research in the epistemic dimension of interdisciplinary collaboration demonstrates the challenging nature of such collaboration: we are familiar with the conceptual artifacts and progressive discourses of our own epistemic culture, but not their counterparts in other cultures. At the same time, participants in the present study are expected to produce *interdisciplinary conceptual artifacts* such as solving a health challenge, developing sustainable building material etc.

Contributions to understanding the epistemic dimensions of interdisciplinary collaboration consider if students can strengthen their ability to develop valuable knowledge in such collaborations. Goodyear and Zenios (2007) view university education as 'apprenticeship in knowledge work' (p. 352). Following this trail of thought, one type of epistemic gain could be developing the

students' *epistemic fluency*, defined by Goodyear and Zenios as the ability to 'recognize, appreciate and understand the subtlety and complexity of a belief system that one has not encountered before, whether that belief system is associated with a religious or ethnic community, or a scientific or professional community' (Goodyear & Zenios, 2007, p. 358). We expect epistemic fluency to appear in the data as reports of better understanding of the logics of others' disciplines and an appreciation of the contributions of these disciplines to the project/activity. Furthermore, increased epistemic fluency may emerge as reports on the experience that one can 'think with' the epistemic tools/conceptual artefacts (concepts, theories etc.) provided by another discipline.

Methods

This interview study investigates projects involving interdisciplinary student collaboration. As the projects were part of a university-wide initiative to promote interdisciplinary collaboration among students, data stems from a heterogenous sample of projects involving different programs and departments. Despite the heterogeneity of the projects, all interviews focus on the experience of collaborating with fellow students from different programs and disciplines and what can be gained from this experience. As the study focuses solely on the student perspective, a qualitative interview study was deemed the most suitable approach to gain a concrete and detailed insight into the practical experience of collaborating across disciplinary boundaries. While an interview study holds the potential of obtaining rich and detailed accounts of interdisciplinary collaboration processes, it also involves practical challenges. In this study, the primary challenge was to recruit interviewees, as the number of potential participants was limited, and only a few (see Table 1) accepted the invitation to participate in an interview. The authors had to accommodate the conditions of each interview to students' busy schedules, which meant that the number of participants varied from interview to interview (as illustrated in Table 1). Students who volunteered to be interviewed may have had a more positive experience than the participants who did not accept an interview invitation. All interviewed students expressed a sense of pride in their final products, which may contribute to their interest in sharing their experience. That said, students also brought critical points to the fore, which may also explain their interest in being interviewed.

As researchers, the authors were involved in a university initiative to support more interdisciplinary collaboration between students and were familiar with the institutional rationale behind promotion of interdisciplinarity. The responsibility for the arrangement of study activities was placed at program

level, implying that the activities were initiated, planned, and carried out by members of the teaching staff of the involved programs. The authors conducting the follow-up research have no affiliation with the programs arranging the interdisciplinary activities. As the authors were not responsible for or involved in arranging or running the interdisciplinary study activities, there were no overlapping interests between the student participants and the researchers. Before the interview, participants received written information on the purpose of the study and the context to which it would contribute. To ensure that every participant fully understood the scope and purpose of the research, every interview session included an introduction repeating the conditions involved in the research. Finally, students signed a letter of consent stating the purpose of the interview. This document detailed the topics of the interview (thematic focus on disciplinary knowledge and learning in interdisciplinary contexts, no questions about personal or sensitive issues). Full anonymity was guaranteed.

The study included students at bachelor and master's level. In the following, the study activity will be referred to as ENG, GAME, and HEALTH reflecting the focus of the activity. The participating student groups will be referred to as ENG1, ENG2, ENG3, GAME1, HEALTH1 and HEALTH2. The GAME group was interviewed twice during the project work, GAME 1a and GAME1b refer to the same group but to different group interviews. The GAME activity involved master's degree students from a range of computer science and media science programs offered by different institutions. During a semester-long collaboration process, students were expected to develop a computer game, drawing on the various competences present in the group. Additionally, the students completed the required program-specific exams. In the HEALTH project (a three-day workshop), the students were asked to identify a health challenge and suggest an innovative solution. Students from different programs (medicine, nursing etc.) worked together in groups. The participants in each HEALTH group were quite diverse in terms of educational background. Two students were enrolled in academic medical programs at the university, while others were completing their final years of the professional bachelor's in nursing. Finally, some participants were from a short-cycle program in social work and healthcare (in Danish: SOSU).

The ENG projects took their point of departure in a technological product requiring the collaboration between different engineering programs. In this program, students joined the project as a group focusing on one specific part of the product. These students faced a double task: developing their part of the product and writing an academic report on the theoretical and disciplinary aspects of product development.

Although all the projects involved students collaborating across program boundaries, the project organization differed. Firstly, in some of the projects students were enrolled as individuals and formed interdisciplinary teams ('intra-group interdisciplinarity'), but the sample also includes projects where students formed groups with students from the same program but collaborated with student groups from other programs ('inter-group interdisciplinarity'). Secondly, the projects also differed in relation to the organizational set-up of the collaboration. In the inter-group projects, students organized frameworks for the inter-group collaboration themselves. Within the individual group, relations were informal without predefined group roles. This organizing principle also applied to the groups involved in the three-day HEALTH workshop, but the organizers provided facilitation of the group process. In the GAME project, students were recruited into predefined roles and had quasi-formal titles/positions from the outset. The table below illustrates these aspects of group organization.

	Intragroup /intergroup interdisciplinarity	**Students are assigned predefined organizational roles**	**Number of participants in the included groups (number of students interviewed)**
HEALTH 1	Intragroup	No	4 (1)
HEALTH 2	Intragroup	No	5 (1)
GAME 1a	Intragroup	Yes	11 (5)
GAME 1b	Intragroup	Yes	11 (2)
ENG 1	Intergroup	No	3(1)
ENG 2	Intergroup	No	7 (3)
ENG 3	Intergroup	No	2 (2)

Table 1. Overview of interviews.

The interviews lasted between 20 and 70 minutes. The interviewer presented herself to the students as a member of a research group studying interdisciplinary collaboration. In nearly all projects, the interviewed students belonged to a larger team. Thus, the statements represent the experiences of the students interviewed and not necessarily the entire group. This point is relevant as interdisciplinary collaboration can be 'thorny', precisely because of the different disciplinary perspectives represented in such projects. As one of the interviewees put it: 'it was not all smooth sailing'. Based on online presentations of the interdisciplinary study, interview guides were developed that on the one hand ensured coverage of the focal themes of the study (the social and organizational set-up of the activity, students' motivation for participating, experiences of disciplinary boundaries, engagement of 'foreign' knowledge, the

resulting products, and the students' experience of outcomes) and, on the other hand, were sensitive to the particular context of the activity. The interview guide sought to encourage participants to provide concrete and detailed descriptions of the collaboration process, the learning experience, and the resulting products. Ironically, the interviewer's unfamiliarity with the disciplinary content of the involved programs (e.g., engineering) prompted rich and detailed accounts of the working processes, the resulting products, and the knowledge involved in creating them. Furthermore, the addressed themes prompted participants to reflect on the entire process from the first acquaintance with the interdisciplinary activity to the final outcomes, including implications for the students' imagined academic and professional futures.

All interviews were transcribed verbatim. Subsequently, data were coded using the data analysis software Nvivo. Data analysis was guided by the principles of thematic analysis (Braun and Clarke, 2021). Student statements on the collaboration processes and their experience of them were primarily coded in terms cognitive, social, or epistemic aspects. Statements that addressed learning beyond one's own discipline (from fellow students, literature, and supervisors) were coded as cognitive gains, and statements that addressed learning from organizational and social issues were coded as social gains. Finally, statements that addressed the involved knowledges, knowledge practices, and knowledge products were coded as epistemic gains.

Findings

The following section presents the study's findings in relation to cognitive gains (*Interdisciplinary collaboration and social learning*) with a focus on the learning outcomes from interdisciplinary collaboration; social gains (*leadership and coordination*) focusing on organizational processes, and finally epistemic gains (*interdisciplinary conceptual artefacts*) focusing on the knowledge produced in the projects.

Interdisciplinary collaboration and social learning

Interdisciplinary groups as social learning communities seem to feature three characteristics:

1. Disciplinary perspectives (and boundaries) become manifest as concrete experiences of different foci and priorities.
2. Participants can learn from disciplinary 'foreigners' by acquiring select mediational means from foreign disciplines.

3. Eclectically familiarizing oneself with certain mediational means from other disciplines (to accomplish specific tasks) is not the same as learning *within* the discipline.

Disciplinary perspectives and boundaries are articulated as experiences of unfamiliarity with knowledge fields and as experiences of discipline-specific approaches and orientations, for example in relation to the understanding and prioritization of tasks. In some cases, these experiences cause frustration, and in others (as the following quote illustrates) they enrich the working process because perspectives are considered that would otherwise be ignored:

> 'Her [medical student] way of thinking was perhaps at a higher level than ours as SOSU or nurses. There were details that she considered that we did not think of, and there were situations where she thought: we cannot present this because this idea is not properly developed. Because if we say we will use AI, she needed to know how we would use AI. While as SOSU and nurses we thought: this will come later in the process.' (HEALTH 2)

In all cases, including cases where different disciplinary perspectives caused certain frictions, the interviewees were able to couple others' behavior to disciplinary backgrounds, understanding that different disciplinary traditions and forms of training result in a particular mix of strengths and weaknesses.
Disciplinary boundaries also become visible to participants as they – due to the interdisciplinary character of their project - are confronted with completely unfamiliar knowledge:

> 'I think that the ENG project has made us improve more than if we had chosen some other project that maybe had included basic energy calculations where I feel that the level of our project was quite high compared to other projects and also in relation to the product that we had to make. We also included a lot of theory that was not included in the curriculum. In the exam, we were asked about much of that theory, including more advanced theory, particularly thermodynamics.' (ENG2).

> 'We knew that we could say something about the absorption of sound, and that this issue was relevant in relation to bricks, as they are supposed to be in a house – but that was more or less the understanding we had of that. We did not really know the advantages and disadvantages of the method, and why precisely we used that method, and what the underlying theory was. We had no clue about all this. So, already here we were far beyond our boundaries.' (ENG1)

Here, the student recalls the sense of perplexity that she and her fellow group members felt when including this unfamiliar knowledge in their project to reach the intended results. Understanding her own field and its boundaries, she also realizes that this was far beyond the scope of her program. Across the projects, participants report on occasions where they had to familiarize themselves with unfamiliar knowledge under time pressure. Here the particular social quality of learning in interdisciplinary groups becomes evident. The material contains multiple reports on how the participants succeeded with their projects because they reached out across disciplinary boundaries to relevant resource persons (more advanced students and experts in other departments/programs) and/or were able to draw productively on other group members' knowledge and skills. For example, design students were forced to acquire basic programming skills to support the GAME project team's overburdened programmers. Similarly, a design student taught his skills in a particular design software to the team's art director. The diversity of knowledge and competences in interdisciplinary contexts allows the individual participants to access their peers' specialized knowledge.

At the same time, acquiring a specific 'portion' of another discipline differs from having gone through semesters of introduction into a discipline's theoretical and methodological universe. Students do not develop a sense of the 'foreign' discipline as a mental map allowing them to navigate knowledgeably between the discipline's different areas and approaches:

> 'I was interested in this because it was totally new, and we did not know anything about it. Also, it was like – I knew I had to familiarize myself with it because it would be part of the exam [because it was included in the project]. But the exact analytic method that we used, I know a lot about that now. But generally – about sound, I think – and now I use some PBL concepts – but this funnel, I have focused a lot [on something specific] at the bottom of the funnel that is 'sound'. But if I had to zoom out – I would not be able to do that – it is a very specific knowledge I have got. (ENG1)

Leadership and coordination

From the outset, the social setup of the interdisciplinary projects differed along two dimensions: the extent to which the involved students had collaborated previously and the organizational arrangement within the group (predefined/formal roles or loose/negotiated collaborative relations). In the ENG groups, the students knew each other from previous semester projects. In the rest of the groups, the students came from different programs and institutions. In one of the latter projects, the GAME project, students were recruited into different roles reflecting project team roles in the game industry.

Recruitment for these roles was based on the students' educational backgrounds. The social setup was predetermined by the responsible programs and institutions. The different organizational approaches to the interdisciplinary groups resulted in different social and organizational processes among the students and in different collaboration experiences.

In the projects without predetermined roles, students did *not* problematize the social and organizational relations among them. Rather, collaborative relations seem to already exist or develop in response to the challenges they met (e.g. having to contact and organize meetings with staff from other programs or having to present results to a large group of people). In hindsight, these challenges are described as opportunities for developing personal confidence and collaboration skills:

> 'I remember when I started my education, just asking a supervisor for help was challenging. Now I am used to that and now I think that it has become a little more […] acceptable to ask someone for help, or can this be done, or could you refer us to others who can help. I think that this is perhaps how I benefitted the most from the project'. [ENG1]

In the ENG groups, no student was assigned a predefined leadership role. In one group, one participant was elected to represent the group in meetings with other groups working on the same product. In the HEALTH groups, participants also managed to define a problem and develop a solution without predetermined organizational roles. Instead, the participants in this project had access to project management manuals and facilitators. In addition, one group devised a code of conduct for group interactions, which helped solve the misunderstandings that occurred. Clearly, the different disciplinary foci of the participants were noticed (different concepts, skillsets etc.) but did not seem to generate conflicts or significant misunderstandings. What seemed to gain currency and matter in decision-making processes was the participants' experience related to the healthcare practice, both in terms of internships and healthcare work.

> 'I think that we quickly realized who was doing which semester in their programs, who had more experience in relation to the healthcare system, So, maybe, the ones that were a bit ahead in their respective programs, their voices were perhaps a bit more influential than the ones who were less experienced. I think we nursing students, we were farthest towards completing our education, we were listened to a bit more compared to the others who had not done so much in terms of internships and did not know so much about that.' (HEALTH1)

Without predefined group roles, participants in the loosely structured groups designed their own collaboration structures. In the ENG multi-group projects,

students experience how complex technological products require a coordinated effort from the involved teams and some understanding of the 'foreign' discipline. Combining disciplinary perspectives to meet program expectations within a relatively short timeframe emulated interprofessional collaboration:

> 'I think that part of what we learn is like when we enter the labor market, what can we use others' education for. We know what others can do, and what we can do, and what the difference is. So, when we enter the labor market, you know, you have studied mechanics, then I have some idea of what that is. And when we are going to collaborate, you can imagine how the collaboration is going to play out. And again, that is preparation for the labor market.' (ENG2)

The ENG students also experienced challenges such as communication difficulties and disciplinary turf wars as the interviewed group gained enough understanding of another group's domain to ask critical questions and challenge the calculations done by that group.

In the GAME project, students were recruited into specific roles based on their disciplinary backgrounds. The project structure combined interdisciplinary collaboration and hierarchical relations between participants. Some were appointed 'leads' and 'directors' while others filled more operational roles as programmers and designers. Adopting these roles, participants were expected to complete a quality product within a short timeframe. Having completed the project, participants hesitate to describe the overall experience simply as 'good'. In hindsight, they characterize their experience as 'educational':

> 'Interviewer: Did you have a good experience?
>
> A: There were both good and bad experiences.
>
> B: Ups and downs.
>
> A: Yes, ups and downs, absolutely. There have been both good and terrible experiences, but overall, it has been an awesome experience.
>
> B: At least very educational
>
> A: Extremely educational, there were really a lot of learning experiences, for example when our [team role] suddenly had to take a break from it all. That was a kind of crisis situation, which we had to handle relatively fast.' (GAME1b)

Through the interdisciplinary collaboration participants experienced the importance of clearly defined project roles matching the discipline-specific skillsets of individual participants. Predefined roles made the participants

reflect on and discuss the role requirements and the available competences and knowledge resources and adapt the predefined role structure to these resources. In the beginning, leadership was understood as a question of logistics, planning, and coordination:

> 'like all the tasks we have on Trello where we have each our little block and then we assign ourselves to that and then we move them around so that everyone has an idea of where people are and what they're working on, but besides that we also have a weekly schedule where we have the daily goals and deadlines and meetings and whatnot on, and then we also have a production plan that spans over the weeks that we are working on a specific thing, where we have more clearly outlined and defined tasks with deadlines on.' (GAME1a).

However, towards the end, leadership is understood as the 'art' of knowing others' strengths and weaknesses and working 'with the person' to bring creative talents to fruition in the project. To practice this more advanced leadership approach, gaining an understanding of others' educational and disciplinary backgrounds is necessary. This complex understanding of leadership developed through the group's experience of collaboration issues related to the discrepancy between a particular (leading) role and the skillset of the person filling this role. Thus, advanced leadership involves combination of social skills (working with different personalities) and epistemic fluency ("recognition", "appreciation" and "understanding" different professional and epistemic communities (Goodyear & Zenios, 2007).

The leadership task was complicated by technological challenges. Access to the programmers' time had to be subject to project management control. 'Anarchistic' work processes, for example designers making unauthorized use of programmers' time, developed as a problem in the GAME project's initial phase because essential leadership tasks were not executed. As participants lost confidence in established collaboration structures, they started to 'silo' and focus excessively on limited parts of the design process. Correction of the role distribution and more confident leadership in the latter part of the process (referred to as 'ownership') instilled adherence to decision-making routines and eventually a less stressful working environment for all.

Interdisciplinary conceptual artifacts

Problem- and project-based learning requires that students engage in knowledge-building and develop conceptual artifacts (discussable and improvable ideas) in the process. Considering the investigated projects, the notion of an 'idea' means at least two things. On the one hand, following Bereiter, it refers to a product of thought processes, a mental artifact as opposed

to a product of material work processes. On the other hand, the notion of idea signals invention or innovation, referring to the *novelty* of the product. In these projects, the organizers expect interdisciplinary collaboration to hold a special potential for development of innovative ideas. The connection between innovation and interdisciplinarity plays out in different ways.

In the GAME project, the interdisciplinary setup emulated the standards of the game industry. Generating creative ideas is a routine task in game production and a sought-after skill in the industry. Consequently, idea generation is supported by the curriculum organization (no traditional semesters with exams) of one of the represented institutions, the school cultivating talents for the film and game industry. Most participating institutions, however, represented classic academic traditions involving formal curricula and exams. Participants point out how these epistemic traditions and their impact on students could explain collaboration issues in the project. As valuable as creativity is for game production, it must be combined with organizational skills in addition to competence in realizing ideas through various forms of advanced craftmanship (such as programming skills). In the end, the team generated an innovative game idea and realized it successfully. This was apparently related to thorough understanding of what individual team members brought to the table, and how these specific qualifications could contribute to the project. The epistemic leadership that it takes to enhance the potential of team members across a range of disciplinary backgrounds involves elements of epistemic fluency:

> 'you can only use others' competences effectively by actually knowing the person and finding out how this personality optimally works in relation to others. And that is something we have found out here. To take the same example, our [team role (leadership position)], brilliant and extremely creative, but a very bad leader, and that is the personality causing this, something with leadership, it is not competence, it has something to do with personality and - education. Some competences are highly attractive to the indie industry, but you cannot leverage these competences if you don't work with the person instead of against the person.' (GAME1b).

Similarly, the HEALTH teams addressed problems amenable to innovation. Insight into healthcare practice (professional and patient perspectives) was a valued resource in identifying the challenge and generating an idea for a potential solution. Despite the short timeframe, the HEALTH participants gained an insight into how different disciplinary and professional perspectives contribute to the identification of the challenge and its solution, which benefitted from academic members' attention to detail and practice-oriented participants' experience of patients' everyday life (e.g. patients with multiple

diseases needing to fit many hospital visits into their calendars). Innovative ideas result from the interplay of the represented knowledges and experiences: The health professionals' understanding of patient perspectives, professional ethical values, and academic participants' insistence on conceptual justifications and methodological awareness.

The experience of one of the ENG groups led to reflections on the nature of the product and interdisciplinary knowledge building. Each group was expected to complete a part of the product, matching the group's disciplinary specialization. Two aspects seem to influence the students' experience of contributing to interdisciplinary and innovative knowledge building. Firstly, while the group imagined constructing a physical product, it turned out that they were to do a virtual version of it instead. While this removed some time pressure, it also meant that the groups were less dependent on each other. Without a physical product, the boundary objects were the calculations resulting from simulations done by each group. That collaboration around a virtual product led to a 'weaker' experience of interdisciplinary collaboration became clear as the interviewed ENG group started to doubt the results they received from another group. While an experimental part involving the physical product could generate correct knowledge about the interaction between the two parts of the product, the students had to explain a potential misalignment between the two parts as a caveat in their project report, and at one point they characterize the entire process as '100% theoretical'. Secondly, the students also articulate what it would take to realize the idea that each group's knowledge product could be seen as a 'real' contribution to an overall project. To realize complex technological development projects, knowledge building should involve a coordinated effort across semesters and specializations integrating existing knowledge contributions.

Summary of findings

Across the interdisciplinary study activities, students report how they acquire elements from the disciplines that their fellow students bring into the investigated projects. Acquiring elements from a foreign discipline differs from being induced into a specific disciplinary universe through education. Learning elements from other disciplines happens for specific purposes in order to complete the task at hand. The participating students demonstrated a precise understanding of the contributions of specific disciplines to the task in front of them and of the boundaries of their own and others' disciplinary knowledge. In fact, disciplinary differences, not interpersonal or work ethics challenges, were used to explain collaboration issues during the work process. Furthermore, all participants emphasize the strengthening of social skills as the interdisciplinary nature of the tasks required outreach beyond their disciplinary

comfort zone. Finally, across groups participants recognize the relevance of the interdisciplinary experience for future work contexts.

Discussion and concluding points

This interview study investigates *the cognitive, social, and epistemic gains that students experience when participating in interdisciplinary study activities.* With the caveat that the interviewed participants may have had a more positive experience than their peers, the study illustrates what students *can* gain from interdisciplinary collaboration in terms of cognitive, social, and epistemic aspects. The participants experienced how being part of more diverse learning environments gave access to acquiring an in-depth understanding of 'foreign' concepts and methods that helped generate a more complete understanding of innovative products (ENG projects). The participants also gained experience of how one can effectively pick up needed skills by collaborating with peers who have expert knowledge in a different field, for example design or programming. Generally, working in interdisciplinary projects gave participants a concrete experience of working – under time pressure – with tasks that required the pooling, integration, and development of different types of knowledge within an environment expecting innovative ideas and quality solutions. The participants were aware of how much such situations resemble contemporary labor market conditions.

At the same time as participants characterize the interdisciplinary collaboration experience as rewarding, educational, and even 'awesome', they also shared less optimal experiences. Some interviewees would have preferred more involvement of external partners, and the shift from physical to virtual product in one of the ENG groups was a disappointment. Other participants describe their experience as both good and bad and at times extremely challenging. At the same time, the participants are aware that they have learned so much from the experience *because* it has been challenging. The ENG students were slightly dissatisfied with the '100 % theoretical' product because it would be *more* challenging to do a physical product. These points bring associations to Barrett's concept of 'hard fun' as a core PBL concept (2012).

The organizers of the investigated projects structured the student collaboration differently. In the GAME project, participants were recruited into predetermined roles, in the HEALTH projects participants collaborated as equals without a defined authority structure but with access to process facilitators, and in the ENG projects the organizers relied on students' already existing organizational skills. The importance of leadership and coordination processes is evident in all projects both in the self-structured HEALTH and

ENG projects and in the explicitly structured GAME project where managing the role structure became essential for successful project completion. In the HEALTH projects leadership appears to happen as collectively accomplished tasks where practical experience counts as much as academic knowledge in the process of giving the project purpose and direction (sensemaking and sense-giving).

Which factors contributed to students' experience of cognitive, social and epistemic gains? With the concept of hard fun, we can – tentatively - list a few connections between the experienced gains and the framework set up for the interdisciplinary study activity. Barrett (2012) argues that for an activity to qualify as hard fun, it should have the following characteristics: it must be a difficult task in itself; it should demand a high activity level, and it should contain transformative potential. These characteristics seem to apply to the activities investigated. Table 2 illustrates how particular types of 'hard fun' challenges seem to relate to the students' experience of cognitive, social, and epistemic gains.

Type of gain	**Challenging factors contributing to the experience of 'hard fun' (Barret, 2012)**
Cognitive gains: Mastery of others' knowledge (e.g. select concepts and methods) Acquisition of new skills through peer-learning	Intra-group interdisciplinarity and/or necessity of outreach beyond one's own discipline (connected to task difficulty)
Social gains: Confidence with outreach Developing skills in leading and/or coordinating groups representing diverse skillsets and knowledges	Intra-group diversity and/or intergroup diversity requiring coordination and leadership contribute to an activity's transformative potential Urgency/time pressure contributing to a high activity level Pre-defined (but negotiable) organizational roles as a productive challenge
Epistemic gains Understanding and appreciating 'foreign' knowledge as essential to the common project. Skills related to knowledge integration to achieve the group goal.	Expectation of innovative products/ideas Accomplishing the set task requires integration (not just juxtaposition) of knowledge from different disciplines.

Table 2. Challenges and gains.

In the ENG projects students needed to move from basic understanding to advanced insight and acquire knowledge above their academic levels, and the GAME students describe expectations as mirroring professional standards. All groups describe the necessity of a high level of activity and a sense of urgency and engagement. All interviews contain transformation stories related to stepping out of one's comfort zone, for example reaching out to 'strangers', coordinating contributions, and telling others what to do to make the project succeed. Clearly, more research is needed to arrive at a thorough understanding of the connection between activity/task characteristics and learning gains in interdisciplinary student collaboration. What this study has demonstrated is that investigating interdisciplinary student collaboration requires interdisciplinary research approaches to capture the multi-faceted and complex experience that such collaboration involves. In this study, a combination of cognitive, social, and epistemic concepts was instrumental in capturing students' gains from interdisciplinary projects. That the concept of hard fun seemed to be highly applicable as well, indicates that future research should pay more attention to *affective* factors as well, both to qualify the experience of fun but also to learn more about potential problematic implications of high-challenge student projects such as higher levels of stress and group tensions.

References

Akkerman, S. F. & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of educational Research 81*(2), 132-169. https://doi.org/10.3102/0034654311404435

Alvesson, M. & Spicer, A. (2012). Critical leadership studies: The case for critical performativity. *Human Relations 65*(3), 367-390. https://doi.org/10.1177/0018726711430555

Amelink, C. T., Grote, D. M., Norris, M. B. & Grohs, J. R. (2024). Transdisciplinary learning opportunities: Exploring differences in complex thinking skill development between STEM and non-STEM majors. *Innovative Higher Education 49*, 153-176. https://doi.org/10.1007/s10755-023-09682-5

Arthars, N., Markauskaite, L. & Goodyear, P. (2024). Constructing shared understanding of complex interdisciplinary problems: Epistemic games in interdisciplinary teamwork. *Journal of the Learning Sciences 33*(2), 405-442. https://doi.org/10.1080/10508406.2024.2341390

Barett, T. (2019). The problem, the group meeting/tutorial, the PBL process and learning. In A. A. Jensen, D. Stentoft, & O. Ravn (Eds.), *Interdisciplinarity and problem-based learning in higher education: research*

and perspectives from Aalborg University (pp. 149-164). Springer Nature. https://doi.org/10.1007/978-3-030-18842-9_12

Bereiter, C. (2002). *Education and mind in the knowledge age*. Routledge. https://doi.org/10.4324/9781410612182

Braβler, M. & Dettmers, J. (2017). How to enhance interdisciplinary competence – interdisciplinary problem-based learning versus interdisciplinary project-based learning. *Interdisciplinary Journal of Problem-Based Learning 11*(2), 1-14. https://doi.org/10.7771/1541-5015.1686

Braun, V. & Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis. *Qualitative Research in Psychology 18*(3), 328-352. https://doi.org/10.1080/14780887.2020.1769238

Ellingsen, P., Tonholm, T., Johansen, F. R. & Andersson, G. (2021). Learning from problem-based projects in cross-disciplinary student teams. *Education Sciences 11*, 259, 1-15. https://doi.org/10.3390/educsci11060259

Gioia, D. A. & Chittipeddi, K. (1991). Sensemaking and sensegiving in strategic change initiation. *Strategic Management Journal 12*(6), 433-448. https://doi.org/10.1002/smj.4250120604

Goodyear, P. & Zenios, M. (2007). Discussion, collaborative knowledge work and epistemic fluency. *British Journal of Educational Studies 55*(4), 351-368. https://doi.org/10.1111/j.1467-8527.2007.00383.x

Gronn, P. (2002). Distributed leadershipas a unit of analysis. *The Leadership Quarterly 13*(4), 423-451. https://doi.org/10.1016/S1048-9843(02)00120-0

Harris, A. & Spillane, J. (2008). Distributed leadership through the looking glass. *Management in Education 22*(1), 31-34. https://doi.org/10.1177/0892020607085623

Holgaard, J. E., Sørensen, M. T., Stenalt, M. H., Jæger, K., Ryberg, T., & Lohmann Bjerg, K. (2025). Challenges, opportunities and educational design for interdisciplinarity in a PBL environment. *Journal of Problem-Based Learning in Higher Education, 13*(1), 49-74. https://doi.org/10.54337/ojs.jpblhe.v13i1.9792

Kirsop-Taylor, N., Appiah, D., Steadman, A. & Huggett, M. (2021). Reflections on integrating the political into environmental education through problem-based learning and political ecology. *The Journal of Environmental Education 52*(1), 1-13. https://doi.org/10.1080/00958964.2020.1825919

Klaassen, R. G. (2018). Interdisciplinary education: a case study. *European Journal of Engineering Education 43*(6), 842-859. https://doi.org/10.1080/03043797.2018.1442417

Lattuca, L. R. (2002). Learning interdisciplinarity: Sociocultural perspectives on academic work. *The Journal of Higher Education 73*(6), 711-739. https://doi.org/10.1080/00221546.2002.11777178

Lindvig, K. (2022). Loud and soft voices of interdisciplinarity in higher education. In T. Øland, S. Sauzet, M. L. Ryberg, & K. Lindvig (Eds.),

Configurations of interdisciplinarity within education. Danish experiences in a global educational space (pp. 94-118). Routledge https://doi.org/10.4324/9781003083245

Lyall, C., Meagher, L., Bandola Gill, J. & Kettle, A. (2015). *Interdisciplinary provision in higher education: current context and future challenges*. University of Edinburgh. https://www.research.ed.ac.uk/en/publications/interdisciplinary-provision-in-higher-education-current-context-a

McMurtry, A. (2024). Learning theory and interdisciplinarity: reframing learning in terms of evolving coherences rather than "true" representations or correspondences. In R. Szostak (Ed.), *Handbook of Interdisciplinary Teaching and Administration* (pp. 13-24). Elgar online. https://doi.org/10.4337/9781035309870.00009

Routhe, H. W., Holgaard, J. E. & Kolmos, A. (2023). Experienced learning outcomes for interdisciplinary projects in engineering education. *IEEE Transactions on Education*, 1-13. https://doi.org/10.1109/TE.2023.3284835

Scholkmann, A., Stegeager, N. & Miller, R. K. (2023). Integrating the integration: The roles and challenges of problem-based learning in bringing together social science and humanities (SSH) and science, technology, engineering and mathematics (STEM*). Journal of Problem-Based Learning in Higher Education 11*(1), 98-123.

Sutherland, N., Land, C., & Böhm, S. (2014). Anti-leaders(hip) in Social Movement Organizations: The case of autonomous grassroots groups. *Organization 21*(6), 759-781. https://doi.org/10.1177/1350508413480254

Thomassen, A. O. & Stentoft, D. (2020). Educating students for a complex future: Why integrating a problem analysis problem-based learning has something to offer. *The Interdisciplinary Journal of Problem-Based Learning 14*(2), 1-9. https://doi.org/10.14434/ijpbl.v14i2.28804

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wertsch, J. V. & Tulviste, P. (1992). L. S. Vygotsky and contemporary developmental psychology. *Developmental Psychology 28*(4), 548-557. https://doi.org/10.1037/0012-1649.28.4.548

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 211-241
doi.org/10.54337/ojs.jpblhe.v14i1.10008

Implementing Hybrid Problem-Based Learning in an English for Specific Purposes Context

Dentistry Students' Perceptions and Challenges

Burçak Yılmaz Yakışık * | Gazi University, Türkiye

Abstract

Problem-based learning (PBL) has been a practical approach in higher education, enhancing collaboration, critical thinking, and problem-solving skills. It has been primarily implemented in medical and dental education, yet research on its use in English for specific purposes (ESP) courses is limited. This study investigates the implementation of PBL in an online ESP course designed for senior dentistry students at a state university in Turkey. The primary aim is to investigate students' perceptions of PBL, its effects on students' problem-solving abilities, professional preparedness, and the challenges they face. A qualitative research design was adopted, utilizing reflection reports and focus group interviews to collect data from 68 dentistry students. Findings display that students generally perceive PBL as beneficial in enhancing autonomous learning, taking responsibility, research skills, academic language, and collaboration. However, they also faced limited access to resources and coordination difficulties. The study highlights the feasibility of implementing hybrid PBL in large classes and emphasizes the need for well-organized

* Corresponding author:
Burçak Yılmaz Yakışık, Email: yyburcak@gmail.com

Received 26 February 2025 | Accepted 3 November 2026 | Published 26 November 2026
© 2026 The Author. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

support systems. Improving access to digital resources, incorporating hybrid instructional models, and further research on the long-term impact of PBL are suggested.

Keywords: Problem-based learning; English for specific purposes; Dentistry students

Introduction

Higher education has increasingly highlighted fostering critical thinking and higher-order cognitive skills in recent years. The higher education curriculum, then, should foster an analytical, creative, and inquisitive mindset in students while developing their intellectual and creative abilities, problem-solving skills, communication skills, and the ability to integrate theory and practice in their field of study.

In the 1960s, problem-based learning (hereafter, PBL) was initially applied to medical education. As it acquired a reputation and credibility in medical education, PBL began to be used in other health disciplines, such as dental education, environmental health, and nursing education, as a component of entire curricula and as an instructional method within traditional curricula (Anthony, 2010). PBL is an instructional method designed by Cockrell and Caplow (2000) to integrate theoretical concepts with practical applications.

Many higher education experts and researchers from several disciplines revealed several advantages of PBL. For instance, Biggs (2003) and Ramsden (2003) advocate the PBL approach, which motivates students to take a deeper approach to learning rather than traditional approaches that rely mainly on memorization with little comprehension. Idrus and Abdullah (2018) further contributed to this argument, stating that PBL, as an inductive learning strategy and team-based approach, enables learners to develop soft skills for higher education. These skills involve inquiry-based, autonomous, and peer-directed learning, yielding enhanced self-esteem, empowered feelings of becoming active learners, and the ability to collaborate in teamwork.

Recent research has highlighted the effectiveness of online PBL in developing students' communication skills, decision-making abilities, and self-directed learning. Li et al. (2024) conducted a comparative study on online versus face-to-face PBL in dentistry. They found that while face-to-face students attended more in the lesson and reported group dynamics, online learners demonstrated significant improvements in self-directed learning, peer interaction, and

communication skills. These findings emphasize the potential of online PBL to foster essential skills necessary for academic and professional success.

Lim and Chen (1999) argue that many institutions are increasingly changing their instructional methods to encourage independent lifelong learners and active learning. Techniques such as cooperative student projects, simulations, case studies, technology-enhanced learning, discussion groups, and problem-based learning are widely adopted to align with the ever-evolving education landscape. Given the benefits of PBL, incorporating it into an English for Specific Purposes (ESP) course for dental students appears to be a reasonable and practical approach.

ESP courses have long aimed to develop more effective strategies for teaching and mastering the language in specialized professional contexts (Baştürkmen, 2021). Despite abundant literature about PBL, research on students' experiences with PBL in online ESP courses remains scarce. To this end, this study aims to design and implement the PBL approach in an ESP course designed for dentistry students at a state university in Turkey. The main aim is to equip dentistry students with the necessary skills to deal with the real problems encountered during their studies at the faculty of dentistry and in their future professional lives. By addressing the research gap, this study aims to provide valuable insights to language teachers, researchers, and lecturers in the faculty of dentistry regarding integrating PBL into their instruction. Considering the above-mentioned motivations, this study is guided by the following research questions.

1. How do dentistry students perceive their learning experience with the PBL approach?
2. How does the PBL experience affect dentistry students' problem-solving skills and preparedness for professional challenges?
3. What challenges do dentistry students face during hybrid PBL, and how do they overcome them?

Theoretical review

Tuzlukova and Sihgn (2018) introduce the concept of ‘self-directed learning’ within the PBL framework, noting that it enables students to apply their problem-solving skills to novel and complex situations beyond their current experiences. Nilson (2010) also supports this view, noting that PBL encourages collaborative learning and critical discussion, thereby enhancing students’ problem-solving capabilities. Considering all these advantages, one can summarize the PBL approach as allowing learners to engage with real-world problems related to their professions. Unlike the traditional learning

environment, where students are passive recipients and the teachers are the primary source of knowledge, PBL enables learners to actively seek information and develop 21st-century skills: research, critical thinking, communication, collaboration, and problem-solving skills (Kırkgöz, 2018).

The benefits of PBL in medical and dental education have been highly investigated, and its significance has been highlighted in previous studies. For example, Aldred and Aldred (1998) and Walton et al. (1997) argue that PBL aligns with adult learning theories, emphasizing goal-setting and informed decision-making. Preeti et al. (2013) further highlight that, in addition to problem-solving and critical thinking, PBL enhances cooperative learning, communication, and interpersonal skills—competencies crucial for professional and personal success.

Lim and Chen (1999) clarified how the PBL process has been implemented within a dental course. After finding a "real-life" problem, question, or puzzle, students conduct an individualized study to gain knowledge and skills. Through iterative evaluation and refinement, students integrate newly acquired knowledge with their existing skills, reinforcing their learning in meaningful, practical ways. Recent studies have also emphasized the role of facilitators in PBL. For instance, Imai et al. (2016) explored how dental educators develop PBL cases and found that structured PBL cases were often preferred due to time constraints and concerns about content coverage. However, their research also highlighted that students tend to engage more deeply in the learning process when allowed more autonomy in case exploration.

The role of PBL in ESP and English for Academic Purposes (EAP) has also been explored in the literature. Basturkmen (2006) defines ESP as "preparing learners to use English within academic, professional, or workplace environments" (p.17). Popovska and Piršl (2013) argue that ESP is a tertiary education subject that can help develop learners' language and subject knowledge by employing strategies and approaches that promote both personal and professional growth. Thus, practicing the foreign language and engaging with the subject matter are integrated into a single course. Kırkgöz (2015) demonstrates the effectiveness of PBL in language education, particularly in courses such as Materials Evaluation and Adaptation, where students engage in authentic and subject-specific tasks. Moreover, Grady et al. (2009) note that PBL is now widely implemented in medical and dental curricula due to its ability to develop teamwork, problem-solving skills, and specialized academic knowledge.

Lythovchenko et al. (2022) designed an online PBL course for engineering students and used online vocabulary learning tools such as Quizlet, Learning Apps, Wordwall, and Quiziz. Their findings suggest that the authenticity of problem scenarios significantly enhances vocabulary acquisition and overall

student motivation. Hybrid PBL models, which are also the focus of this study, offer greater flexibility and accessibility for students. A hybrid learning environment is defined as the integration of face-to-face instruction with online activities (Garrison & Vaughan, 2008). This combination aims to maintain both personalized interaction and the socio-emotional support of the physical classroom while enabling flexibility in the digital space. The primary significance of the hybrid model is its capacity to enhance self-regulated learning (SRL). In a hybrid framework, learners can manage their time, select appropriate digital resources, and track their progress (Lobos et al., 2024), while in traditional settings, content and pace are controlled mainly by the instructor. Furthermore, the hybrid model supports the development of digital literacies, which are now considered 21st-century skills (Van Laar et al., 2017). These skills, supported by hybrid learning models, are critical evaluation, digital communication, and online collaboration. Therefore, a hybrid learning program can be a good pedagogical choice for ESP courses as learners become self-regulated and digitally competent problem-solvers, while simulating the multidimensional communication demands of the modern workplace.

Despite its many advantages, PBL has also received criticism. One concern is that PBL can be overly time-consuming and may lack the structured guidance found in traditional instructional methods (Lim & Chen, 1999). The effectiveness of problem-based learning depends not only on the pedagogical model itself but also on several implementation factors, including the quality of problem design, tutor facilitation, and group dynamics (Chan, 2009). Another concern is the assessment within the PBL curriculum, as objective evaluations of the students' analytical and problem-solving skills are hard to standardize. However, many different methods of assessment have been suggested, including objective examinations, written assignments, objectively structured clinical evaluations, clinical proficiencies, staff/peer evaluations, clinical journals, or progress tests (Aldred & Aldred, 1998; Walton et al., 1997) Likewise, Dolmans et al. (2005) claim that while PBL has strong theoretical foundations, its success depends on how well it is implemented. They emphasize the need for better tutor training, improved problem design, and stronger group dynamics to address these challenges. Bassir et al. (2014) conducted a systematic review. They found that while PBL enhances students' perceived preparedness and knowledge application skills, there is insufficient evidence to support its effectiveness in developing clinical hand skills.

In summary, while PBL presents a promising pedagogical approach for ESP and dental education, its implementation must be carefully organized to achieve benefits while addressing the limitations of curriculum design and student assessment.

Method

Research design

This study adopted a qualitative descriptive design guided by the principles of Glaser and Strauss (1967) and Braun and Clarke (2006). Data were analyzed using an inductive thematic approach, incorporating the constant-comparison method to ensure analytical depth. The aim was not to generate a fully grounded theory, but to develop a data-driven conceptual understanding of dentistry students' experiences with hybrid Problem-based Learning (PBL) in an English for Specific Purposes (ESP) context. By adopting an inductive approach, this study allowed themes to emerge directly from participants' experiences rather than applying pre-existing agendas. This exploratory design was selected as there was a scarcity of empirical research on hybrid PBL within ESP dentistry contexts. While the constant comparison method guided iterative coding and category development, the main objective was not to construct a formal grounded theory but to identify recurring themes within participants' reflective journals and focus group interviews.

Participants and setting

The study involved 68 senior dentistry students enrolled in an English for Specific Purposes (ESP) course at the Faculty of Dentistry of a state university in Turkey. Participants were selected through non-probability convenience sampling (Creswell, 2012) as they were readily available and voluntarily agreed to participate. Participants attended theoretical courses and internship training during the study's academic year. The researcher merged online settings and face-to-face interactions for the study. The online learning environment introduced challenges, including large class sizes and limited face-to-face interaction due to the university's use of the "Perculus" platform. This platform did not allow lecturers to see students during live sessions, requiring discussions and meetings to be conducted in writing, with only the teacher allowed to speak. However, students conveyed their messages via writing in the chatbox. However, they could meet once or twice a week face-to-face because they were taking other dental courses, which are subject-specific and offered by the university faculty on campus in a face-to-face format. Thus, the representative of each group organized these face-to-face meetings to maintain the steps of the problem-based learning process. Discussions were held, and the end products (presentations) were designed accordingly. These challenges led to some alterations in the implementation of PBL. Instead of oral presentations, students submitted posters or PowerPoint presentations, which were later shared via Padlet for peer review and discussion.

Instructional design of PBL approach for the ESP dental course

The steps of implementing Problem-Based Learning (PBL) in the online English for Specific Purposes (ESP) dentistry course were displayed to students, as shown in Figure 1 below.

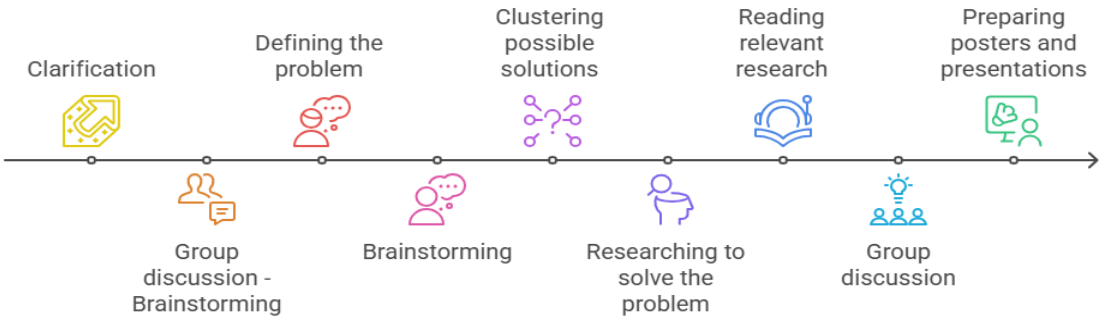


Figure 1. Steps for implementing the PBL experience in the Dental ESP course (napkin.ai).

The steps of the PBL experience were clarification of the problem-based learning, group discussions, brainstorming about the probable problems in the field of dentistry, defining the problem, brainstorming ideas regarding the causes of the problems and possible solutions, clustering possible solutions, researching to solve the problem, individual research, group discussion, and preparing their presentations as the final work. The researcher described each step during the first online class. The steps represented each task within the PBL approach. The whole process was executed in 8 weeks as part of an academic semester.

To execute the steps above, the researcher organized the implementation of the PBL in three key stages: planning, process, and evaluation, and fit the steps mentioned above in an organized framework. Stages are displayed in Figure 2.

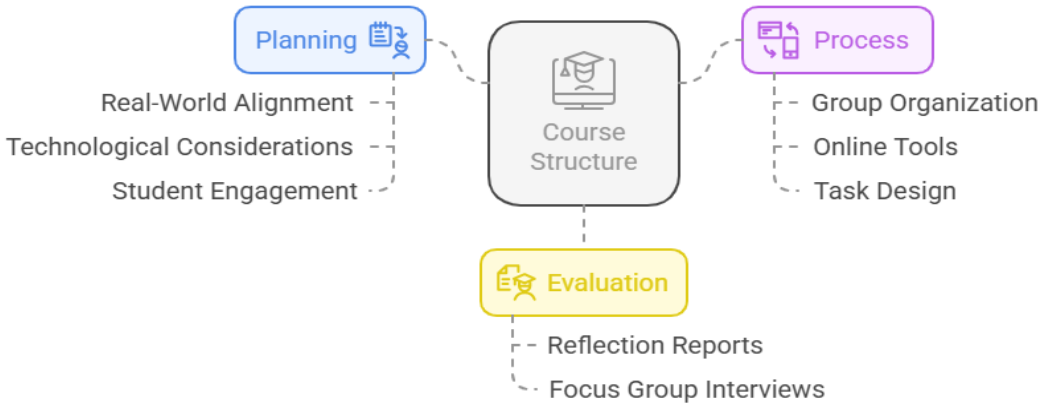


Figure 2. Stages in the organization of Hybrid PBL in the ESP Dentistry Course (napkin.ai).

As shown in Figure 2, the hybrid problem-based learning experience in the ESP dentistry course was designed in three stages. First, the researcher planned the entire PBL experience, considered technological constraints, and determined how to implement the tasks, while also considering students' needs and motivation throughout. The researcher handled the research and collaboration through group work. Finally, the researcher evaluated the entire experience and collected students' reflections, which will serve as the data collection instruments for this study. Each stage is explained in detail below.

Planning: The course objectives were set to align with real-world challenges in dentistry. Insights from practicing dentists were gathered to ensure the authenticity of the problems. Anticipated challenges were considered, including technological issues and student engagement in an online setting. The course structure emphasized collaborative learning while integrating digital tools to facilitate group work.

Process: Students were divided into small groups, each selecting a representative to coordinate tasks. Online tools, including Padlet and Perculus, were used to manage discussions and submissions. Due to platform limitations that restricted face-to-face interaction, discussions were primarily written, except for the meetings outside class sessions. Tasks were designed to support research, discussion, and solution development, as evidenced in the final products presented as posters or PowerPoint presentations.

Evaluation: Students submitted individual reflection reports detailing their learning experiences and problem-solving approaches. Additionally, focus group interviews were conducted to assess students' perceptions of the PBL process, challenges encountered, and the effectiveness of online and face-to-face collaboration.

The researcher aimed to engage students in self-directed learning, identify problems in their field from a student's perspective, develop problem-solving skills, collaborate effectively despite the limitations of the online environment, and increase the feasibility of the PBL process in digital learning contexts.

Data collection instruments

Two qualitative data collection methods were employed to examine students' experiences with problem-based learning (PBL) in the ESP course. The first is the reflection form, which participants complete to address key aspects of their PBL experience, including perceived benefits, challenges, group dynamics, professional preparedness, and the effectiveness of hybrid collaboration. A total of 68 forms were collected. The second is two focus group interviews, in which a randomly selected subset of 10 students participated in semi-structured

groups of 5 to provide deeper insights. With participant consent, the interview was audio-recorded and transcribed for analysis.

Data analysis procedure

Data gathered from the reflection reports were analyzed through an inductive thematic approach, incorporating the constant comparison method to ensure the analytical depth. The Constant Comparison Method filters, categorizes, and connects data based on emerging patterns and themes rather than established categories (Dantas-Whitney, 2002; Leong, Joseph, & Boulay, 2010). This method was selected because the primary aim of the qualitative design was not only to describe perceptions but also to generate a conceptual model of how students make sense of the PBL experience through the emergent structure of grounded theory. The Constant Comparison Method enabled the researcher to move between data collection, coding, and categorization, ensuring that the theoretical output was grounded in participants' voices. Analysis was conducted manually and proceeded in four stages:

First, all reflection reports were read multiple times to understand the dataset fully. Reflexive journals, which were used to document the researcher's position as the course instructor, were also used to record analytic notes on the first preliminary interpretations and emerging patterns.

Second, line-by-line coding was conducted to identify the phrases or sentences. Each meaning unit was assigned a descriptive code, such as practical, coordination difficulty, or research skill improvement. To preserve participants' intended meanings, coding remained close to the raw data at this stage.

Third, codes were compared across participants and the data source using constant comparison (Smith, 2008). The Constant Comparison Method was applied here by continuously comparing new incidents within a code to existing categories to refine those categories. Then, similar codes were grouped into broader categories, and overlapping codes were merged.

Finally, categories were synthesized into four embracing themes reflecting the central dimensions of students' experiences: 1. Cognitive Gains, 2. Collaborative and Professional Engagement, 3. Challenges in Implementation and 4. Professional Outcomes.

To foster analytical transparency, qualitative codes were quantified descriptively. Frequency (n) represents the number of participants who mentioned a given code at least once. Frequency counts were calculated from reflection forms only; interview data were used to elaborate on and contextualize themes.

Code frequencies were calculated to assess their salience across the larger dataset in reflection reports (N=68). Numerical information served as a descriptive indicator of how widely a particular perception was shared among participants. In contrast, focus group interviews (n=10) were not subject to frequency counting since the analytic purpose was explanatory rather than distributive. Interviews were used to deepen the interpretation of reflection-based themes and to reveal affective and contextual dimensions of the PBL experience. As Braun and Clarke (2006) emphasize, thematic analysis is a flexible qualitative approach in which quantification may be used when appropriate; however, it is not essential when the aim is interpretative rather than distributional.

The credibility of qualitative research is related to the researcher's reflexivity and awareness of the potential biases (Creswell & Poth, 2018). In this study, the researcher adopted the role of both observer and reflector during the research process. A reflective journal was maintained during the PBL experience to track student-teacher meetings and observations from the online classes. Because the process lasted 8 weeks, the researcher could easily lose track of each session mentioned in the instructional design section above. Besides, analytical decisions, emerging interpretations, and potential assumptions were documented in this journal. To enhance trustworthiness, an experienced qualitative researcher reviewed the coding framework and a subset of the data. Differences in interpretation were discussed until conceptual agreement was reached, which is commonly recommended in qualitative thematic analysis to ensure interpretative consistency (Braun & Clarke, 2006; Saldaña, 2021)

Results

Results are presented under three research questions guiding this study. Reflection reports (N=68) constituted the primary dataset for quantifying codes and themes, while two focus group interviews (N=10) were used to deepen the themes emerging from the written materials. Table 1 presents the thematic structure derived from the reflective reports, and Table 2 presents the results from focus group interviews.

Themes	Codes	N
Cognitive Gains	Problem Identification	42
	Active Learning	38
	Research Opportunities	35
	Critical thinking	20
	Logical Reasoning	16
Collaborative and Professional Engagement	Collaboration	27
	Responsibility	21
	Professional Awareness	12
Challenges in Implementation	Limited Resources	40
	Coordination Difficulties	38
	Stress	28
	Difficulty evaluating solutions	14
Professional Outcomes	Real-life applicability	36
	Problem-solving competence	35
	Stress management skills	16
	Communication skills	12

Table 1. The thematic structure of the qualitative data obtained from the reflection reports.
*N refers to the number of participants who mentioned each issue at least once. Participants could refer to multiple subthemes.

The themes and subthemes that emerged during the focus group interviews are illustrated in Table 2 below.

Theme 1	Theme 2	Theme 3
Professional Learning through Authentic Tasks	English for Academic and Professional Engagement	Logistical Constraints in the Hybrid Learning Context
Subthemes		
Problem-solving skills	Global professional opportunities	Coordination challenges
Faculty Interaction	Access to specialized academic resources	Group size
Cultural Awareness in Dental Practice	Flexible use of L1 and L2	Limited Resources

Table 2. Themes and Subthemes emerged in focus-group interviews.

As Table 2 illustrates, the focus group interviews generated three main themes related to students' engagement with hybrid PBL. These are professional learning through authentic tasks, the role of English for Academic and Professional Engagement, and logistical constraints in the hybrid learning

environment. The subthemes represent the key aspects through which participants described their experiences with the PBL process. The themes and subthemes were identified during inductive thematic analysis as the research questions were addressed.

Research Question 1

How do dentistry students perceive their learning experience with the PBL approach?

Reflection forms indicated that students found hybrid PBL cognitively engaging and professionally relevant. The most salient aspect was problem identification (n=42). Participants emphasized that defining the problem was very significant to developing appropriate solutions. One student noted:

> "Problem-based learning enables us to establish cause-and-effect relationships." (Reflection Form, ST4)

In the focus group interview, one student reported:

> "The biggest benefit of learning based on problems in the field of study is that we made the problems clearer and were able to focus better on the solutions." (Focus Group 2)

Students also highlighted active learning (n = 38) and research opportunities (n = 35), describing the process as requiring independent investigation and engagement with academic sources:

> "The greatest benefit of this subject for me was to research subjects that I had not researched before." (Reflection Form, ST18)

Frequencies for critical thinking (n = 20) and logical reasoning (n = 16) further indicate that students perceived PBL as promoting analytical engagement rather than memorization. One student noted:

> "When the problem is learned by logic rather than memorization, it allows us to make logical analyses in our professional life." (Reflection Form, ST5)

Similarly, a student contrasted PBL with traditional learning environments:

> "When the problem is learned by logic rather than memorization, we learn to analyze each case in our professional life." (Reflection Form, ST21)

Under Theme 2 in Table 1, students emphasized collaborative learning. Collaboration (n = 27) and responsibility (n = 21) were frequently mentioned,

reflecting shared task distribution and collective responsibility. The following excerpt from a student shows the shared responsibility:

> "Problem-based learning is in an environment where many perspectives coexist, enabling all participants to take responsibility." (Reflection Form, ST26)

Although less frequently mentioned, professional awareness (n=12) indicated the connection between learning activities and professional identity development.

The findings revealed by focus group interviews deepened these patterns under the theme 'professional learning through authentic tasks'. Students described the hybrid PBL model as fostering autonomy and intellectual curiosity:

> "When you are the one identifying the problem and researching it, you stay much more curious and engaged with the material. It was nice to have a voice in the lesson finally." (Focus Group 1)

The subtheme *Problem-solving skills* reflected affective engagement beyond procedural participation. Moreover, *Faculty Interaction* emerged as a distinctive focus group element. Students described interviewing faculty members as bridging theoretical English instruction and clinical dental practice, strengthening the perceived authenticity of tasks.

> "The biggest benefit of learning based on problems in the field of study is that we made the problems clearer and were able to focus better on the solutions." (Focus Group 2)

> "I do believe that the solutions we came up with as a group, and the whole process in general, will help me in real-life experiences." (Focus Group 1)

Both data sources indicate that hybrid PBL was perceived as an active, collaborative, and cognitively demanding learning experience.

Research Question 2

How does the PBL experience affect dentistry students' problem-solving skills and preparedness for professional challenges?

Professional preparedness emerged under Theme 4, shown in Table 1 (Professional Outcomes). The most frequently mentioned outcomes were real-life applicability (n = 36) and problem-solving competence (n = 35). Students reported that the PBL process strengthened their ability to approach professional challenges systematically and apply theoretical knowledge in practical contexts. One student noted:

> "The solutions we came up with as a group will help me in real-life experiences." (Reflection Form, ST24)

> "PBL, a small-group teaching approach, requires students to use information to solve a problem, which is more effective than learning by reading or listening." (Reflection Form, ST 54)

> "Students are more active and thus can develop various skills, such as teamwork, problem formulation, information finding, explaining new information to others, and decision-making." (Reflection Form, ST 25)

Participants reported that engaging with authentic problems increased their confidence in handling future professional situations. The emphasis on problem identification (n = 42) and research opportunities (n = 35) further supports the perception that analytical reasoning developed during the PBL process was transferable to professional practice.

The subsequent examples display students' thoughts and reflections about the connection between theoretical knowledge and real-world applications:

> "The solutions we came up with as a group will help me in real-life experiences." (Reflection Form, ST 24)

> "When the problem is learned by logic rather than memorization, it allows us to make logical analyses in our professional life." (Reflection Form, ST 5)

Some students also referred to gains in stress management skills (n = 16) and communication skills (n = 12). One student described becoming more aware of patient communication and managing professional anxiety:

> "We experience controlling both our own stress level and the patient's stress level in case of complications." (Reflection Form, ST 33)

Emerging themes gathered from focus group interviews introduced a conceptually richer framing under the theme English as a 'Professional Resource.' Students explicitly positioned English as a means to access global knowledge and advance professionally. Two subthemes, global opportunity and specialized resources in English, were identified. Students articulated their stance clearly:

> "English is a key that opens the doors to new opportunities. For our professional life as dentists, mastering these journals is required." (Focus Group 2)

Some students predominantly highlighted the advantage of searching both English and Turkish resources. Therefore, the following quotations from group interviews emphasize another recent popular topic, which is translanguaging:

> "Being able to search in both English and Turkish freely gave us the comfort of communicating without anxiety." (Focus Group 1)

> "Though we discussed in English and kept the conversation going in English in the online sessions, having the chance to communicate in my mother tongue in group discussions outside the online sessions made me feel relaxed and helped me understand better." (Focus Group 2)

> "Yes, I learned how to talk about problems that are special to our Turkish culture about dental topics in English, so I feel I can talk about these issues in an international conference." (Focus Group 2)

While data gathered from reflection reports emphasized problem-solving competence, focus groups viewed language as symbolic and a tool for professional life. Students highlighted the difficulty of navigating medical journals, yet recognized mastery of this terminology as essential to their future professional identities.

Research Question 3

What challenges do dentistry students face during hybrid PBL, and how do they overcome them?

Challenges were depicted under Theme 3 (Implementation Constraints). The most frequently reported issue was limited resources (n = 41). Students described difficulty accessing reliable academic sources and clinical data:

> "Access to the right information, especially clinical experience, was difficult." (Reflection Form, ST14)

A focus group participant similarly stated:

> "We could not find enough scientific data about the problem given to us." (Focus Group 1)

Coordination difficulties (n = 38) were also prominent. Students reported challenges organizing meetings due to internships and academic workload. The quotations below display students' perceptions:

> "Access to the right information, especially clinical experience, was difficult." (Reflection Form, ST 14)

> "We could not coordinate well with our group mates, which created problems." (Reflection Form, ST 64)

Stress (n=28) was associated with workload intensity and clinical responsibilities. One student wrote:

> "Both research and discussion workload can put us under stress and psychological pressure. (Reflection Form, ST 7)

A smaller group of students (n = 14) reported difficulty evaluating the adequacy of their solutions in Theme 3, particularly when determining whether proposed interventions fully addressed the identified problem. Within the constraints framework, some students mentioned their preference for traditional instructions.

The quotations that advocate this finding are provided below:

> "We like lectures in large classes because they are the easiest and quickest way to obtain information." (Reflection Form, ST 28)

> "If all my lecturers used this method, I would doubt how objectively they evaluate students." (Reflection Form, ST 45).

Focus group interviews elaborated on these issues under the theme *Logistical Constraints*. Three subthemes were identified: Coordination Challenges, Group Size, *and Limited Resources.* During the interview, participants emphasized that both online and face-to-face scheduling made peer collaboration more difficult. The examples of students' ideas are indicated below:

> "The groups were crowded, and it was difficult to organize discussion sessions outside the class. While the topics were interesting, the logistics of the hybrid setup were our biggest obstacle." (Focus Group 1).

4 of the 10 students in the focus group interviews criticized PBL and focused on its challenges. The quotations from these students' conversations are provided below:

> "We like the lectures in big classes as they are the easiest and the quickest way for us to reach information." (Focus Group 1)

> "As a dentistry student, I think I need only lectures and clinical experience." (Focus Group 2)

> "I think the PBL process is more time-consuming than traditional approaches. Time should be used efficiently." (Focus Group 2)

> "If all my lecturers used this method, I would feel doubtful if they evaluate the students objectively." (Focus Group 2)

Students also suggested improving access to online resources and scheduling support to ease these challenges. Overall, perceived challenges were primarily structural rather than pedagogical.

In response to research questions, reflection reports highlighted cognitive engagement, research focus, and professional relevance as dominant patterns. Focus group interviews corroborated these findings while adding some more dimensions, particularly regarding autonomy, faculty interaction, and the symbolic role of English within the profession.

Discussion

Perceptions of dentistry students about the PBL process

The first research question explored dentistry students' perceptions of their experience with the PBL approach. The findings indicate that students view PBL as a beneficial approach, highlighting its advantages in exposing them to different perspectives and fostering collaboration and active engagement in problem-solving.

Students agreed that problem identification was a critical component, as it helped them tackle the problems they encountered and would likely encounter in their future careers more effectively. This supports Nilson (2010), who claimed that PBL enhances problem-solving skills by systematically analyzing cases and establishing cause-and-effect relationships. Similarly, students believed that PBL prepared them for future challenges by offering exposure to professional problem-solving situations. This finding is consistent with what Preeti et al. (2013) highlighted: that PBL helps medical students make decisions and apply their learning in practical contexts.

As deduced from students' reflective journals, dental students found this process highly practical because seeking solutions to problems related to domain-specific academic courses and their professional lives was perceived as directly relevant. Conducting meetings, engaging in individual research, and collaboratively creating presentations developed their sense of responsibility and increased autonomous learning. This autonomy aligns with socio-constructivist interpretations of PBL, where learners are positioned not as passive recipients of knowledge but as active agents, responsible for inquiry (Hmelo-Silver, 2004). In the present ESP context, autonomy was not limited to task completion but extended to ownership over disciplinary subjects.

Working cooperatively with group members also altered group dynamics. Students approached challenges from multiple perspectives, including

sociological and economic viewpoints, recognizing that some dental problems require broader cultural understanding. Researching diverse topics helped them realize that social education from a sociological standpoint may help remediate some of the problems they encountered. Maintaining dental hygiene should be a cultural norm. For instance, maintaining dental hygiene should be a cultural and social norm, patients should honestly disclose systemic disease at the clinic, and patients should learn how to tackle dental anxiety. They also agreed that economic problems could be solved through rational, grounded educational policies. For example, they expressed in focus group interviews that purchasing educational materials (dental filling materials, dental models) with their financial means was challenging for many students studying at state universities. As students, trying to solve the issues they observed during their education at school, internships, and in the field, from an academic perspective gave them the chance to view problems from a different perspective.

Such multi-perspectival reasoning indicates that PBL in this hybrid ESP format functioned as interdisciplinary reasoning training rather than isolated language instruction. As Hyland (2006) proposed, effective ESP pedagogy should situate language within authentic professional problem ecologies rather than decontextualized linguistic exercises.

Translanguaging within Hybrid PBL

Although students did not explicitly label their practices as translanguaging, their descriptions clearly reflected dynamic shifts between Turkish and English during problem-solving. Students reported searching for sources in both languages, clarifying complex issues in Turkish, and presenting or documenting final products in English. In the focus group interviews, some students stated that they used academic corpora related to dentistry in their sentences, using English and Turkish as a single system. This corroborates what Cenoz and Gorter (2020) also reported: when solving problems, learners transitioned fluidly between L1 and L2 for cognitive clarity. Furthermore, Canlı and Canlı (2023) discussed the interplay between translanguaging and online courses and found that students felt more encouraged and enthusiastic when free to use their first language.

The present findings extend this literature by situating translanguaging within a cognitively demanding PBL framework. The PBL approach demands a significant cognitive load as learners discuss, search for, and find solutions to problems. Specialized knowledge, critical thinking, and diagnostic reasoning are strongly required. Therefore, employing translanguaging within the PBL framework might scaffold learners as they discuss complex issues with peers in L1, then strategically switch to L2 to present final decisions and document the case for reporting. Here, translanguaging did not function as linguistic

avoidance but as cognitive mediation. It was not an anticipated finding in this research; however, it can shed light on further studies of the relations between translanguaging and ESP courses or translanguaging and problem-based learning, as these relations have not been explored.

From a sociocultural perspective (Lantolf & Thorne, 2006), such mediation is expected in complex knowledge construction. Translanguaging in this context acted as a temporary cognitive bridge, enabling deeper engagement with disciplinary content while maintaining English as the final medium of language. Significantly, students continued to label English as essential for professional growth. Rather than weakening L2 use, strategically placing two languages may foster progress in subject-specific courses.

Resistance to the PBL approach

Despite the positive views, some students preferred traditional theoretical instruction. This aligns with Bassir et al. (2014), who highlighted inadequate clinical hand skills in some PBL contexts, and with Dolmans et al. (2005), who noted that problems are often paper-based rather than being based on actual patients (in medical education), reducing their realism and contextual learning potential.

However, in the present study, resistance seemed to stem less from dissatisfaction with problem-based learning itself and more from concerns about efficiency and assessment objectivity. This distinction is important because it suggests challenges to adaptation rather than a total rejection, echoing Fincham and Shuler's (2001) observations on transitional resistance in PBL environments.

Impact of PBL on professional preparedness

The second research question examines how the PBL experience affects dentistry students' problem-solving skills and preparedness for professional careers. Students' views provide essential information about how they believe Problem-Based Learning (PBL) has affected their abilities to solve real-world issues in their future professional careers and during their higher education. Many students thought their suggestions would be helpful in practical situations. For instance, they discussed utilizing technology and evidence-based procedures and applying knowledge to patient care. As PBL was frequently characterized as a skill-development-promoting, transformative learning strategy, students felt better prepared to manage complexity professionally. Similar results were reported by Lim and Chen (1999), who emphasized the long-term advantages of PBL in fostering the development of critical life skills.

Though students mentioned 'critical thinking' skills at a moderate frequency compared to the other categories, one can still admit that the students believe that PBL improves their critical thinking skills to a certain extent. As critical thinking skills are considered 21st-century skills, a study covering students' analytical abilities will prepare them for their future careers. This finding also aligns with Lim and Chen's (1999) study, which found that PBL promotes higher-order thinking and real-world problem-solving abilities.

This finding corroborates the findings of Hmelo-Silver (2004) and Imai et al. (2016). They maintained that PBL increases students' motivation because learning is driven by real-world problems and their personal needs, which fosters students' intrinsic motivation. Likewise, Imai et al. (2016) mentioned that real-world, patient-centered cases make learning more meaningful. Fincham and Shuler (2001) maintained that learning through realistic problems and patient cases improved long-term recall and clinical reasoning, resulting in enthusiasm and higher student motivation.

Challenges of Hybrid PBL

The third research question examined challenges within hybrid PBL. Overall, students reported limited access to scientific resources, coordination difficulties, and scheduling-related stress. Dolmans et al. (2010) similarly argued that logistical constraints may reduce PBL effectiveness.

Crucially, the majority of identified challenges were structural rather than conceptual. Students did not fundamentally reject the PBL model; instead, they highlighted infrastructural barriers such as database access, scheduling conflicts, and group size constraints. Hmelo-Silver (2004) similarly noted that some PBL students struggled with the uncertainty of directing their learning.
Furthermore, managing the end products posed challenges in terms of scheduling and communication, as they had internships that provided hands-on experience with patients. Groups were too crowded, and each group member had a different internship hour, and they did not want to miss the hands-on practice time. Hmelo-Silver's (2004) and Imai et al.'s (2016) studies also noted unequal group participation and the need for more scaffolding from tutors. Students appreciated PBL's interactive and engaging nature compared to traditional teaching methods but acknowledged that it is time-consuming. In the focus-group interviews, students suggested improving access to digital resources and scheduling opportunities by requesting more meetings with the faculty administration to address these issues. Nilson (2010) advocated for integrating support systems to strengthen PBL's effectiveness, which aligns with the students' recommendations. They also proposed using collaborative digital platforms to facilitate group discussions and restructure project coordination. Concerns about time consumption and assessment fairness were

also similar to Aldred and Aldred's (1998) critique of efficiency in standardized contexts. Likewise, Fincham and Schuler (2001) argued that converting a traditional program to PBL required a complete restructuring of the learning materials, assessment methods, and faculty training.

These challenges suggest that institutional support mechanisms may significantly mediate the success of hybrid PBL implementations. If the PBL approach is introduced within the ESP curriculum designed by the faculty, the administration could plan the internship hours, research work, online classes, and face-to-face meetings more efficiently; otherwise, the whole PBL design becomes the ESP instructor's personal choice, and the instructor and the students try to find the most feasible solution to handle the PBL process. As Dolmans et al. (2005) also emphasized, successful PBL requires institutional alignment, tutor preparation, and access to relevant materials.

To sum up, dentistry students generally view hybrid PBL as a valuable educational approach that fosters research skills, collaboration, and professional preparedness. More importantly, the findings suggest that hybrid PBL in ESP contexts strengthens the relationship between language, cognition, culture, collaboration, research skill development, and professional identity. English was seen as the language of research and professional life. However, translanguaging functioned as cognitive mediation, scaffolding students during their face-to-face group discussions, and the reinterpretation of problems emerged as the primary perceived benefit. Therefore, this study primarily demonstrated the feasibility of implementing hybrid PBL in large ESP classes and also contributed to the field of applied linguistics by illustrating how subject-specific literacy, translanguaging, and problem-based learning intersect within professional education. Finally, addressing challenges such as resource limitations and coordination issues would further enhance the effectiveness of this learning approach. Finally, addressing structural challenges such as resource limitations and coordination issues would further enhance the sustainability and effectiveness of this pedagogical model.

Conclusion

The findings of this study highlight the potential of hybrid Problem-Based Learning (PBL) to enhance dentistry education by fostering critical thinking, collaborative problem-solving, and professional awareness. Its success, however, depends on institutional support and access to resources. By framing PBL as a mediating bridge between language learning and professional and academic fields, this study contributes to ongoing discussions in ESP course design.

In an English for Specific Purposes (ESP) course offered in the faculty of dentistry, students demonstrated how PBL bridges theoretical knowledge with practical application, equipping them with strategies to tackle complex academic and professional challenges. This result aligns with previous research, showing that PBL fosters logical reasoning and teamwork (Lim & Chen, 1999) while preparing students for real-world decision-making (Preeti et al., 2013). Additionally, findings suggest that students naturally engage in translanguaging, using their native language (Turkish) and English for research, discussion, and problem-solving. This helped them grasp complex concepts and navigate academic discourse more effectively.

Despite these advantages, certain challenges of the PBL experience must be considered. Issues such as limited access to academic resources, time constraints, and coordination difficulties posed challenges for students, while some preferred traditional instructional methods and expressed concerns about assessment objectivity.

To maximize the benefits of PBL while addressing its limitations, educators and institutions should provide students with access to comprehensive digital libraries, clinical tools, and other resources to alleviate the frustrations caused by information scarcity. Structured schedules and collaborative digital platforms could ease time management and coordination issues, while a hybrid curriculum integrating both PBL and traditional instruction could accommodate diverse learning preferences. Furthermore, training ESP instructors to facilitate PBL sessions can ensure students receive structured guidance.

While this study provides valuable insight into the efficacy of hybrid PBL in an ESP dentistry context, some limitations remain. First, participants were drawn from a single context within a single faculty of dentistry. This means that the findings may not be directly transferable to institutions with different curricular structures, student profiles, or technological infrastructures. Second, the study relied primarily on self-reported perceptions collected through reflection reports and focus group interviews. While these data sources provided rich insights into students' experiences, they do not necessarily reflect measurable improvements in language proficiency, clinical competencies, or problem-solving performance. Future studies may complement qualitative findings with performance-based or longitudinal assessment measures. Third, this study did not use an experimental design with a group of students with traditional, non-PBL experience. Therefore, although the results indicated the benefits of hybrid PBL, no significant differences were observed between the two groups (control and experimental). Next, the study was conducted over one semester, which was a limitation. Studies over extended periods would investigate knowledge

retention from PBL and skills transfer across the program's different academic and clinical settings. Finally, because the course instructor also served as the researcher, the interpretation of the data might be influenced by personal biases. While using reflexive journals or expert opinion enhanced the credibility of the analysis in this study, future studies may benefit from independent researchers analyzing to minimize potential bias further.

Pedagogical implications

The findings suggest several pedagogical implications for ESP instructors working in diverse professional disciplines. First, integrating problem-based learning into ESP courses can create opportunities for students to engage with authentic disciplinary problems while simultaneously developing language and research skills. In this study, students reported that discussing real-life dental cases increased their engagement and encouraged them to investigate academic sources independently.

Second, the results indicate that allowing strategic translanguaging practices may support cognitive processing in complex tasks. Rather than restricting students to English only, instructors may consider allowing flexible movement between L1 and L2 during collaborative problem-solving, while maintaining English as the primary language of presentation and documentation.

Third, the hybrid model used in this study highlights the potential of combining digital platforms with face-to-face collaboration in ESP courses. Online discussion spaces and collaborative platforms can facilitate peer interaction, while in-person meetings may support deeper problem analysis and group coordination.

Institutional implications

At the institutional level, the findings highlight the importance of providing adequate organization to implement PBL in ESP courses. Students identified limited access to scientific resources and scheduling constraints as significant challenges. Universities may therefore consider expanding digital library access, integrating discipline-specific corpora, and coordinating schedules between language courses and professional internships.

Furthermore, faculty development programs may help ESP instructors acquire the necessary facilitation skills required for PBL implementation. As PBL shifts the instructor’s role from knowledge provider to learning facilitator, training in collaborative task design and group management may enhance the effectiveness of this instructional model.

Implications for further research

Future research should investigate the long-term effects of PBL on clinical competencies and its role in professional identity formation. Comparative studies between PBL and traditional approaches could provide deeper insights into their strengths and limitations, informing curriculum development.

Moreover, integrating AI-driven tools such as bilingual corpora, AI translation models, and digital academic databases could enhance PBL's accessibility in dentistry education. Another critical area for future exploration is the role of translanguaging in ESP-PBL instruction, particularly in professional disciplines like dentistry. A comparative analysis of monolingual (English-only) and translanguaging-friendly PBL environments could determine whether allowing students to use their L1 promotes deeper subject-specific learning and vocabulary acquisition. Further research can integrate and evaluate AI-driven tools, such as bilingual corpora for complex terminology and AI search tools for digital academic databases. Research could evaluate how these tools influence self-regulated learning.

In conclusion, ESP courses prepare students for professional challenges in a rapidly evolving global landscape. By integrating PBL, universities can enhance students' ability to navigate complex subjects, develop professional communication skills, and adapt to dynamic academic and workplace environments. While this study provides valuable insights into PBL's role in dentistry education in a hybrid context, further research is essential to refine its implementation and explore its full potential in ESP settings.

References

Aldred, M. J., & Aldred, S. E. (1998). Problem-based learning: the good, the bad, and the ugly. *Journal of Dental Education, 62*(9), 650–655. https://doi.org/10.1002/j.0022-0337.1998.62.9.tb03227.x

Anthony, E. (2010). *Language Learning: Collaboration in English for Specific Purposes (ESP) Problem-Based Learning (PBL) Classroom*. Applied Linguistics, Global and Local. Proceedings of the 43rd Annual Meeting of the British Association for Applied Linguistics. Eds. Millar, R.M. & Durham, M. Scitsuingil Press.

Bassir, S. H., Sadr-Eshkevari, P., Amirikhorheh, S., & Karimbux, N. Y. (2014). Problem-Based Learning in Dental Education: A Systematic Review of

the Literature. *Journal of Dental Education, 78*(1), 98–109. https://doi.org/10.1002/j.0022-0337.2014.78.1.tb05661.x

Basturkmen, H. (2021). ESP Research Directions: Enduring and Emerging Lines of Inquiry. *Language Teaching Research Quarterly, 23*, 5–11. https://doi.org/10.32038/ltrq.2021.23.02

Baştürkmen, H. (2006). Ideas and Options in English for Specific Purposes. Mahwah: Lawrence Erlbaum Associates.

Biggs, J. (2003). *Teaching for quality learning at university: What the student does.* (2nd ed.). Society for Research into Higher Education: Philadelphia, PA, USA.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Canlı, B., & Canlı, Z. (2023). Translanguaging in online foreign language classrooms: Students' perceptions. *Erciyes Akademi, 37*(3), 1162–1181. https://doi.org/10.48070/erciyesakademi.1324480

Cenoz, J., & Gorter, D. (2020). Teaching English through pedagogical translanguaging. *World Englishes, 39*(2), 300–311. https://doi.org/10.1111/weng.12462

Chan, L.-C. (2009). Factors affecting the quality of problem-based learning in a hybrid medical curriculum. *Kaohsiung Journal of Medical Science, 25*(5), 254–257. https://doi.org/10.1016/S1607-551X(09)70070-1

Cockrell, K. S., Caplow, J. A. H., & Donaldson, J. F. (2000). A Context for Learning: Collaborative Groups in the Problem-based Learning Environment. *The Review of Higher Education, 23*(3), 347–363. https://doi.org/10.1353/rhe.2000.0008

Creswell, J. W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research. (4th ed.). Pearson.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Thousand Oaks, CA: Sage.

Dantas-Whitney, M. (2002). Critical Reflection in the Second Language Classroom through Audiotaped Journals. *System, 30*(4), 543–555. https://doi.org/10.1016/S0346-251X(02)00046-5

Dolmans, D. H., De Grave, W., Wolfhagen, I. H., & Van Der Vleuten, C. P. (2005). Problem-based learning: future challenges for educational practice and research. *Medical Education, 39*(7), 732–741. https://doi.org/10.1111/j.1365-2929.2005.02205.x

Fincham, A.G., & Shuler, C.F. (2001). The changing face of dental education: the impact of PBL. *Journal of Dental Education, 65*(5), 406–421. https://doi.org/10.1002/j.0022-0337.2001.65.5.tb03410.x

Hmelo-Silver, C. E. (2004). Problem-based Learning: What and How do Students Learn? *Educational Psychology Review, 16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hyland, K. (2006). *English for academic purposes: An advanced resource book.* London: Routledge.

Idrus, H., & Abdullah, M.R. (2018). Implementation of PBL to enhance the soft skills of engineering students. SHS Web of Conference. 53 03008 (ICHSS 2018). https://doi.org/10.1051/shsconf/20185303008

Imai, P.H., Kresyman, S., & Asadoorian, J. (2016). Factors influencing dental educators as they develop problem-based learning cases. *Journal of Dental Education, 80*(6), 731–740. https://doi.org/10.1002/j.0022-0337.2016.80.6.tb06136.x

Garrison, D. R., & Vaughan, N. D. (2008). *Blended learning in higher education: Framework, principles, and guidelines*. Jossey-Bass. https://doi.org/10.1002/9781118269558

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Chicago: Aldine Publishing Company.

Grady, R., Gouldsborough, I., Sheader, E. & Speake, T. (2009). Using innovative group-work activities to enhance the problem-based learning experience for dental students. *European Journal of Dental Education, 13*(4), 190–198. https://doi.org/10.1111/j.1600-0579.2009.00572.x

Kırkgöz, Y. (2018). Implementing problem-based learning into an ESP course in pre-service teacher education. In the 1st International Conference on Language Education and Culture (ICLEC).

Kirkgöz, Y. (2015). Designing and implementing an innovative problem-based teacher education course. *American Journal of Educational Science, 1*(5), 229–239.

Lantolf, J. P., & Thorne, S. L. (2006). *Sociocultural theory and the genesis of second language development.* Oxford: Oxford University Press.

Leong, P., Joseph, S.R.H., Boulay, R. (2010). Applying Constant Comparative and Discourse Analyses to Virtual Worlds Research. *Journal of Virtual Worlds Research, 3*(1), 3–26.

Li, G., Alam, B. F., Bashir, R., Tarhini, A., & Nayab, T. (2024). A comparative analysis of online learning versus face-to-face learning approach in problem based learning in dentistry. *Work (Reading, Mass.)*, *79*(1), 203–213. https://doi.org/10.3233/WOR-220674

Lim, L.P., & Chen, A.Y. (1999). Challenges and relevance of problem-based learning in dental education. *European Journal of Dental Education. 3*, 20–26. https://doi.org/10.1111/j.1600-0579.1999.tb00062.x

Lobos, K., Cobo-Rendón, R., Bruna Jofré, D., & Santana, J. (2024). New challenges for higher education: self-regulated learning in blended learning contexts. *Frontiers in Education, 9*, 1457367. https://doi.org/10.3389/feduc.2024.1457367

Lytovchenko, I., Ogienko, O., Kriukova, Y., Meleshko, I., Yamshinska, N., Voronina, H., & Kutsenok, N. (2022). Online Problem-Based Learning: Possibilities for Engineering Vocabulary Acquisition in an ESP Course at

a Technical University. *International Journal of Information and Education Technology, 12*(9), 905–911. https://doi.org/10.18178/ijiet.2022.12.9.1700

Nilson, L. (2010). Teaching at its best: A research-based resource for college instructors. 3rd ed. San Francisco, CA: Jossey-Bass.

Popovska, S. & Piršl, D. (2013). The role of ESP in society's value system. *The Journal of Teaching English for Specific and Academic Purposes, 1*(1), 29-43.

Preeti, B., Ashish, A., & Shriram, G. (2013). Problem-Based Learning (PBL) - An Effective Approach to Improve Learning Outcomes in Medical Teaching. *Journal of clinical and diagnostic research, 7*(12), 2896–2897. https://doi.org/10.7860/JCDR/2013/7339.3787

Ramsden, P. (2003). *Learning to teach in higher education.* (Vol 1). Routledge: London, England. https://doi.org/10.4324/9780203507711

Saldaña, J. (2021). The Coding Manual for Qualitative Researchers (4th ed.). London: Sage.

Smith, J.A. (2008). *Qualitative psychology: A practical guide to research methods* (2nd ed.). SAGE Publications.

Tawney, J.W., & Gast, D. L. (1984). *Single Subject Research in Special Education.* Columbus, OH: Charles E. Merrill Co.

Tuzlukova, V., & Singh, V. (2018). Twenty first century skills through problem-based learning: An ESP perspective. *Journal of Teaching English for Specific and Academic Purposes (ESPEAP), 6*(3), 413-423. https://doi.org/10.22190/JTESAP1803413T

Van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills or literacy: A systematic literature review. *Computers in Human Behavior, 72*, 577–588. https://doi.org/10.1016/j.chb.2017.03.010

Walton, J. N., Clark, D. C., & Glick, N. (1997). An outcomes assessment of a hybrid-PBL course in treatment planning. *Journal of Dental Education, 61*(4), 361–367. https://doi.org/10.1002/j.0022-0337.1997.61.4.tb03126.x

Appendix A

The list of real-life problems dentistry students generated at the beginning of the PBL process

Real-life problems
• *Posture disorder and pain when working in the wrong positions* • *As the number of school quotas increases every year, it makes finding a job difficult.* • *The impatience of sick people makes the treatment difficult.* • *Communication problems with non-compliant patients* • *The patients' fear of dental treatment makes it difficult for the dentist to treat them.* • *In dentistry faculties, students buy most of the materials to be used for patients with their own money.* • *Failure of prosthesis patients to arrive on the appointment date prolongs the treatment period* • *We cannot benefit from current technologies in the treatment of patients.* • *Dentists are the high-risk group for infectious respiratory diseases during dental treatment* • *Session times are very short because there are too many patients. It is not easy to get good treatment in such a short time.* • *The patients' fear of dental treatment makes it difficult for the dentist to treat them.* • *In dentistry faculties, students buy most of the materials to be used for patients with their own money.* • *Traditional, more challenging treatments are applied to the students in the faculty. We cannot benefit from current dental technologies.* • *As the number of dentistry faculties increases, finding a job in the private sector is not easy. Some people who exploit this opportunity exploit labor by offering newly graduated dentists work at minimum wage.* • *Due to the import of all kinds of equipment used in dentistry, the prices of dental equipment are increasing daily, depending on our country's economy. This makes it almost impossible for us to open a private clinic in the future*

Appendix B

Students' end products uploaded to padlet



https://padlet.com/yyburcak/9nfowabo34p298aj

Appendix C

Samples from final products

Group 6:



Group 10:

GROUP-10

Dealing With Patient's Dental Anxiety

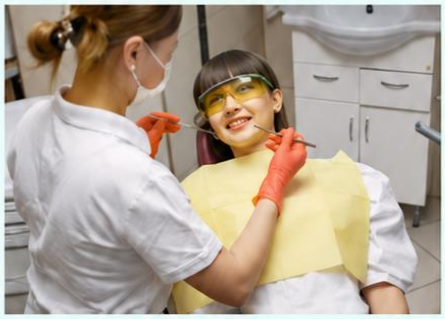


Dental anxiety is a state of intense restlessness that develops with fears and delusions related to dental treatment.

1 In order to reduce the patient's anxiety, we need to tell the patient about the treatment we will do and the situations that he will encounter afterwards. If we explain the treatment in a way that the patient can understand, the level of anxiety will be minimized. And since the patient will be comfortable during the procedure, the treatment is carried out more easily.

2 Dental anxiety occurs in the patient because of the scary and painful stories he hears from his social environment. To avoid this anxiety, the appointment time should be adjusted according to the patient and no action should be taken at the first oppointment.

3 In order to reduce dental anxiety, materials such as syringes and bloody cotton that may trigger the patient's anxiety should not be shown to the patient. In such cases, the dentist may tell the patient to close their eyes and take a deep breath.

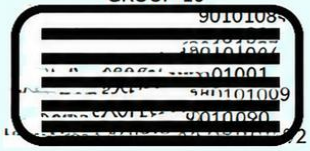


4 To overcome dental anxiety, your dentist can create a comfortable environment for you. Maybe there is a music or a picture that relaxes you. Or the dentist can tell you about the procedures he has done. If your dental anxiety is against anesthesia, it can numb you with hypnosis.

5 If you cannot find a way to overcome dental anxiety, you can request sedation or general anesthesia from your dentist. If there is no harm in your health, these will help you a lot in overcoming your fear.

6 Pharmacological methods of treatment:
1) In the sedation; the central nervous nervous system of the patient is suppressed and his consciousness towards the environment is reduced.
2) In the general anesthesia; the patient is completely unconscious, he(she cannot respond to verbal stimuli . Also, the patient is connected to the respiratory support unit.

GROUP-10



Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 242-254
doi.org/10.54337/ojs.jpblhe.v14i1.11409

Making the Classroom Inevitable

The Role of Dialogic Learning and Teaching in Problem-Based Learning Environments

Joachim Wiewiura * | Aalborg University, Denmark

Abstract

This case study examines how dialogic learning and teaching (DLT) can strengthen problem-based learning (PBL). Conducted in a fifth-semester communication course at Aalborg University, Denmark, the intervention explored whether the physical classroom can function as a meaningful dialogic space that enhances group work, collaboration, and student responsibility in alignment with PBL. Drawing on theoretical accounts of dialogue, particularly Wegerif's framework, the study investigated class-level and group-level dialogue facilitated by the teacher rather than self-facilitated dialogue outsourced to isolated student groups. Empirical findings from surveys and classroom observations indicate that DLT fostered deeper engagement, strengthened mutual accountability, and improved students' willingness to contribute, while also revealing tensions such as reduced opportunities for digital note-taking and the significant time required for high-quality dialogue. The study concludes that DLT can substantively enrich PBL by supporting shared problem exploration and collaborative meaning-making when adequate time and flexibility are provided.

* Corresponding author:
Joachim Wiewiura, Email: jswi@ikk.aau.dk

Received 2 March 2026 | Accepted 28 August 2026 | Available online in Early View 27 October 2026 | Published 26 November 2026
© 2026 The Author. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

Keywords: Dialogic learning and teaching; problem-based learning; student responsibility; higher education pedagogy

Introduction

We live in an era of digitalization. Teaching previously reserved for the classroom can now be transported out of it and take place elsewhere: if the teacher uses slides, students can check them out later at home. If the teacher does not say more than what is in the text, students may simply read it at home. If the teacher records their lecture, then why not watch it when convenient? If the teacher is bad, watch a MOOC with a skilled teacher instead.

No matter what one thinks of these examples, one may didactically challenge them in all sorts of ways, it still remains true that the era of digital learning and teaching environments forces us to ask the question: what is the point of the classroom – is there still a point to it, not only as a social place, but as a didactically engaging place?

The group-work focus of problem-based learning (PBL) can be seen as extending the fragmentation of the traditional classroom. PBL emphasises supporting student groups, often through teacher-facilitated in-group reflection and engagement. But what happens when the teacher also facilitates dialogue in plenary with all groups together, and could this enhance learning and aid problem-solving in PBL? Can an explicit focus on dialogue in the classroom, not just in groups, strengthen PBL?

In this case study conducted at Aalborg University (AAU) with its AAU PBL principles in mind (see Askehave et al., 2015), I show how dialogic learning and teaching (DLT) can contribute to PBL.[1] I demonstrate that DLT can substantiate student responsibility (Principle 6) as well as collaboration (Principle 4) and group work (Principle 2), and how physical classroom courses support the PBL framework when facilitating dialogue. In sum, this case study explores how dialogue supports PBL and makes the case for a stronger integration of DLT in PBL.

[1] I made this case study in 2025, which means that I refer to the "old" AAU PBL Principles. The new ones can be found here: https://www.en.aau.dk/about-aau/profile/pbl#

Problem formulation

How can the physical course classroom meaningfully support Aalborg University's PBL Principles by functioning as a dialogic space, and in what ways might DLT strengthen group work, collaboration, and student responsibility within the PBL framework?

Theoretical foundations: dialogue within PBL

In this case study, I wanted to empirically test a theoretical hypothesis: whether DLT, as outlined by Rupert Wegerif, who is one of the leading scholars in this field, can be meaningfully envisioned as a form of PBL. That is, whether the goals of PBL could be fulfilled via DLT in the classroom.

In an influential article, Diana Dolmans et al. (2005) argue that although there is evidence that students and teachers are satisfied with PBL, most problems arise from its poor implementation; for example, when tutors are too directive and problems are too well structured. I wanted to investigate whether DLT could help guide teachers to be PBL facilitators rather than directive or monological instructors, and in this case study, students identified their own problems through observation, opening the problem space to interpretation and avoiding the over-structuring identified by Dolmans et al.

In the PBL literature, dialogue is not a foreign concept, but it is often understood as a group-internal classroom practice. This case study tests dialogue as a class-level practice, involving the teacher as a dialogue partner, not only as a distanced facilitator of dialogue within student groups. This places additional responsibility on the facilitator role envisioned in PBL.

Seminal overviews define or unpack PBL as "facilitated problem-solving" through "self-directed learning" (Hmelo-Silver, 2004), as a "cognitive endeavour whereby the learner constructs mental models relevant to problems" (Schmidt et al., 2011), or by emphasising that PBL is not only problem-focused but also problem-structured in curricular design (Jonassen & Hung, 2012). None of these studies mention dialogue. Moreover, one study assessed the prevalence of dialogue in problem-based teaching with discouraging results, examining the presence of dialogue in collaborative problem-solving groups and finding "a low incidence of high-quality dialogue" (Innes, 2007).

This, however, does not mean that dialogue is absent from PBL. Some emphasise Socratic dialogue as a value of PBL (Savin-Baden, 2020). Another

study repositions the facilitator role in PBL, specifically within a design-based research context, as that of a coach, accentuating the dialogue between teachers and students and underscoring the need for facilitators (or coaches) to be "skilled improvisers" (van Diggelen et al., 2021). One may also look to Mark Newman's (2005) listing of "capabilities" developed through PBL, such as "active listening," "reasoning critically and creatively," and "interpersonal skills," which are neighbouring concepts to 'dialogue' and, if realised in the classroom, would also naturally embed dialogic elements.

What is currently missing, however, is how, or if, DLT can work as a *structuring framework* for, and not just a product of, PBL. That is, can DLT help enhance PBL's own core values or principles through a compatible conception of dialogue? How would that look, and would it work? What parts of DLT can, if any, be integrated into PBL fruitfully?

What dialogic learning and teaching is

Wegerif (2006) describes dialogic learning as situated in Mikhail Bakhtin's concept of dialogue in which "meaning is always a response to a question", alluding to pragmatist educational philosophy (e.g., John Dewey) where inquiry in a vacuum is a chimera and must be based on experience within the context of a problem/intervention. One may allude to dialogue as having an intention towards others (Dysthe, 2003) or as a matter of shared responsibility for moving forward (Høegh, 2018, p. 78). But often dialogue in education is so ill-defined that either all teaching is by definition dialogic (reducing dialogue to all types of talk) or an ideal hard to realise at any level. Certainly, dialogue is not just verbal engagement, and we may here define DLT broadly as an educational approach that makes students learn by being taught through dialogue, that is, a *harnessed* form of talkative engagement. Below, I outline the specific form of such engagement mobilised in this PBL case.

Dialogic learning and teaching, which, as a caveat, may take several different shapes (e.g., Dialogic teaching (Alexander, 2020), Philosophy for Children (Lipman, 2003), or Thinking together (Dawes et al., 2004)), is a robust phenomenon that has proven to be successful in making students solve the specific problem they are working on faster, meaning that they learn the subject matter faster, and it has proven that what they learn is stored longer term in their memory and/or understanding (see, e.g., Wegerif, 2006, 2019).

How successful and failed dialogues look

Dialogue has both outward and inward aspects. Outwardly, what Wegerif terms identity-in-dialogue involves orienting toward the shared dialogic space rather than one's utterances as personal expressions. Contributions are treated

as tentative steps toward solving a problem together, allowing even one's own position to be evaluated and criticised (Wegerif, 2006). In this mindset, "wrong" contributions invite clarification and shared reasoning, while correct ones (or the *reasons* for them) function as scaffolding for others, deepening understanding for all involved.

Inwardly, dialogue requires reflexivity: the ability to change one's mind, question one's position, and ask for help (Wegerif, 2006). These qualities contrast with failed group talk characterised by domination (asymmetrical influence) or uncritical agreement (premature consensus). Integrating these dialogic orientations into PBL shaped the intervention in this case study.

Pedagogical intervention

I taught Designing Communication 2: Learning, Network and Organisation, a design-based fifth-semester bachelor's course in Communication and Digital Media at Aalborg University, Copenhagen Campus, in autumn 2025. According to the curriculum regulations, students are expected to develop and implement communication and information-science solutions related to learning, networks, and organisation, translating theoretical and methodological knowledge into practice. The course is structured around a case – in this instance, a second-year high school (gymnasium) class – for which students design a learning intervention aligned with the class's learning goals.

Having taught the course the previous year without this intervention, I knew that encouraging students to speak in class was a challenge. My aim was not merely talk, but effective dialogue that would support learning outcomes. I co-taught the course with a PhD student, who covered the practice-oriented components, while I taught the theoretical elements.

The intervention spanned ten lectures (45 minutes each), divided over three slots (1×2 and 2×4 lectures) within a relatively short period of eight days (Tuesday, Thursday, and the subsequent Wednesday), with c. 20-25 students attending each class slot. The evaluation was conducted immediately after the classes.

Four times dialogue

Notably, the students' teaching designs were themselves encouraged to be based on DLT, making DLT part of the theoretical content I was responsible for teaching. This meant a quadruple relation to dialogue in the course: the students were 1) taught through dialogue, 2) they were taught about dialogic

teaching and learning, and were expected 3) to embed dialogue in their teaching design, and 4) to execute this in practice.

As stated, my intervention focused only on the theoretical parts of the course I taught, which meant excluding elements such as feedback seminars. I chose these lectures because I had full control over them and because they allowed me to explore how abstract concepts, such as pragmatism and interpretivism, affordance and multimodality, could be taught dialogically and applied by students in their own high school interventions.

Prompting the students

In the first lecture, I wanted to address upfront the extent to which higher education learning has become digitalised (as noted in the Introduction) and to invite the students to reflect on what the physical classroom should be for if learning can so easily take place elsewhere: why meet at all, beyond convention? I also wanted to prepare this particular cohort – one I knew from experience tended to be quiet – for a pedagogical experiment that would require substantial participation. This, I felt, called for a framed introduction that acknowledged their experience of being "quiet" in the classroom. I presented the robust results of DLT supporting deeper, more durable learning, and since the students were themselves expected to design dialogic interventions for high schoolers, it seemed appropriate that they learn what dialogue entails through their own experience.

I therefore asked, "What's not to like?" – and answered myself: "Ugh… the *talking* part." I then explained that our first activity would be to talk about what makes it difficult to speak in class. The students immediately began talking. I had three aims. First, to understand what they found challenging so I could adjust my teaching. Second, to have them talk about something they cared about, breaking the ice through low-threshold contributions in a shared classroom space, and thereby preparing the ground for subsequent theoretical dialogue. Third, and this was the only aim I made explicit, to make them aware of their own reasons for not speaking and their bodily experiences of speaking aloud. These insights could then be projected onto their high school students and used as a starting point for their own teaching designs.

Intiatives to "produce" dialogue

I want to highlight the most important initiatives of the intervention. First, I used no slides and relied exclusively on the whiteboard, as I wanted us to "think together" through the gradual drawing of diagrams and figures. Second, I asked students to leave their computers in their backpacks; but recognising their strong attachment to digital note-taking, I planned 3–5-minute note-taking

breaks every 15–20 minutes. Third, to ensure that dialogue fed directly into the students' ongoing coursework, I arranged the tables in group formations rather than traditional rows, encouraging not only discussion within the groups that would later design their own interventions but also class-level discussion (more on the ground rules for discussion shortly). Fourth, I sought to "break up the room" by minimising my presence in authoritative positions such as in front of a table or the whiteboard. Instead, I deliberately moved around, sat to the side, and at times joined the student tables during class dialogue.

Finally, I introduced explicit ground rules, beginning with two and adding a third later: "Say what you mean" ("Sig, hvad du mener"), "Ask for help" ("Spørg om hjælp"), and the third, "Why do you think that?" ("Hvorfor mener du det?"). These rules were semi-gamified through the use of tokens: each student received two tokens (and three when the third rule was introduced), and students were instructed to take a token whenever they enacted one of the rules, with the aim that everyone would collect their full set.

I should clarify that I initiated both group-level and class-level dialogue, meaning that when they discussed in groups, they used the tokens as a structured form of initiating (by harnessing) their own dialogue. I would give them specific tasks in the groups that they should solve through dialogue. For example, in the case of the difference between interpretivism and pragmatism, I read aloud a text passage and asked them in groups to highlight as many different points as they could. In this way, I was sure that everyone had something to "bring" to the class-level dialogue, and that we would indeed have an object of discussion *for* our class-level dialogue. While group-level dialogues went on, I was active, trying to get around to each group to help them if they were stuck. The group-level dialogues were held in the classroom, since I wanted to be able to see the students work in groups, which I would not have been able to do had they left the classroom to conduct their group dialogue. To concretely initiate a dialogic space, I moved around the classroom a lot, sometimes sitting in the back or around the middle, trying to create a sense of "let's talk together" in a meaningful way about this or that theoretical concept. I tried to ask them questions that were more responses to their reflections than blank questions, since then it feels, I think, more like a dialogue and less like pressure to answer correctly. If dialogue is a meaningful response to a question, it is my job as a facilitator to offer that contextualization, setting my students up for success rather than failure.

Evaluation and analysis of intervention

The anonymous survey (n = 21) provided useful insight into what students felt worked, and did not work, in the intervention. The most frequently mentioned challenge concerned limited opportunities for computer-based note-taking (n = 10), identified as something that should be changed "next time." In retrospect, I underestimated the importance of the note-taking breaks I had explicitly promised and planned. Due to poor time management, these breaks were often cut when discussions became lively, when in fact they should have been treated as a core rather than expendable component of the teaching design.

Relatedly, when asked whether the dialogic format made learning or engagement more difficult, several students again pointed to the lack of note-taking opportunities as a barrier (n = 7), while one student described the same absence as liberating (n = 1). At the same time, a number of respondents (n = 6) explicitly reported experiencing "no barriers."

Overall, student preferences leaned toward a blended format: most students expressed a preference for a mix of dialogic teaching and standard lectures (n = 11), while nearly as many preferred exclusively dialogic teaching (n = 9). Only one student expressed a clear preference for traditional lecturing alone (n = 1) (see Figure 1).

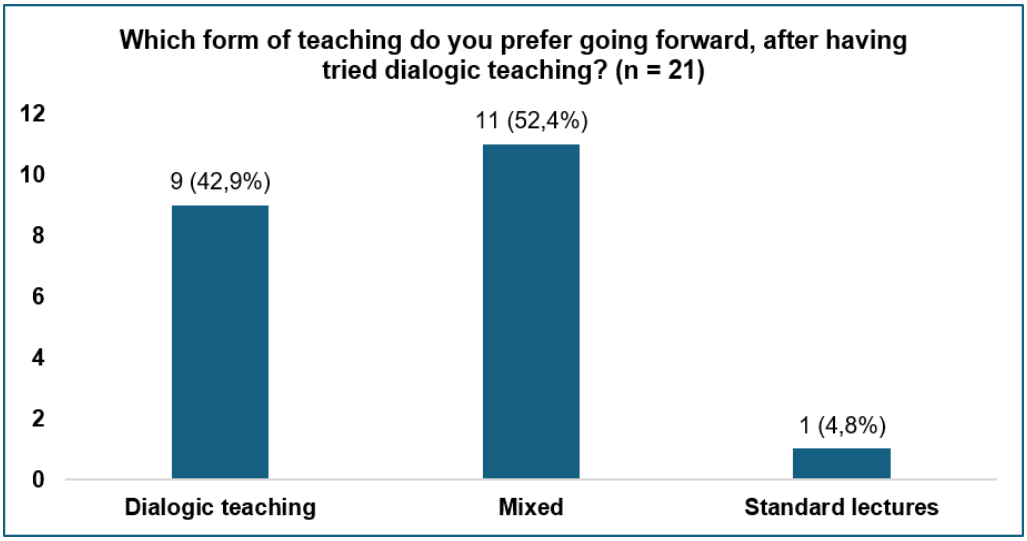


Figure 1.

Students highlighted several qualities (not mutually exclusive) as particularly effective in the dialogic intervention, including dialogic engagement (n = 15), table arrangement in groups rather than rows (n = 10), and extensive use of the whiteboard and no PowerPoint (n = 6). When asked to characterise the classes

in which they felt most active, students most frequently pointed to dialogue (n = 11), the close integration of theory and practice (n = 7), and, somewhat notably, the "put your computers away" policy (n = 4) (not mutually exclusive).

Overall, the results indicate that there is good reason to interpret the intervention as a general success from the students' perspective, with average ratings of 4.2 (Figure 2) and 4.0 (Figure 3) on a five-point Likert scale. Here, success is simply defined as above neutral (point three on the Likert scale).

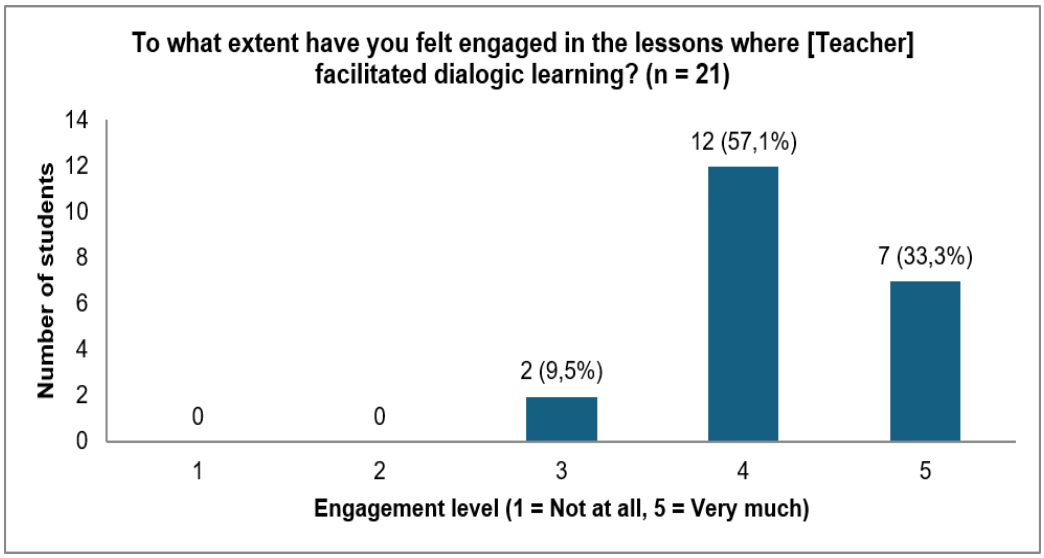


Figure 2.

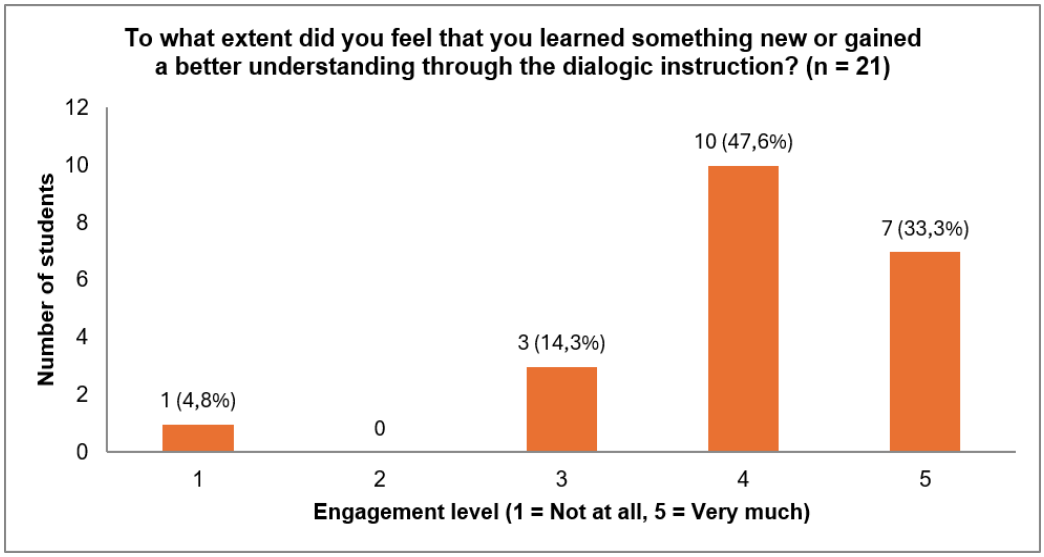


Figure 3.

I shall here highlight some student quotes that I will address in the discussion below:

Student #7:

> "I've found that the more hours we've had with [Teacher], the better people have become at speaking up and contributing. We were good at it in the first semester, but since then it has got worse and worse. It's as if people have regained the confidence to contribute again after these sessions, and I hope the effect lasts. So the best element is probably that we continually follow up together, and that people feel a shared responsibility to take part in the follow-up."

Student #11:

> "I feel that I've learnt far more in these sessions than in others – also because it was more text-focused; we worked specifically with the texts we had read for that session and got to 'know' the author/theorist better than if it had just been classic PowerPoint, sitting-in-rows teaching. Really great teaching! I've never learnt this much before."
>
> And adds:
>
> "Compared with other sessions, I haven't experienced myself or other fellow students contributing as much in class as we do now."

Discussion: Enriched mutual accountability, lack of note-taking and a crucial trade-off

As evident from the quotes, the dialogic intervention created an optimistic stance for many of the students and also a positive side effect: mutual normative accountability. I noticed this when one student, after three hours, decided to go home during the break because he "was tired," but decided to come back after five to seven minutes because he "could not leave his friend behind," implying that if he left, his friend would lose his dialogue partner. This is a fragment of what will hopefully extend to a positive spillover effect in other courses, as also mentioned above by Student #7.

The largest problem of the intervention was the recurrent lack of meeting the students' needs for computer note-taking. However, this may also have provided them with a new experience that may help them see the qualities of paper notes, but that is uncertain and would need further evaluation several months after the intervention, which is beyond the scope of this case study.

Another main takeaway point is that dialogue needs a lot of preparation to work, and when it works, time should be allowed to flow. Especially as a form of PBL, DLT encourages fruitful group work, and in this case it is a positive sign – but also something to be aware of – that some students felt they were interrupted in good dialogue when I wanted to move on through the curriculum (Student #8). To fully integrate PBL and DLT means giving much time to allow dialogue for the sake of problem-solving, and not simply dialogue for the sake of dialogue itself, nor for the sake of learning the curriculum. In PBL, curriculum suits the needs of the problem, and dialogue should be tailored to this end as well.

In this sense, DLT as a form of PBL involves a trade-off: dialogue requires time and may necessitate deprioritising parts of the curriculum. What is gained is collaborative investigation and problem-solving through dialogic competence, which is, arguably, more valuable than covering content back-to-back. As such, DLT strengthens PBL at its core.

Conclusion

In response to Aalborg University's six PBL Principles, this case study has investigated how or if dialogic learning can support group work (Principle 2), collaboration (Principle 4), and student responsibility (Principle 6) by taking the problem as a point of departure (Principle 1) with the support of courses (Principle 3).

I find that where dialogue specifically can contribute to PBL pedagogy is in the heightening of student responsibility, Principle 6. While sharing collaborative approaches to group work with PBL, DLT can strengthen mutual accountability by offering a shared space in which students together directly form a shared understanding of the problem as well as generate solutions to the problem. Not least, DLT can enhance student responsibility throughout the collaborative setting, spilling over into other parts of study life and future work life.

Going forward, the dialogic addendum to, or interpretation of, PBL requires, however, integrating enough time in the pedagogical model to make dialogue flourish in order to be truly beneficial for solving the problem at hand.

References

Alexander, R. J. (2020). *The dialogic teaching companion*. Routledge. https://doi.org/10.4324/9781351040143

Askehave, I., Prehn, H. L., Pedersen, J., & Pedersen, M. T. (Eds.) (2015). *PBL: Problem-Based Learning*. Aalborg: Aalborg University Press.

Dawes, L., Mercer, N., & Wegerif, R. (2004). *Thinking together: A programme of activities for developing speaking, listening and thinking skills for children aged 8–11* (2nd ed.). Imaginative Minds.

Dolmans, D. H. J. M., De Grave, W., Wolfhagen, I. H. A. P., & Van Der Vleuten, C. P. M. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical Education*, *39*(7), 732–741. https://doi.org/10.1111/j.1365-2929.2005.02205.x

Dysthe, O. (Ed.) (2003). *Dialog, samspil og læring*, Klim.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Høegh, T. (2018). *Mundtlighed og fagdidaktik*. Akademisk Forlag.

Innes, R. B. (2007). Dialogic communication in collaborative problem solving groups. *International Journal for the Scholarship of Teaching and Learning*, *1*(1). https://doi.org/10.20429/ijsotl.2007.010104

Jonassen, D. H., & Hung, W. (2012). Problem-based learning. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 2687–2690). Springer. https://doi.org/10.1007/978-1-4419-1428-6_210

Lipman, M. (2003). *Thinking in education* (2nd ed.). Cambridge University Press.

Newman, M. J. (2005). Problem based learning: An introduction and overview of the key features of the approach. *Journal of Veterinary Medical Education*, *32*(1), 12–20. https://doi.org/10.3138/jvme.32.1.12

Savin-Baden, M. (2020). What are problem-based pedagogies? *Journal of Problem-Based Learning*, *7*(1), 3–10. https://doi.org/10.24313/jpbl.2020.00199

Schmidt, H. G., Rotgans, J. I., & Yew, E. H. (2011). The process of problem-based learning: What works and why. *Medical Education*, *45*(8), 792–806. https://doi.org/10.1111/j.1365-2923.2011.04035.x

van Diggelen, M. R., Doulougeri, K. I., Gomez-Puente, S. M., Bombaerts, G., Dirkx, K. J. H., & Kamp, R. J. A. (2021). Coaching in design-based learning: A grounded theory approach to create a theoretical model and practical propositions. *International Journal of Technology and Design Education*, *31*(2), 305–324. https://doi.org/10.1007/s10798-019-09549-x

Wegerif, R. (2006). Dialogic education: What is it and why do we need it? *Education Review*, *19*(2), 58–66.

Wegerif, R. (2019). Dialogic education. In R. Wegerif (Ed.), *Oxford Research Encyclopedia of Education*. Oxford University Press. https://doi.org/10.1093/acrefore/9780190264093.013.396

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 255-265
doi.org/10.54337/ojs.jpblhe.v14i1.11406

Establishing a Learning Community to Support Master's Thesis Writing Students in a Problem-Based Learning Context

Martin B. Østergaard * | Aalborg University, Denmark

Abstract

Universities practicing problem-based learning (PBL) activities as part of their educational foundation teach students to work problem oriented through group work. At Aalborg University, the students are typically divided into groups of four to seven. Though, the master's thesis is often written individually or in pairs. This study addresses the contradiction of PBL promoting a collective, group-oriented approach to teaching while the final thesis is individually or in pairs. A learning community (*LC*) was established among master's thesis writing students supervised by the author to complement the traditional supervision. The LC was framed as monthly research meetings with progress presentations by the students followed by discussions among the students with the supervisor present. Thus, this pedagogical intervention aims to inspire new PBL practices in environments where students primarily work on individual projects. The purpose is not to create new teams or groups, but to create a learning community among students working problem and project based on their individual projects. The students find the LC a valuable addition to their thesis year. Individual students

* Corresponding author:
Martin B. Østergaard, Email: mbo@bio.aau.dk

Received 27 February 2026 | Accepted 2 July 2026 | Available online in Early View 14 September 2026 | Published 26 November 2026
© 2026 The Author. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

appreciate the group feeling for discussions, while paired students use the meetings to follow up on their own work and get new inputs to their work.

Keywords: Problem-based learning; Learning community; Master's thesis students; Individual project; Student interactions

Introduction

Problem-based learning (PBL) is the root of teaching at Aalborg University, where students perform group-based studies under supervision using their creativity and skills to solve research questions, industrial problems, or a generic problem (Servant-Miklos, 2020). PBL is used to teach students to become effective collaborators through group-work (Hmelo-Silver, 2004). At the Department of Chemistry and Bioscience, Aalborg University, the number of students per project group varies greatly depending on the experience of the students and the total number per year, however typically the students are four to seven students per group. The final two semesters, most students write a so-called long thesis (nine months from September to May), which is written individually or in pairs based on experimental or computational research projects. Thus, a contradiction between group oriented PBL and individual work exists. The transformation from group members to individuals results in a significant change in their learning environment due to the missing social interdependence from the group (Shimizu et al., 2021). As an individual, the students are to maintain track of all parts of the project management such as time planning, literature reading, lab work, data analysis, and thesis writing. Meanwhile, the discussion of results and theory relies on the students' own reading and interactions between students and supervisors.

The starting point in PBL activities is a problem (de Graaff & Kolmos, 2003) which students are to solve through collaborative group work to enhance their learning outcomes (Stentoft, 2019). The project groups can be considered as small learning communities. A learning community relies on social connections and sharing of learning experiences through peer-to-peer learning (Campbell et al., 2024), however, without the necessity to solve a specific problem. Thus, students help each other understand fundamental theory in learning communities where PBL settings are used to solve a problem, however, during a project the students should help each other understand the background theory necessary to solve the problem. Both learning communities and group-oriented PBL seek to enhance the learning through active participation and student engagement. As the students start to write the master's thesis individually, the learning community from group work disappears.

Communities can be formal and informal, where PBL-based communities often are considered informal with focus on voluntary sharing and trust (Goglio et al., 2023). Learning communities are groups that work towards a common goal, and the communities can be described in terms of access, relationship, vision, or function (West & Williams, 2017). Access requires either physical or online contact, so-called ready access (Rovai et al., 2004). Relationships rely on emotional belonging (Blanchard et al., 2011), and can be described through three different modes i) engagement (do it together), ii) imagination (reflection to see new possibilities), and iii) alignment (mutual progress) (Wenger, 1999, 2000). Vision requires a shared goal or mission in the community (West & Williams, 2017).

Here, a pedagogical intervention is introduced to overcome the contradiction in PBL-based group work and individual thesis writing. A learning community (referred to as *LC*) was organized among six master's thesis writing students establishing a knowledge-sharing group despite individual or pair work. All students were supervised by the author performing their projects individually (two students) or in pair (four students in two groups). As part of LC, the supervisor provided a common meeting place (access) where the students could engage in scientific discussions related to each other's projects (sharing function). LCs were organized monthly by the supervisor as an extra initiative to supplement supervisor meetings. The focus was on presentations by the students covering their topic, status, progress, and current problems, while the supervisor was to secure a psychologically safe culture for everyone to benefit. LC provides an opportunity to establish a relationship for discussions among the students as if they were a group. This is expected to provide benefits from both student and supervisor perspectives. The students are expected to benefit from a group feeling and relationships (Wichmann-Hansen et al., 2020) where they assist each other and learn through presentations, discussions, and reflections of the work by themselves and their peers (Wichmann-Hansen et al., 2020). The supervisor is expected to save time by answering general questions in plenum (Vincent, 2009; Wichmann-Hansen et al., 2020) and reduce ad-hoc supervision due to the students' common interactions. As an additional benefit, the discussions at LC may lead to new research ideas (Vincent, 2009).

Methodology

The establishment of a learning community was based on monthly research meetings organized as typical research meetings (Delamont & Atkinson, 2001), where the students presented their progress either individually or in pairs. However, at LCs there was a deeper focus on support and learning among the students rather than scientific sharing. At each LC, students presented their

project status as well as current problems (such as experimental design, data interpretation, etc.) where they needed support from other students (or supervisor), typically 1-3 focus points. After the presentation, the focus points were the starting point for discussion among the students, however, the students were allowed to ask questions or provide any feedback they had on the presentation.

Six master's thesis students supervised by the author evaluated LCs along with other learning activities based on two questionnaires. The author created open-ended questionnaires to gain feedback from the students on the role of different learning activities in comparison to LC. The students were identifiable to the authors as the expectations and experiences of the students were to be compared. Identifiable questionnaires were considered feasible in this study as the students were to comment on a teaching method that was developed for enhancing their own learning and not comment on their supervisor. Thus, the feedback of the students was simply to determine if LC provided a room for learning and reflection, or if the students preferred more traditional learning activities. Therefore, it is expected that the students provided their honest opinions. First, the students stated their expectations within two weeks of starting their thesis followed by a new questionnaire after approx. three months to evaluate their experiences. As part of the questionnaires, the students were to consider the following learning activities: Literature reading, Lab work, Ad-hoc supervisor assistance, Supervisor meetings (individual/pair), the learning community (LC), Research group meetings (with other professors, Postdocs, PhDs, and MSc student supervised by other professors in this group), and Daily discussions with other students. The students were then to consider in which project situations (idea generation, theoretical understanding, troubleshooting problems, experimental work, and data interpretation) they expected certain learning activities to play a key role. This was designed for the students to reflect upon their own use of the different learning activities in the project situations to provide input on connections between learning activity and project situations. In addition, the key feedback from the students has been obtained through open-ended questions such as

> *"What have been the main difference in your MSc work (individual/pair) compared to a typical semester project (group)? What did you gain and miss?"* and *"Have LC contributed to enhanced communication in your daily work with students within same topic?"*

These questions were asked to gain information on whether the students benefited from LC or whether it was considered waste of their time.

Results

The nine-months master's thesis writing period differs from previous student projects as the duration is longer (typical semester project 3.5-4 months) and the students are only one or two to perform the project. This is a contradiction to the PBL-focused group work, and it is thought upon among the students. The fact that students work either individually or in pairs provides differences in their expectations for the work. As one student explained,

> *"I do not expect it to change much (as) I work in a two-person group"* while a student working alone told *"I expect that it will be more challenging, but also more rewarding, as I have to do everything by myself."*

The students generally agree that they expect interaction and relationship with the supervisor will be more important due to the missing study group.

After three months the expectations were confirmed as experiences among the students were either 1) working alone they do everything alone and must prioritize between tasks or 2) as a pair they have someone for discussions, and they can distribute tasks such as writing and laboratory work. A student working individually expresses "*it feels like the laboratory work is always behind and lacking*" confirming the frustrations going from group work to being alone.

The need for a learning community

LCs were introduced to establish a community among the students, and the benefits are reflected in positive feedback on both LC and daily discussions with other students. As stated by one student "*It gives some kind of belonging, and we help each other-feeling*." As a follow up, the students were asked which learning activity they expected and experienced being most relevant for different project related activities. The students neither expected nor experienced LC as a place for discussing fundamental theory and experimental work. In contrast, they experienced it useful for troubleshooting and data interpretation compared to their expectations. The daily discussions were experienced to be a more frequent use for discussing fundamental theory, troubleshooting, and experimental work compared to their expectations. In contrast, the students experienced less discussion on data interpretation on daily basis with other students. Thus, LCs have positively provided room for discussions and know-how of each other's project resulting in engaged daily discussions.

Student thoughts on the learning community

The students had different expectations regarding the usefulness of the learning activities. Their expectations were based on their knowledge and experience as

group members and thoughts on how this would change during individual or pair work. All agreed that laboratory work and supervisor assistance would be key activities for learning during their master's thesis work given the experimental nature of their projects. The effect of LCs on learning outcome was subject to the largest disagreement among the students. The main reason for the large discrepancy is the fact that some students write individually and others in pairs. Furthermore, the students were skeptical about LC and the daily discussions emphasized by statements such as

> *"None of the others are working on the same subject"* and *"the knowledge of students compared to supervisor(s) are limited."*

Despite this, the same student expressed positive thoughts on LCs after three months:

> *"Sometimes the other MSc students have come with productive ideas, and I can only imagine it has an even greater impact on those who work alone,"*

and the student stated that the LCs had been the foundation for daily interactions with other students as a result of the knowledge obtained on each other's projects. The student expressing skepticism about the necessity of the LC argues for the students provide their honest opinions in the questionnaires despite being identifiable. A student working in a pair stated that they would rank the LCs higher if working individually as this allows for discussions with peers. Another student working individually told:

> *"I learn a lot from discussing the problem with others. I have also experienced that people who don't work with the same problem as me can provide other aspects which can be useful."*

Thus, LC has acted as a foundation for discussions and interactions among the students and the students feel comfortable in asking for help because they know that the other students have pre-knowledge which enhances their changes of helping.

Focusing on LCs and daily discussions among the students, these learning activities were considered important in different phases of the project by the students. Students state that they expect or hope to receive new perspectives and ideas on their project from other students during daily discussions or at LCs. After three months, more students found LCs more useful in troubleshooting and data interpretation than expected based on the continuous presentations of the projects and thereby knowledge of the projects. This also led to daily discussions where the students helped each other in understanding relevant theory. The students also started assisting other students in the laboratory with analytical equipment or experimental design. As an example,

students from two different projects that were rather different found a mutual angle to discuss design of temperature profiles of experiments.

Learning community – from a supervisor perspective

A few key points were listed as expected positive outcomes from a supervisor perspective. The opportunity to answer common questions in plenum was also experienced following different literature (Vincent, 2009; Wichmann-Hansen et al., 2020). However, some questions were also discussed during supervisor meetings with individuals or pairs, thus, a few duplicate discussions occurred. This may need to be highlighted to the students that non-urgent, general questions should be discussed during LCs to save time. While LC was added as a supplement to ordinary supervisor meetings, a successful implementation of LCs would most likely save time for the supervisor. This has also been observed in this study by a reduced number of ad-hoc meetings.

Discussion

Problem based learning at Aalborg University is introduced through project-oriented group work, however, how are students affected when writing a master's thesis individually or in pairs? In this pedagogical intervention, master's thesis writing students supervised by the author were introduced to several learning activities with a key focus on an established learning community (LC). Based on feedback from the students as well as observing their engagement in discussions, the students need a psychological safe room illustrated by two things; 1) the students needed a few LC meetings to become familiar with each other's projects and be safe in asking questions to their fellow students, and 2) the students were less engaged during research group meetings with other professors, PhD students, postdoctoral researchers, and other MSc students. This was confirmed by students stating,

> *"The meetings with other MSc students (LCs) seem to offer better learning, as they create a debate with the other students, who through several meetings have a better knowledge of the project and the issues that have arisen."*

LC meetings had a focus on learning rather than presented research. An approach to enhancing the discussions at earlier stage of the process could be to have an open first LC where the students could be curious about each other's projects rather than solving issues. This way the students become more confident with all projects. In addition, the framing of the LC potentially needs to be presented better by the supervisor: what is expected from the students? What are they supposed and allowed to do during LCs?

The students were asked to include few (1-3) current issues by the supervisor. However, the issues became too project specific rather than a starting point for discussions. The students found it difficult to phrase relevant issues for two reasons 1) some already discussed them with the supervisor and 2) the issues were project specific and required background knowledge. However, one student was positive stating

> *"I believe it have been beneficial as there often is issues that can be at least partially solved by getting other people to look at one's work."*

For the future the first meetings should potentially be performed differently, so what could be changed to have the students engaged in discussions? Rather than taking a passive role as supervisor, the supervisor should set a good example (Rosen et al., 2007) teaching the students how to ask open-ended questions starting discussions. Examples:

- What was the key takeaway from presentations (from the listeners' point of view)?
- Do peers have any questions regarding the project itself?

Asking the other students about the key takeaway will show if the presenter had the right (expected) focus in the presentation and showcase any potential misunderstandings. Thus, this could allow for learning in presentations and start the discussions on multiple levels from overall project objective to fundamental scientific understanding of results or methodologies.

Conclusions and reflections

To overcome the individual PBL work and feeling of being alone, a learning community (*LC*) among six master's thesis students of a single supervisor (the author) was introduced. LC was organized to introduce a group-feeling to enhance the daily scientific discussions and assistance among the students. LC was found to provide a safe space for discussions; however, an initial barrier exists as a mixture of psychological insecurity and insufficient knowledge of each other's projects. Overcoming this barrier leads to discussions and reflections among the students both at LCs and in their daily activities shown by enhanced engagement at LC meetings. The students find LC a great supplement to traditional supervisor meetings, however, in the future LC should substitute either supervisor meetings or ad-hoc supervision to not extend the supervision time. Interestingly, the students use LCs in two different ways depending on whether they work individually or as a pair. Individually working students found a group feeling and room for discussion, while the students working in pairs greatly benefited from continuous reflections on their

progress. Thus, the knowledge of each other's projects allowed for daily assistance and discussions.

Considering the four terms used to describe learning communities (West & Williams, 2017), LCs have provided access to a joint room for students sharing a function and it built a relationship between the students. The students all agree that the LCs provided the feeling of being part of a group. The students have illuminated the similarities in their projects resulting in safe discussions on the projects daily outside the LC. Generally, the students have worked more closely with others than in previous projects for at least two reasons: 1) the LCs provided the opportunity to become familiar with each other's projects, and 2) the students required discussions with others for feedback.

Further improvements to the established LC can include thematic meetings for students to focus on *data visualization* or the *oral presentation* with an emphasis on use of body language, slides, or showcasing physical samples. A couple of focus areas as supervisor could be:

- *How to enhance learning from the student presentations?* The students should teach peers about their project rather than only expecting assistance. This leads to a mutual process towards higher goals following Etienne Wenger's thoughts on alignment (Wenger, 2000).
- *How to teach the students to think academically in their questions?* The students should be taught how to reflect on their own knowledge and set that in play for curious and critical questions.

This pedagogical intervention aimed at inspiring a new PBL practice for individually working students to create a learning community for discussions rather than forming teams for same project. It is expected that the establishment of learning communities can be extended not only to other technical and natural science educations, but also to social science and humanities studies.

References

Blanchard, A. L., Welbourne, J. L., & Boughton, M. D. (2011). A model of online trust. *Information, Communication & Society*, *14*(1), 76–106. https://doi.org/10.1080/13691181003739633

Campbell, J., Shaul, K., Slagle, K. M., & Sovic, D. (2024). Sustainable community development through peer-to-peer learning in the online and in-person classroom. *International Journal of Sustainability in Higher Education*, *25*(8), 1803–1819. https://doi.org/10.1108/IJSHE-07-2023-0321

de Graaff, E., & Kolmos, A. (2003). Characteristics of Problem-Based Learning. *International Journal of Engineering Education*, *19*(5), 657–662.

Delamont, S., & Atkinson, P. (2001). Doctoring Uncertainty: Mastering Craft Knowledge. *Social Studies of Science*, *31*(1), 87–107. https://doi.org/10.1177/030631201031001005

Goglio, K., Crespin-Mazet, F., Simon, L., Cohendet, P., & Wenger-Trayner, E. (2023). Managing with communities for innovation, agility, and resilience. *European Management Journal*, *41*(4), 534–539. https://doi.org/10.1016/j.emj.2023.07.005

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Rosen, B., Furst, S., & Blackburn, R. (2007). Overcoming Barriers to Knowledge Sharing in Virtual Teams. *Organizational Dynamics*, *36*(3), 259–273. https://doi.org/10.1016/j.orgdyn.2007.04.007

Rovai, A. P., Wighting, M. J., & Lucking, R. (2004). The Classroom and School Community Inventory: Development, refinement, and validation of a self-report measure for educational research. *The Internet and Higher Education*, *7*(4), 263–280. https://doi.org/10.1016/j.iheduc.2004.09.001

Servant-Miklos, V. (2020). Problem-oriented Project Work and Problem-based Learning. *Interdisciplinary Journal of Problem-Based Learning*, *14*(1). https://doi.org/10.14434/ijpbl.v14i1.28596

Shimizu, I., Matsuyama, Y., Duvivier, R., & van der Vleuten, C. (2021). Contextual attributes to promote positive social interdependence in problem-based learning: a focus group study. *BMC Medical Education*, *21*(1), 222. https://doi.org/10.1186/s12909-021-02667-y

Stentoft, D. (2019). Problem-based projects in medical education: extending PBL practices and broadening learning perspectives. *Advances in Health Sciences Education*, *24*(5), 959–969. https://doi.org/10.1007/s10459-019-09917-1

Vincent, M. A. (2009). The Value of Research Group Meetings. *Biological Research For Nursing*, *11*(2), 117–118. https://doi.org/10.1177/1099800409337525

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press. https://doi.org/10.1017/CBO9780511803932

Wenger, E. (2000). Communities of Practice and Social Learning Systems. *Organization*, *7*(2), 225–246. https://doi.org/10.1177/135050840072002

West, R. E., & Williams, G. S. (2017). "I don't think that word means what you think it means": A proposed framework for defining learning communities. *Educational Technology Research and Development*, *65*(6), 1569–1582. https://doi.org/10.1007/s11423-017-9535-0

Wichmann-Hansen, G., Wirenfeldt Jensen, T., & Skytte O'Toole, M. (2020). "Den varme stol". En model for peer-feedback i kollektiv vejledning. *Dansk Universitetspædagogisk Tidsskrift*, *15*(28), 71–85. https://doi.org/10.7146/dut.v15i28.115661

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 266-280
doi.org/10.54337/ojs.jpblhe.v14i1.10566

Integrating the Curriculum for Respiratory Scientists

Evaluating the Impact of Online Problem-Based Learning Integrating Pulmonary Pathophysiology with Pulmonary Function Testing Interpretation

Alison White * | Griffith University, Australia

Abstract

An online, asynchronous, self-paced problem-based learning (PBL) workbook was introduced into the curriculum for postgraduate Respiratory Science students to complement lecture-based teaching. The PBL activity was horizontally integrated, drawing on concepts from multiple subjects, and aimed to develop critical thinking, understanding of pulmonary pathophysiology, and confidence in interpreting pulmonary function tests (PFTs). These skills are increasingly required by Respiratory Scientists due to a rising prevalence in global lung disease. Delivered after didactic teaching, the workbook engaged students in complex clinical scenarios. Post-activity questionnaires indicated increased engagement, improved conceptual understanding, and greater confidence in PFT analysis. Students also reported feeling better prepared to manage unfamiliar clinical problems. These findings suggest that flexible, non-traditional learning approaches can effectively support diagnostic reasoning and problem-solving skill development and thus support clinical readiness. The

* Corresponding author:
Alison White, Email: alison.white@griffith.edu.au

Received 1 July 2025 | Accepted 22 June 2026 | Available online in Early View 18 August 2026 | Published 26 November 2026
© 2026 The Author. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

model of online learning described in this manuscript shows potential for broader application across allied health education to better prepare graduates for clinical practice.

Keywords: Respiratory Scientist; Pulmonary Function Technologist; Problem-Based Learning; Pulmonary pathophysiology; Pulmonary function testing

Introduction

Problem-Based Learning (PBL), grounded in constructivist theory, places students at the center of their education, promoting active learning through guided exploration of real-life problems (Beachey, 2007; Günter, 2018). This approach fosters critical thinking and encourages learners to build upon existing knowledge, progressing from foundational concepts to clinical application (Beachey, 2007; Boud, 1985). In health education, Case-Based Learning (CBL) is a practical extension of PBL, presenting students with authentic clinical scenarios linked to previously taught content (Günter, 2018; Dulloo & Pathare, 2013; Donkin, et al., 2023). Delivered in various formats, including small groups, online, or asynchronously, CBL challenges students to analyze cases, research concepts, synthesize knowledge and identify knowledge gaps with the aim of elucidating a solution to the clinical case (Sistermans, 2020). This approach prompts students to move beyond mere recall and lays the foundations for growth of academic performance and clinical competency as the knowledge built can be utilized to guide decision making in future clinical cases (Donkin, et al., 2023; Sistermans, 2020). This process of analysis and synthesis which CBL provides, enhances critical thinking and clinical decision-making skills (Sistermans, 2020).

CBL has proven effective in teaching pathophysiology in medicine and nursing; improving student autonomy and integration of theory with practice (Brown, et al., 2012; Grønlien et al., 2021; Zhang et al., 2018; Peng & Wei, 2021). In addition, CBL can cover multiple different subject areas which enables assimilation of concepts across curricula. The concept of an integrated curriculum can be defined as education which crosses subject matter boundaries and academic time periods where concepts from separate subjects are combined over time in the curriculum with the aim to create meaningful associations (Brauer & Ferguson, 2015). The benefits of an integrated curriculum for students is that it supports students to demonstrate how knowledge from various subjects are related to each other beyond memorization of facts (Winarno, et al., 2020).

Respiratory Scientists (RS) are allied health professionals who conduct, interpret, and report Pulmonary Function Tests (PFTs) and in some instances provide therapy support. The role of an RS requires advanced critical thinking to operate equipment, follow protocols, adhere to evidence-based practice and interpret data accurately so as to optimize patient care (Barnes, et al., 2010; Doorely, et al., 2019; Zaccagnini et al., 2024). The educational level of Respiratory Scientists varies globally, ranging from Diploma to Master's level; with variations in role titles including Respiratory Therapists, Technicians, Technologists, Respiratory Physiologists and Clinical Scientists (Shakespeare, et al., 2019; Australian Council for Clinical Physiologists, 2020; Kollet, 2017; Danzy, et al., 2022; Sreedharan, et al., 2022). Respiratory Scientists differ from medical doctors as they do not undertake medical training and are thus unable to prescribe treatments. The COVID-19 pandemic intensified demand for RS, a trend expected to continue to rise due to increasing lung disease prevalence globally (Danzy, et al., 2022; Doorley et al., 2019).

The evolving clinical landscape for RS necessitates educational strategies which cultivate critical thinking and problem-solving skills. The use of PBL supports the development of critical thinking skills, yet evidence of the inclusion of PBL or CBL in the curriculum for RS remains scant in the literature (Ismaiel, Y., et al., 2014; Jones, T.D., et al., 2023). To address the gap in the use of PBL in the curriculum for a group of postgraduate RS in Australia, an asynchronous, self-paced CBL workbook was developed using the online software platform of PebblePad. The workbook was completed by students in their first semester of a two semester program, prior to undertaking clinical work integrated learning (clinical placement or clinical experience). Based on classroom content taught across multiple subjects, the workbook included clinical case histories, diagnostic PFT data, multimedia resources including both audio and image files, and guided questions. The content of the online CBL activity integrated concepts from pulmonary physiology, pulmonary pathophysiology and pulmonary function testing results data. On completion of the online CBL, students were provided with feedback on their answers from faculty members. Students were invited to reflect on their experiences with the CBL activity post-completion of the activity. This paper explores how integrated online CBL activities can extend learning beyond traditional methods of didactic classroom teaching, deepen understanding of respiratory diagnostics test interpretation, and enhance student confidence in approaching complex clinical scenarios.

Methods

Workbook design and rationale

The manner in which PBL is delivered can vary and be tailored to meet the needs of a specific cohort of students. In spite of potential variations, at the core of PBL are three key elements 1.stimulate, 2.consolidate and 3.extend; presenting content as a problem to stimulate learning, providing faculty or group feedback to consolidate learning and group or tutor discussions to extend learning (Ghani, et al., 2021). The online workbook design described in this manuscript is summarised in the table below, in order of how the content appears in the workbook. The progressive nature of the order in which the content was presented in the workbook was curated to reveal information in staged segments such as would occur in a real clinical encounter. The progressive disclosure encourages revision of content, metacognition and active engagement (Vuma, S., & Sa, B., 2015). Aligning with the key principles of PBL design, learning objectives and patient case history stimulate learning; diagnostic testing data and pathophysiology explanations consolidate learning; whilst reflection supports extension of learning. Tudor Car and colleagues in their 2019 systematic review compared online PBL to traditional learning and found that online PBL improved knowledge retention through a greater level of student engagement and interaction with the content in comparison to traditional learning methods (Tudor Car, et al., 2019). Online learning can be passive if open questions which challenge critical thinking are not incorporated. Featuring open PBL questions in online learning promotes critical thinking through the use of an enquiry based approach where students can take ownership of their learning through goal setting and reflection (Saqr, M., & Lopez-Pernas, S., 2023). The aim of the online workbook was to provide an asynchronous realistic patient scenario to support students to apply theoretical knowledge from multiple subjects to a genuine clinical problem in a stepwise manner to provide relevance and motivation for learning.

Workbook design description	Description of incorporation of PBL principles in the online workbook
List of learning objectives	Initiate learning by prompting student recall from content presented in previously delivered didactic lectures
Patient case history	To provide contextual background to support the practice of clinical reasoning
PFT data	Authentic case study results from a real-life patient are presented to introduce students to abnormal diagnostic test results
Guided questions on PFT data	The guided questions are designed to prompt students to critical analyse testing results in order to prompt diagnostic reasoning skills
Signs and Symptoms	Multimedia artefacts including auscultation, sputum images and X-ray images are presented in the workbook which enhances the realism of the case. Questions regarding the artefacts, clinical signs and symptoms are presented with the aim to encourage the development of the skill of differential diagnosis
Pathophysiology questions	Complex questions regarding the potential pathophysiology involved in the patient case were presented. This step in the workbook is crucial for promoting active and independent learning, rather than merely recalling or reciting facts. In this section of the workbook, students are required to integrate pathophysiology knowledge to explain the derangements to functional capacity as well as determine the cause of the presenting signs and symptoms (i.e. linkage of the pathophysiology to diagnostic data and clinical manifestations).
Reflection	Due to the asynchronous nature of the online workbook, the element of immediate tutor or group feedback was absent. To support this element of traditional PBL design, students were required to undertake a reflection with guided prompts subsequent to receiving feedback from tutors on their workbook answers. The reflection supports students to identify gaps in their knowledge and encourages students to extend their learning through independent research.

Table 1. Online workbook design principles and rationale.

Research design

This qualitative study was conducted over three separate academic years (2022, 2023, 2024) to three different cohorts of postgraduate Respiratory Science students enrolled in the Graduate Diploma of Clinical Physiology at Griffith University Australia. Participation in the research project was voluntary. All students enrolled in the postgraduate program had previously completed a three-year undergraduate level bachelor's degree in biomedical science or clinical science. Participants were asked to complete a survey on their experiences prompted by a Likert scale questionnaire as well as open-ended (free response) questions. The research described in this paper was approved by Griffith University's Research Ethics Committee (Griffith University ethics reference number: 2022/151).

A total of 30 students were enrolled in the program over the three year period that the research was conducted, and 16 students chose to complete the questionnaire. All survey questions were answered by all respondents, except for 1 survey question in which 1 participant did not answer the question of "The digital case based learning helped me to develop my problem solving skills for this module". The demographics of survey participants were: 70% birth sex female, 30% birth sex male, 100% were domestically enrolled, age ranged between 21 and 35 years of age.

Results

Cross-course integration (the integrated curriculum)

Student perceptions on the effectiveness of the online clinical CBL workbook were captured and are shown in Figure 1. Results of the 5-point Likert scale questions revealed that no student disagreed or strongly disagreed with any of the survey questions.

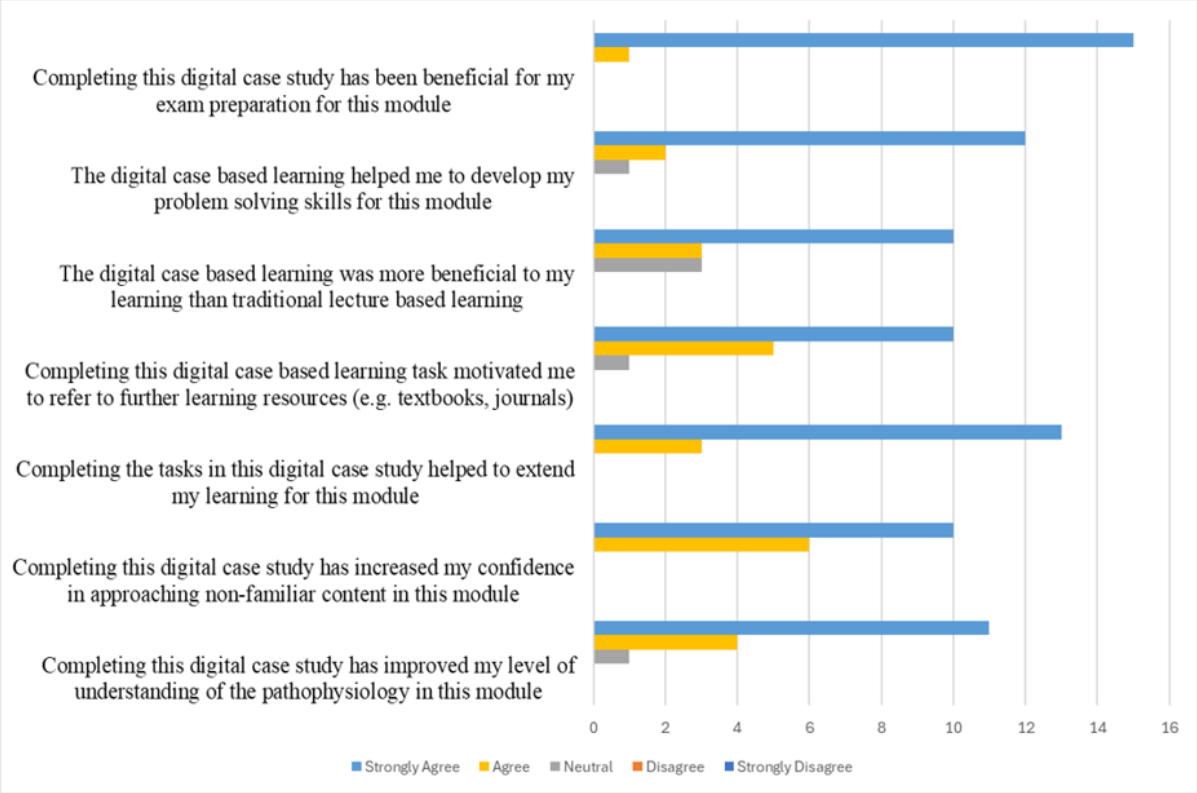


Figure 1. Student perceptions of the effectiveness of the asynchronous online integrated curriculum clinical CBL activities. Legend: Blue = Strongly Agree, Yellow = Agree, Grey = Neutral. There were no responses for Disagree or Strongly Disagree.

Students reported that their level of understanding of the pathophysiology content related to coursework increased after engaging with the online CBL, as 73% of students strongly agreed that their knowledge of respiratory pathophysiology improved due to completing the online CBL. Representative comments to the open, free response question of "What was the most beneficial aspect of completing the digital case study?" include:

> "I found linking the evaluation techniques and pathophysiology content very beneficial. it is a holistic approach to learning, not just reciting facts."

> "I got to implement what I've learnt from two courses and integrate my knowledge. I now see how everything comes together, and it does make me appreciate the details of lung function testing, and how important patient symptoms and trends over the years predict their prognosis."

> "The combination of x-rays, spirometry, symptoms and clinical manifestations and pathophysiology helps to link together all the foundational knowledge and skills gained during separate courses and pull them together to create a solution"

These results reflect that students value the integration of theoretical knowledge (e.g., pathophysiology) with practical evaluation techniques, as it promotes a more comprehensive and meaningful learning experience. Students appreciated the opportunity to synthesize knowledge from multiple subjects which helped them see connections between content module areas. This integration of the curriculum enhanced students' appreciation for the complexity and clinical significance of pulmonary function testing for patient outcomes. These positive results link to the key PBL elements of stimulating and extending learning.

Online PBL and confidence with content

Student RS in the Graduate Diploma of Clinical Physiology are expected to develop advanced and integrated knowledge of the theoretical, practical, professional and critical analysis skills required of a RS in the clinical diagnostic testing environment. Given the level of expectation required of these students in their professional role, supporting the development of the level of confidence was a driving factor in developing the online CBL activities. The online CBL workbook was effective in building levels of student confidence in approaching unknown content, with 62.5% of respondents strongly agreeing and 37.5% of respondents agreeing that their level of confidence with the content and their ability to manage unfamiliar content directly increased as a result of engaging with the online CBL workbook. The degree of impact on developing student confidence is also evidenced from answers to the free-response question:

> "Provided a very good starting point for exam revision and allowed me to gauge my confidence on certain topics as well as apply my knowledge to a simulated real world example of a patient with lung disease. It also encouraged me to go back through my notes to revise topics I had less confidence in."

> "Helps me have a well-rounded education and makes me more confident going into the workplace."

> "I am not confident in respiratory, particular interpreting data, and found that this learning experience has allowed me to improve and further understand respiratory conditions and their associated pathology."

The online case-based learning (CBL) workbook enhanced student confidence in managing unfamiliar clinical content by fostering integrated knowledge and practical application. This approach effectively supported the professional readiness of students, aligning with the advanced expectations of their future roles.

Online CBL vs. lecture based CBL

Over half of the survey respondents (65.5%) strongly agreed that the online CBL was more beneficial to their learning than traditional lecture-based learning. Student comments on the benefit of the online CBL versus traditional in-class learning showed consistency in the themes of that the online activity was more effective in providing a vehicle for them to step through the content at their own pace and allowed them to focus on concepts more thoroughly then the traditional in-class learning permitted them to.

When responding to the open question of "What was the least beneficial aspect of completing the digital case study?" students were overwhelming positive about their experiences and commented that *"nothing was unbeneficial"* and *"There was nothing that wasn't beneficial to me."* The only criticism of the online PBL was reflected in a single students' comment of they did not like the "*inability to immediately check some answers*." A limitation of the model of how the CBL was delivered in the current research project was students were unable to receive immediate feedback on their answers because the CBL was offered online asynchronously to the content delivery. However, there was minimal time for students to wait for feedback as written feedback on students answers was provided within 48 hours of students completing the online CBL workbook. The concern of the inability to receive immediate feedback could be addressed in future offerings of the workbook by having a deadline for submission of the workbook with a subsequent online discussion forum to review answers.

Discussion: Reflections and recommendations

Graduate RS must possess the ability to problem solve in the clinical workplace (Barnes, et al., 2010; Doorely, et al., 2019, Jones, et al., 2023). Possessing high levels of problem solving skills in clinical practice is a key factor in the adaptability of healthcare professionals (van der Merwe, et al., 2023). The ability to approach and solve unfamiliar problems (problem solving ability) can be enhanced in student healthcare professionals through the use of CBL in integrating multiple subject areas (Ummat & Kochhar, 2021; Vedi, 2021; Gasim, et al., 2024). The link between utilizing CBL to elevate learning skills in clinical practice was demonstrated in a study of undergraduate medical students by Tiwale and colleagues (2019) who found that 76% of research participants strongly agreed that by participating in CBL, they felt that their ability to apply knowledge in their clinical practice will improve. Although the education and curriculum of RS varies from medical students, similar results were captured in the current study with 85% of participants strongly agreeing that CBL improved

their problem solving ability and 62.5% strongly agreeing that their ability to approach and adapt to unfamiliar content improved as a result of engaging with CBL. The current study has demonstrated that the incorporation of CBL for student RS allows students to recognize the importance of pathophysiology concepts, how they drive changes in pulmonary function, which in-turn, expands clinical reasoning capability and correct diagnosis of pulmonary function testing results.

Brown and colleagues (2012) reported that health sciences students preferred CBL to didactic lectures and that CBL promoted a greater ability to identify concepts and integrate basic science knowledge. Studies of nursing students have reported that when traditional didactic teaching of bioscience concepts (including anatomy, physiology and interpretation of physiological data) are combined with digital learning opportunities, knowledge acquisition and integration are enhanced (Grønlien, et al., 2021). The current study aligns with the findings of multiple studies that by utilizing online CBL, student RS can expand and integrate their knowledge of pulmonary pathophysiology with PFT analysis and interpretation (Kollef, 2017; Dulloo & Pathare, 2013; Brown, et al., 2012; Grønlien, et al., 2021). The outcome of the current study is that students felt that their knowledge of respiratory pathophysiology and their ability to interpret PFT results with reference to derangements in lung function increased as a result of the online CBL.

Kollef and colleagues (2017) in their study of RS in Missouri, USA reported the need for RS to have an in-depth knowledge of pulmonary pathophysiology and PFT due to the crucial role that RS play in the care and management of patients with respiratory diseases. The American Thoracic Society (ATS)/European Respiratory Society (ERS) in their 2022 Technical Standards on Interpretive Strategies for Routine Lung Function Tests, emphasize that for appropriate functional classification of impairments to lung function to occur, knowledge of disease processes needs to be considered and integrated when classifying test results (Stanojevic, et al., 2022). The consolidation and integration of pulmonary pathophysiology knowledge with PFT interpretation can be achieved through the use of CBL. The results of the current study clearly demonstrate the benefits of an integrated curriculum CBL.

Lastly, the confidence of student RS to face uncertainties in clinical practice can be supported by exposing students to real-life situations through the application of online CBL. Student RS in the current study who participated in online CBL reported a clear increase in their confidence and this finding is consistent with the literature. Traditional learning methods of didactic lectures or even classroom PBL can result in students learning more passively and not exerting initiative to drive their learning (Liu, et al., 2024). Lecture based

teaching can result in an inefficient transfer of knowledge and provides minimal opportunities to apply knowledge which is disparate from the professional needs of health professionals in the clinical workplace (Liu, et al., 2024). Online learning through CBL enables students to progress at their own speed and plan their studies to achieve optimal outcomes (Donkin, et al., 2023; Grønlien, et al., 2021; Wang, et al., 2022). Students who engage with online CBL can undergo a change in mindset from needing to be prompted to learn to wanting to learn in order to obtain solutions to problems (Wang, et al., 2022). This shift in mindset increases student confidence (Wang, et al., 2022).

Limitations

The author acknowledges the limitations of the current study. Firstly, all students (30) enrolled in the program completed the online workbook, however, just over half of the students choose to participate in the research project survey. This could be contributed to survey fatigue as the students undertook several university wide surveys at the same time as the research survey was deployed. It should be noted that those students who chose not to respond to the survey still demonstrated improvements in learning through the accuracy of their answers in the workbook and their positive comments and engagement with tutor feedback.

The small sample size could restrict the findings of this study being applied on a larger scale or generalizing the findings; however, the results of this project are encouraging and affirm the benefits of integrating concepts across the curriculum in the format of an online CBL for the professional development of allied health professionals.

Conclusion

This study highlights the role of an integrated curriculum approach to Case-Based Learning (CBL) in enhancing the clinical problem-solving abilities, knowledge integration, and confidence of student respiratory scientists (RS). CBL fosters adaptability by encouraging students to apply theoretical knowledge to real-life clinical scenarios, particularly in interpreting pulmonary function tests (PFTs) and understanding the underlying respiratory pathophysiology which results in the PFT results. The findings align with existing literature, demonstrating that CBL not only improves knowledge acquisition but also promotes active learning and a shift in student mindset toward self-directed learning. Online CBL, in particular, offers flexibility and supports deeper engagement with complex clinical content. Despite the limitation of a small sample size, the results affirm the value of integrating CBL

into health science curricula to better prepare students for the demands of clinical practice.

References

Australian Council for Clinical Physiologists. (2020). Home. https://theaccp.org.au/

Barnes, T. A., Gale, D. D., Kacmarek, R. M., & Kageler, W. V. (2010). Competencies needed by graduate respiratory therapists in 2015 and beyond. *Respiratory Care, 55*(5), 601–616. https://doi.org/10.4187/respcare.10550601

Beachey, W. D. (2007). A comparison of problem-based learning and traditional curricula in baccalaureate respiratory therapy education. *Respiratory Care, 52*(11), 1497–1506. https://doi.org/10.4187/respcare.07521497

Boud, D. J., & Higher Education Research and Development Society of Australasia. (1985). Problem-based learning in education for the professions. Sydney: HERDSA.

Brauer, D. G., & Ferguson, K. J. (2015). The integrated curriculum in medical education: AMEE Guide No. 96. *Medical Teacher, 37*(4), 312–322. https://doi.org/10.3109/0142159X.2014.970998

Brown, K., Commandant, M., Kartolo, A., Rowed, C., Stanek, A., Sultan, H., Kabir, T., & Wininger, V. (2012). Case based learning teaching methodology in undergraduate health sciences. *Revue interdisciplinaire des sciences de la santé | Interdisciplinary Journal of Health Sciences, 2*(2), 48-66. https://doi.org/10.18192/riss-ijhs.v2i2.1521

Cooper, B. G., Troosters, T., Burge, G., Field, D., Hrafnkelsdottir, S. S., Pitta, F., Lloyd, J. K., & Steenbuggen, I. (2010). Allied respiratory professionals. *The European Respiratory Journal, 36*(4), 701–703. https://doi.org/10.1183/09031936.00127110

Danzy, J. N., Gilmore, T. W., Smith, S. G., Endee, L. M., & Wissing, D. R. (2022). A pre-pandemic evaluation of the state of staffing and future of the respiratory care profession: Perceptions of Louisiana respiratory therapists. *Respiratory Care, 67*(10), 1254–1263. https://doi.org/10.4187/respcare.09894

Donkin, R., Yule, H., & Fyfe, T. (2023). Online case-based learning in medical education: A scoping review. *BMC Medical Education, 23*(1). https://doi.org/10.1186/s12909-023-04520-w

Doorely, P. A., Goodfellow, L. T., Goss, J., Napolitano, N., & Wiles, K. S. (2019). Entry requirements to respiratory therapy practice: 2030 and thereafter. Issue Paper. https://www.aarc.org/wp-

content/uploads/2019/09/statement-entry-requirements-to-respiratory-therapy-practice-2030-and-therafter.pdf

Dulloo, P., & Pathare, N. A. (2013). Case based methodology: A method to enhance the learning of physiological basis of cardiovascular and respiratory system to undergraduate medical students. *American Journal of Educational Research, 1*(10), 425–429. https://doi.org/10.12691/education-1-10-3

Gasim, M. S., Ibrahim, M. H., Abushama, W. A., Hamed, I. M., & Ali, I. A. (2024). Medical students' perceptions towards implementing case-based learning in the clinical teaching and clerkship training. *BMC Medical Education, 24*(1), 200. https://doi.org/10.1186/s12909-024-05183-x

Grønlien, H. K., Christoffersen, T. E., Ringstad, Ø., Andreassen, M., & Lugo, R. G. (2021). A blended learning teaching strategy strengthens the nursing students' performance and self-reported learning outcome achievement in an anatomy, physiology and biochemistry course: A quasi-experimental study. *Nurse Education in Practice, 52*, 103046. https://doi.org/10.1016/j.nepr.2021.103046

Günter, T. (2018). Effectiveness of a problem-based learning (PBL) scenario for enhancing academic achievement of energy metabolism. *Research in Science Education, 50*(5), 1713–1737. https://doi.org/10.1007/s11165-018-9750-7

Ismaiel, Y., Agha, S., Restrepo, R., & Al-Oraibi, S. (2014). The Effect of Teaching Methods on Changes of Respiratory Therapy Students' Critical Thinking. *World Journal of Medical Sciences*, *11*(2), 166-170.

Jones, T. D., Willis, L. D., Spray, B. J., & Berlinski, A. (2023). Curriculum and competency evaluation in respiratory therapy entry-to-practice programs. *Respiratory Care*, *68*(10), 1356-1364. https://doi.org/10.4187/respcare.10996

Kollef, M. H. (2017). Evaluating the value of the respiratory therapist: Where is the evidence? Focus on the Barnes-Jewish Hospital experience. *Respiratory Care, 62*(12), 1602–1610. https://doi.org/10.4187/respcare.05807

Liu, K., Liu, S., Ma, Y., Jiang, J., Liu, Z., & Wan, Y. (2024). Comparison of blended learning and traditional lecture method on learning outcomes in the evidence-based medicine course: A comparative study. *BMC Medical Education, 24*(1). https://doi.org/10.1186/s12909-024-05659-w

Peng, X., & Wei, L. (2021). Exploration of online and offline hybrid teaching of pathophysiology. *Open Journal of Social Sciences, 9*, 433–438. https://doi.org/10.4236/jss.2021.99031

Saqr, M., & López-Pernas, S. (2023). The temporal dynamics of online problem-based learning: Why and when sequence matters: M. Saqr, S. López-Pernas. *International Journal of Computer-Supported Collaborative Learning*, *18*(1), 11-37. https://doi.org/10.1007/s11412-023-09385-1

Shakespeare, J., Parkes, E., Bryce, M., & Hull, J. H. (2019). Advanced roles in respiratory healthcare science: It's not just spirometry. *Breathe, 15*(4), 267–269. https://doi.org/10.1183/20734735.0310-2019

Sistermans, I. J. (2020). Integrating competency-based education with a case-based or problem based learning approach in online health sciences. *Asia Pacific Education Review, 21*, 683–696. https://doi.org/10.1007/s12564-020-09658-6

Sreedharan, J. K., Rao, U. K., Al Ahmari, M., Kotian, S. M., & Mokshanatha, P. B. (2022). Validation of a structured questionnaire to assess the perception and satisfaction of respiratory therapy students toward career prospects and learning resources. *Canadian Journal of Respiratory Therapy, 58*, 162–168. https://doi.org/10.29390/cjrt-2022-032

Stanojevic, S., Kaminsky, D. A., Miller, M. R., Thompson, B., Aliverti, A., Barjaktarevic, I., ... & Swenson, E. R. (2022). ERS/ATS technical standard on interpretive strategies for routine lung function tests. *European Respiratory Journal, 60*(1). https://doi.org/10.1183/13993003.01499-2021

Tiwale, S. M., Patil, V. S., Desai, P. R., & Kumbhar, A. N. (2019). Effectiveness of case based learning in first MBBS students in physiology: An educational strategy to promote clinical diagnostic reasoning. *International Journal of Health Sciences Research, 9*(9), 1–8.

Tudor Car, L., Kyaw, B. M., Dunleavy, G., Smart, N. A., Semwal, M., Rotgans, J. I., ... & Campbell, J. (2019). Digital problem-based learning in health professions: systematic review and meta-analysis by the digital health education collaboration. *Journal of medical Internet research*, *21*(2), e12945. https://doi.org/10.2196/12945

Ummat, A., & Kochhar, S. (2021). An approach towards integrated teaching: Case-based learning (CBL) in physiology. *Journal of Punjab Academy of Forensic Medicine & Toxicology, 21*(1), 179-186. https://doi.org/10.5958/0974-083X.2021.00034.0

van der Merwe, A., Barnes, R., & Nel, M. (2023). Becoming comfortable with the uncomfortable: The tale of adaptability. *South African Journal of Physiotherapy, 79*(1). https://doi.org/10.4102/sajp.v79i1.1889

Vedi, N., & Dulloo, P. (2021). Students' perception and learning on case based teaching in anatomy and physiology: An e-learning approach. *Journal of Advances in Medical Education & Professionalism, 9*(1), 8–17. https://doi.org/10.30476/jamp.2020.87332.1304

Vuma, S., & Sa, B. (2015). Evaluation of the effectiveness of progressive disclosure questions as an assessment tool for knowledge and skills in a problem based learning setting among third year medical students at The University of The West Indies, Trinidad and Tobago. *BMC research notes*, *8*(1), 673. https://doi.org/10.1186/s13104-015-1603-0

Wang, D., Zhou, J., Wu, Q., Sheng, G., Li, X., Lu, H., & Tian, J. (2021). Enhancement of medical students' performance and motivation in

pathophysiology courses: Shifting from traditional instruction to blended learning. *Frontiers in Public Health, 9*, 813577. https://doi.org/10.3389/fpubh.2021.813577

Winarno, N., Rusdiana, D., R., Susilowati, E., et al. (2020). Implementation of integrated science curriculum: A critical review of the literature. *Journal for the Education of Gifted Young Scientists, 8*(2), 795–817. https://doi.org/10.17478/jegys.675722

Zaccagnini, M., West, A., Khor, E., Quach, S., & Nonoyama, M. L. (2024). Exploring knowledgegaps and research needs in respiratory therapy: A qualitative description study. *Canadian Journal of Respiratory Therapy, 60*, 1–12. https://doi.org/10.29390/001c.91184

Zhang, Y., Zhang, H., Li, Y., & Peng, X. (2018). CBL significance in pathophysiology teaching. *Health, 10*(12), 1673–1678. https://doi.org/10.4236/health.2018.1012126

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 281-297
doi.org/10.54337/ojs.jpblhe.v14i1.11403

Experiences of the Introduction of Project-Based Learning at Széchenyi István University

Eszter Sós * | Széchenyi István University, Hungary
Katalin Deé-Kovácz | Széchenyi István University, Hungary
Szabolcs Kiss | Széchenyi István University, Hungary
Zsolt Kovács | Széchenyi István University, Hungary
Éva Happ | Széchenyi István University, Hungary

Abstract

The aim of this study is to present the experiences and outcomes of introducing project-based learning (PBL) in higher education, with a particular focus on preparing students for the labor market. PBL was introduced on a pilot basis in the fall semester of the 2024/2025 academic year in 12 undergraduate programs at Széchenyi István University. The research employed both qualitative (interviews, "Lessons Learned" workshop) and quantitative (362-student questionnaire) methods. According to the results, PBL effectively develops skills relevant to the labor market by engaging students in tasks based on real-world problems. Instructors highlighted the benefits of active, student-centered learning, while the redesign of courses and the selection of appropriate projects emerged as challenges. Students reported positive experiences, particularly in teamwork, problem-solving, and the application of practical knowledge. The research highlights that successful PBL integration requires thorough planning,

* Corresponding author:
Eszter Sós: sos.eszter@ga.sze.hu
Received 26 February 2026 | Accepted 27 April 2026 | Available online in Early View 26 May 2026 | Published 26 November 2026
© 2026 The Authors. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

ongoing faculty support, and institutional backing.

Keywords: Project-based learning; higher education; innovation; soft skills

Introduction

Project-based learning, as one of the most essential types of practice-based training, is increasingly important at all levels of education (Guo et al., 2020). Today, there is both a demand and an expectation for introducing this type of course, especially from employers, to enable workers with the right competencies to integrate more quickly into the corporate sphere and to create value effectively (Frank et al., 2003).

This method also helps link the labour market and higher education, as companies can provide universities and university courses with the tasks and project ideas to be developed, which benefits both parties (Bell, 2010).

The strategic goal of Széchenyi István University is to innovate education, including the widespread introduction of project-based learning. The reason for the planned development of training is the lack of socialisation, but it would also be essential to implement competence assessment during training. In addition, the new strategic objectives also place great emphasis on strengthening soft skills to help students find their place in the labour market.

The Student Project Support Programme aimed to pave the way for the introduction of project-based education by:

- Established the Student Project Support Programme as an organisational unit.
- Provided the appropriate methodologies for all stakeholders, in collaboration with the Directorate General for Methodology, Digital and Teacher Training.
- Launched the first project-based training courses on a pilot basis.

The project was launched on May 1, 2024, as part of the University's training and development activities. Its principal activities, in line with its objectives, are the creation of the Student Project Support Programme, the provision of methodologies, the launch of the pilot training courses, and project management and communication.

As a methodological and organisational unit, the Student Project Support Programme registers and coordinates student projects, which focus on two areas: university and company projects linked to subjects and training courses. In the first semester of university courses, students are introduced to the basics

of project management, and they mainly work on university problems and plan institutional developments. In the second semester, they deal with issues and developments in local (or national) companies.

Literature review

Project-based learning (PBL) (Kövecsesné Gősi, 2023) involves students working on complex, open-ended, often interdisciplinary problems that require research, analysis, creativity, and collaboration. It focuses on authentic, real-world projects, helping students apply theoretical knowledge in practical contexts and develop a deeper understanding of the subject (Doppelt, 2003)

A key advantage of PBL is that it strengthens critical and analytical thinking, as students must evaluate multiple perspectives and develop well-reasoned solutions (Kovecses-Gosi, 2019). It also enhances problem-solving skills and encourages active, hands-on learning. In addition, presenting project outcomes to real audiences improves communication and public speaking skills, while feedback supports reflection and continuous improvement (Marnewick, 2023). This helps them develop analytical and critical thinking skills that they can apply in other situations in the future (Bell, 2010).

An international perspective on project-based learning is presented in Table 1.

Institution	**Description**
Polytechnic Institute of Cávado and Ave (2025)	The FASA combines hard skills, project work, and soft skills; ends with a 2-week company project.
Phil Cocchiola (2020); Zeppelin University (2011)	Student Project Offices mainly support student initiatives and activities.
(Guo et al., 2020)	Provides support for planning and writing project proposals.
NHL Stenden University of Applied Sciences (2025)	Design-based education focused on "learning by doing."
Väänänen et al. (2023)	Interdisciplinary, industry-linked projects (1–16 weeks), also supporting pedagogy.
España & Soosaar (2022)	Annual project competition with funded student ideas.
Hartescu (2020); Lancaster University (2025)	~200 real business projects/year with strong industry collaboration and support structures.
University of Edinburgh (2025)	Team-based business projects (10 weeks) with company involvement and a structured timeline.

Table 1. International experience of project-based learning (Source: own compilation).

There are no known methodological centres of this kind in Hungarian universities. However, student projects are being launched elsewhere (e.g. Debrecen - Student Innovation Idea Development Programme or the Project Conference on Project-Based Learning at Óbuda University).

Materials and methods

Research design

This study applies a mixed-method case study approach to explore the introduction and early implementation of project-based learning (PBL) at Széchenyi István University. The case study design was chosen to provide an in-depth understanding of a real institutional intervention within its authentic context, while the mixed-method approach enables the triangulation of qualitative and quantitative data.

RQ1: How is project-based learning implemented in a higher education institutional context?

RQ2: What are the perceived outcomes of this implementation from student and instructor perspectives?

RQ3: What lessons can be drawn from the pilot phase to support large-scale institutional adoption?

Research context

Figure 1 illustrates the stages involved in implementing project-based education. For the course to be implemented in the autumn semester, instructors will receive training materials: theoretical materials, practical examples, and tests. The knowledge material of the Project Management course supported the theoretical part.

The study was conducted during the pilot phase of PBL implementation in the 2024/2025 academic year across 12 undergraduate programmes. During the study, courses were deliberately selected from various faculties and fields of study at the university, ensuring that the participating students represented a wide range of majors and disciplines.

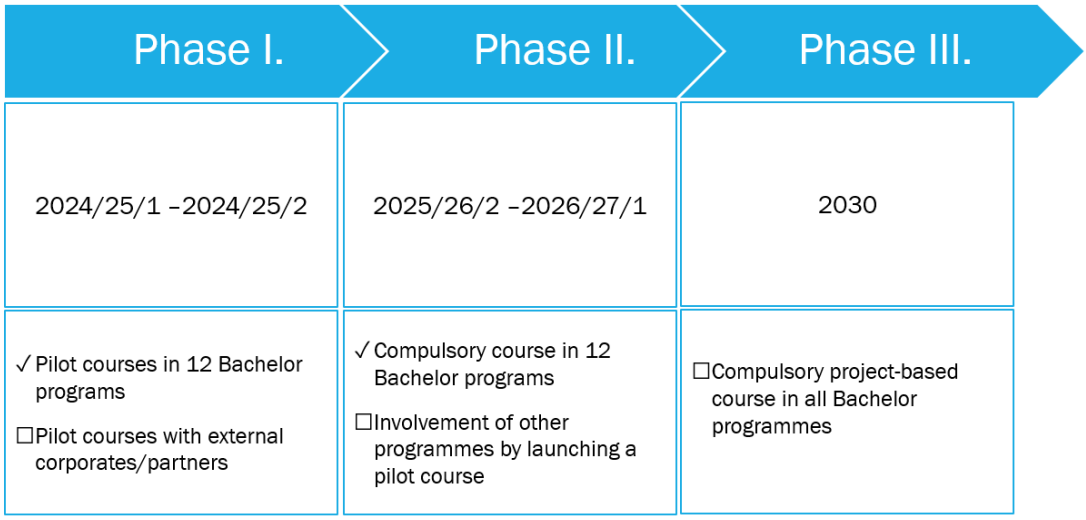


Figure 1. Stages of implementing project-based learning. (Source: own compilation).

The quantitative component is based on a questionnaire completed by 362 students, representing approximately 70% of those participating in the pilot courses. Data were collected in two consecutive semesters (199 students in the first semester and 163 in the second).
The qualitative component includes:

- in-depth interviews with instructors involved in the pilot courses, and
- a Lessons Learned workshop, where instructors reflected collectively on their experiences.

Data collection

A structured questionnaire using a five-point Likert scale (1 = absolutely not, 5 = absolutely) was administered to students at the end of each semester. The questionnaire focused on:

- perceived contribution of PBL to learning,
- development of practical skills,
- teamwork and collaboration,
- and open-ended questions on experiences and suggestions.

Qualitative data were collected through:

- semi-structured interviews conducted during the semester, focusing on instructional challenges and course redesign, and
- a Lessons Learned workshop, where instructors discussed their experiences, challenges, and best practices in a guided group setting.

In addition, students' open-ended responses in the questionnaire were included as qualitative data.

Data analysis

Quantitative data were analysed using descriptive statistical methods, including frequency distributions and percentage analysis, to identify patterns in student perceptions across the two semesters.
Qualitative data were analysed using a thematic content analysis approach. Responses from interviews, workshops, and open-ended questionnaire items were coded and grouped into thematic categories. The analysis focused on identifying:

- perceived benefits,
- challenges,
- and recommendations for improvement.

Validity and reliability

The study enhances validity through methodological triangulation, combining multiple data sources (student surveys, instructor interviews, and workshop discussions). The inclusion of both student and instructor perspectives provides a more comprehensive understanding of the phenomenon.

However, the findings should be interpreted with caution, as they are primarily based on self-reported perceptions rather than objective performance measures.

Conclusions of the Lessons Learned workshop experience and in-depth interview

The lessons learned from the workshop experiences and the results of in-depth interviews with teachers after the introduction of project-based learning are presented in three parts.

Positive experiences

Introducing project-based learning has brought many positive benefits for teachers and students. Opinions have been collected by category:

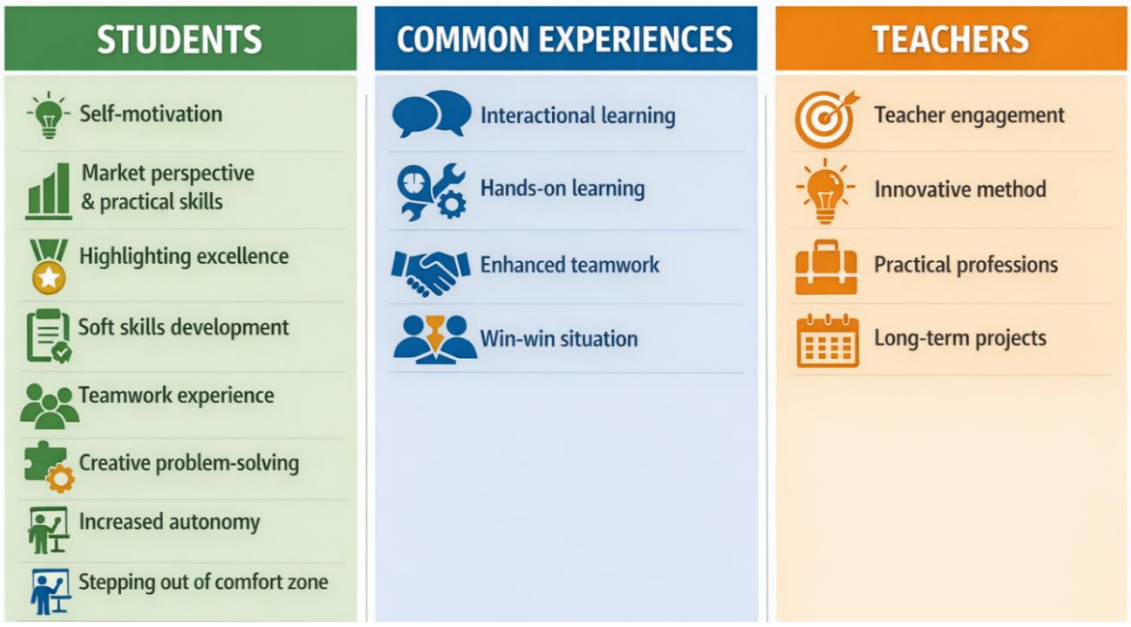


Figure 2. Categorising the positive aspects of project-based learning (Source: our compilation generated with ChatGPT).

These experiences confirm that project-based learning is more effective and inspiring for both students and teachers.

Perceived difficulties and shortcomings

The introduction of project-based learning at the university level has encountered several obstacles due to structural, organisational, and motivational problems. Main problems:

At the systemic level: insufficient infrastructure and system support, no standardized PBL-approach, high administrative burden, and weak communication.

Student perspective: challenges in team formation, lack of project management and software skills, fluctuating motivation, unclear expectations, "free-rider" issues.

Teacher perspective: difficulty estimating workload, time-consuming mentoring, motivational challenges, and scheduling issues.

Lack of projects: real projects require external partners, not feasible for all courses, company burden and limited resources.

Developing university infrastructure, supporting participants, and strengthening collaboration with external partners are key to successfully implementing project-based learning.

Development required for the introduction of PBL

Improvements are needed in several areas to make project-based learning more effective, including administrative simplification, support for students and trainers, and cooperation with enterprises. This section presents proposals for development in these areas.

Administration & systems: simplify administration, introduce S2D and Neptun integration, create a unified assessment and monitoring system, and establish a dedicated unit for corporate relations. The S2D system is a proprietary program used to register projects and their team members. Neptun is a student management system designed for educational administration.

Projects: provide clear guidelines, build project databases, expand partnerships (incl. international), and ensure real, company-based projects.

Teacher training: offer structured training (project management, methods), pedagogical support, and standardized tools/tests.

Students: support interest-based teams, address free-rider issues, and define clear expectations, reporting, and rewards.

Timetabling: ensure clear schedules, introduce flexible formats (e.g. project weeks), allow longer projects, and integrate PBL into courses.

Technology & infrastructure: provide tools, software training, and shared databases.

Strategy: strengthen interdisciplinary and university-wide collaboration and continuously update best practices.

Overall, it can be concluded that the teaching colleagues gained several experiences during the pilot period, which are briefly summarised in Figure 3.

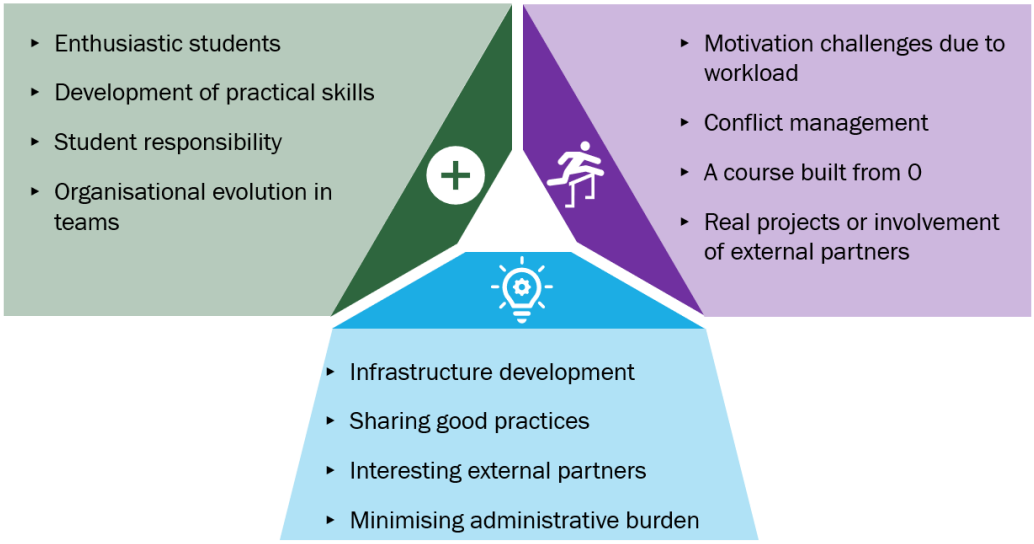


Figure 3. Feedback from teachers. (Source: own compilation).

Integrating the challenges and suggestions can help implement and run project-based learning more efficiently and smoothly in the long term, reducing the administrative burden and increasing participant engagement.

Analysis of student questionnaire

A total of 362 students from 12 courses completed a questionnaire on project-based learning, 199 in the first semester and 163 in the second semester. This percentage was approximately 70% of the students participating in the pilot program of project-based learning in both cases.

The questions asked how the students evaluated the project-based learning in the pilot semester. The results of the key questions are presented in Figures 4, 5, and 6. For each question, a range of 1-5 was available, where 1 meant "Absolutely not" and 5 meant "Absolutely".

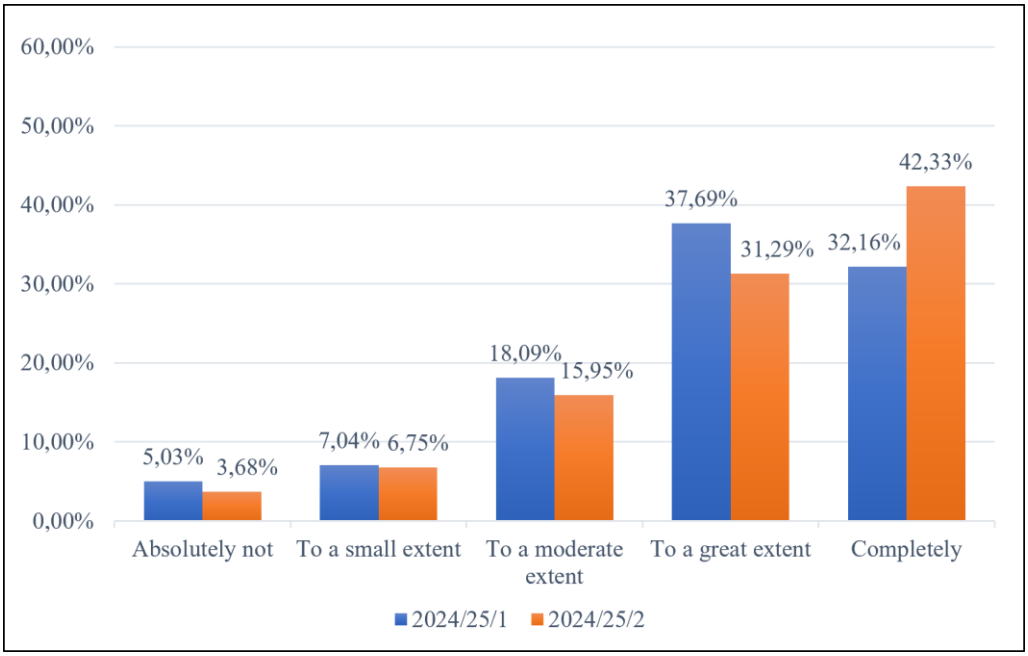


Figure 4. How supportive was the project for your learning process?
(Source: own compilation)

As shown in Figure 4, in the first semester (2024/25/1), 32.16% of students reported that the project completely supported their learning process, while 37.69% indicated that it contributed to a great extent. Altogether, 69.85% of respondents selected either 4 or 5 on the scale, suggesting that approximately two-thirds of the students perceived the project as making a substantial contribution to their learning.

In the second semester (2024/25/2), the distribution of responses shifted further in a positive direction. The proportion of students selecting "Completely" increased markedly to 42.33%, representing a rise of more than 10 percentage points compared to the first semester. Although the percentage of students choosing 4 decreased to 31.29%, the combined share of the two highest categories increased to 73.62%. At the same time, the proportion of low ratings (1–2) declined from 12.07% to 10.43%.

Overall, these results indicate a modest but clear improvement in students' perceptions of the project's effectiveness. The shift from "to a great extent" toward "completely" suggests not only sustained positive evaluation but also a strengthening of students' confidence in the project's contribution to their learning process.

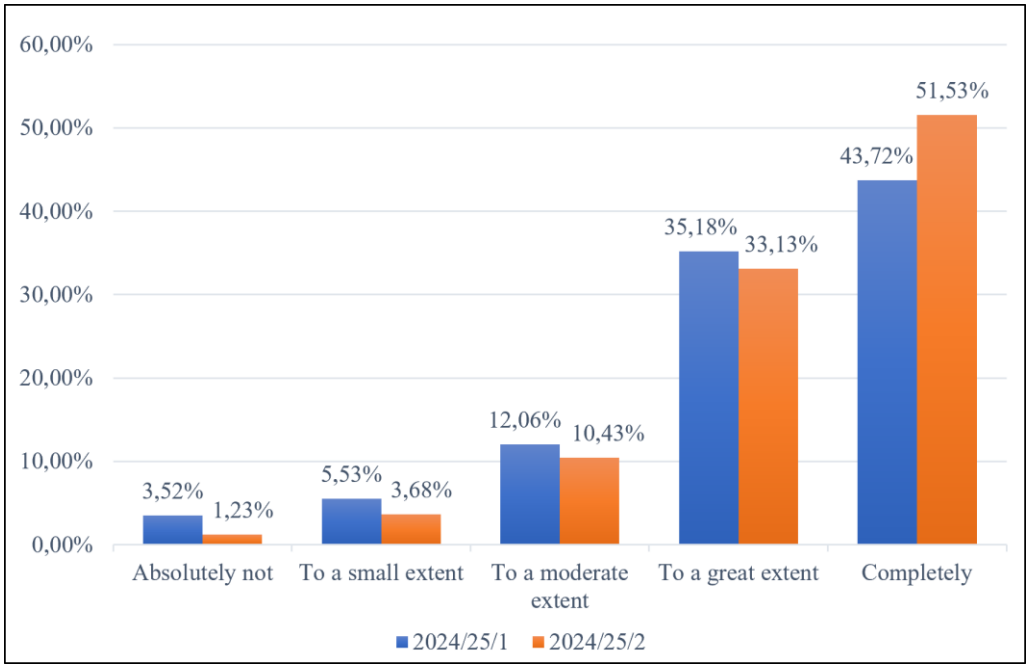


Figure 5. How supportive was the project in developing your practical skills? (Source: own compilation).

Figure 5 shows that in the first semester (2024/25/1), 43.72% of the students reported that the project completely supported the development of their practical skills, while a further 35.18% selected 4. Overall, 78.90% of respondents chose one of the two highest categories, indicating that more than three-quarters of the students perceived project-based learning as highly effective in developing their practical competencies.

In the second semester (2024/25/2), a further positive shift can be observed. The proportion of students selecting "Completely" increased to 51.53%, representing a rise of nearly 8 percentage points. Although the percentage of students choosing 4 decreased slightly to 33.13%, the combined share of the two highest categories increased to 84.66%. At the same time, the proportion of low ratings (1–2) declined from 9.05% to 4.91%, while moderate evaluations (3) also decreased slightly.

Overall, the results indicate a clear improvement in students' perceptions of the project's contribution to the development of practical skills. The substantial increase in the highest rating category suggests that students in the second semester experienced the project-based approach as even more effective in fostering practical competencies than those in the first semester.

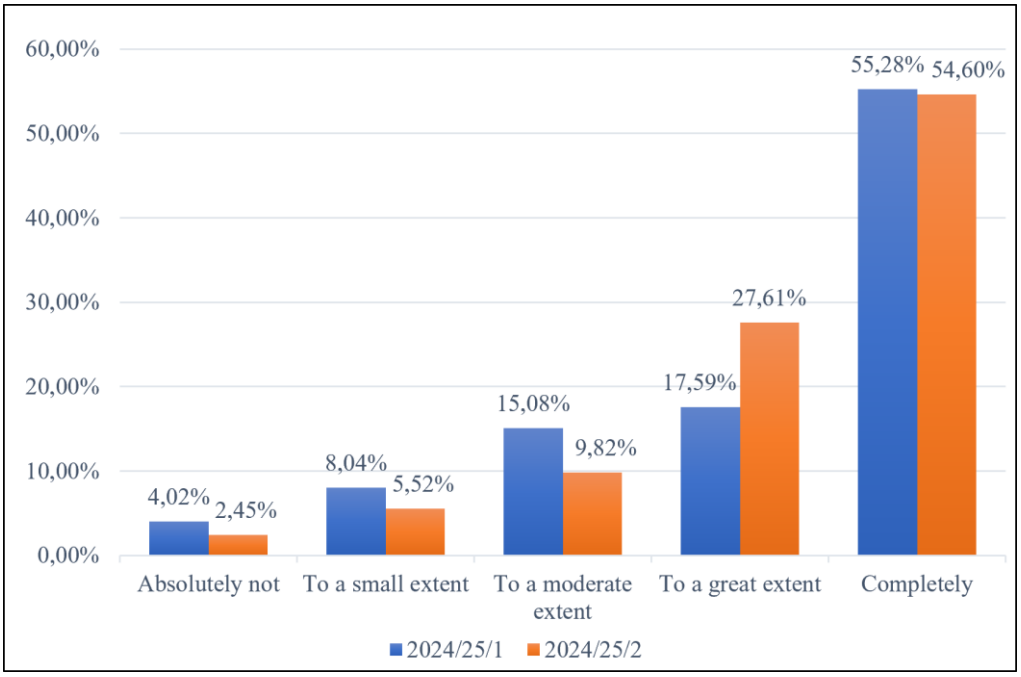


Figure 6. How satisfied were you with teamwork and cooperation between team members? (Source: own compilation).

As shown in Figure 6, in the first semester (2024/25/1), 55.28% of students reported being completely satisfied with group work and cooperation among group members, while a further 17.59% selected 4. In total, 72.87% of respondents chose one of the two highest categories, indicating that nearly three-quarters of the students expressed a high level of satisfaction with teamwork.

In the second semester (2024/25/2), the distribution of responses shows a slight shift. The proportion of students selecting "Completely" remained consistently high at 54.60%, representing only a marginal decrease compared to the first semester. However, the percentage of students choosing 4 increased markedly to 27.61%. As a result, the combined share of the two highest categories rose to 82.21%, reflecting an overall increase of more than 9 percentage points. At the same time, the proportion of moderate and low ratings (1–3) decreased substantially, suggesting a more uniformly positive perception of teamwork.

Overall, while the proportion of students expressing complete satisfaction remained stable at a high level, the increase in the 4-category and the decline in lower ratings indicate a general strengthening of students' positive attitudes toward group work and cooperation in the second semester.

Regarding the qualitative component, students in both semesters were asked to briefly describe the perceived similarities and differences between project-based learning and traditional face-to-face instruction, as well as to suggest

potential improvements to the project-based approach. The comparison of semesters allows for the examination not only of shifts in overall satisfaction but also of possible changes in students' reflective evaluations of the methodology.

The free-text responses are presented in tabular form and categorised. As a significant proportion of the responses were identical or very similar, the categories were structured by topic for the two questions, which are presented in Tables 2 and 3.

Briefly, in headings, describe the differences and similarities you have found between project-based learning and the traditional frontal teaching approach.	
1. Autonomy and time management	More independence and responsibility, but more complex coordination.
2. Practical learning	More hands-on, interactive, and easier to understand than theory-based teaching.
3. Teamwork and cooperation	Stronger collaboration and communication, but scheduling and unequal participation can be challenging.
4. Creativity and problem-solving	Encourages critical thinking and deeper, more lasting knowledge.
5. Motivation and interest	More engaging, interesting, and enjoyable than traditional methods.
6. Traditional vs. PBL	Traditional = theory-focused; PBL = practical, skill- and communication-oriented.
7. Difficulties and challenges	Time-consuming, coordination difficulties, unclear expectations, and "free-rider" issues.

Table 2. Differences betweenproject-based and classical learning.
(Source: own compilation).

As Table 2 shows, students perceived a significant difference between classical and project-based learning in the free-text feedback. In other words, the benefits of project-based learning were already apparent during the first pilot semester. Table 3 presents the suggestions for improvement.

What and how do you think could or should be changed in the project task in the future? Briefly (max. 3-4 sentences or headings).	
1. Teaching methodology and class organisation	Use a hybrid model (theory + projects), clearer structure, upfront semester planning, and more consultations.
2. Assignments and assessment	Clearer tasks, expectations, and deadlines, with examples from previous years.
3. Teamwork and team dynamics	Smaller teams, defined roles, better communication, and accountability.
4. Deadlines and workload	Better scheduling, fewer overlaps, realistic deadlines, more in-class project work.
5. Practical implementation and technical development	More hands-on sessions, real industry projects, and visual/digital support.
6. Motivation and student enjoyment	More engaging, relevant projects, stronger teacher-student interaction, and team-building support.

Table 3. Student suggestions for project-based learning (Source: own compilation).

Overall, it can be concluded that, in addition to the positive aspects, the students also identified challenges and observations that should be considered in implementing project-based learning.

Results and discussion

The results show that students generally viewed project-based learning (PBL) as a supportive and effective learning method, particularly in terms of developing practical skills and teamwork. The slight improvement observed in the second semester suggests that both students and instructors are becoming increasingly familiar with the method. These findings are consistent with previous research highlighting the benefits of PBL in fostering engagement and developing applied competencies (Guo et al., 2020).

The qualitative findings complement these observations by revealing the most significant challenges of implementation. Instructors highlighted the increased workload, the lack of standardized processes, and the difficulties of integrating real-world projects. Students also reported problems related to coordinating teamwork and unclear expectations. These results suggest that while PBL has clear pedagogical advantages, its effectiveness depends heavily on institutional support and careful course design.

The study also highlights differences between the perspectives of students and instructors: students primarily experienced the benefits of PBL, while instructors tended to focus on the complexity of implementation. This underscores the importance of structured support systems and clear guidelines.

Overall, the findings suggest that the successful implementation of PBL requires methodological support, advanced infrastructure, and closer cooperation with external partners.

Conclusions

The introduction of project-based learning (PBL) at Széchenyi István University represents an important step toward practice-oriented educational innovation in higher education. The study's findings suggest that students generally view PBL as a valuable method for supporting learning, particularly in the development of practical skills and teamwork competencies.

At the same time, the results highlight several challenges related to implementation, including increased workload for instructors, organizational complexity, and the need for proper project planning and institutional support. Experiences gathered from both instructors and students underscore that the successful integration of PBL requires careful planning, clear expectations, and ongoing methodological and organizational support.

This study contributes to understanding the early-stage implementation of PBL by embedding the perspectives of students and instructors within a real institutional context. However, the results should be interpreted with caution, as they are primarily based on self-reported perceptions and a single case.

Overall, the results suggest that PBL has great potential in higher education, but its effectiveness depends on a well-structured implementation and sustained institutional commitment.

Practical recommendations for implementing PBL

Based on the above results and experiences, several general recommendations can be formulated for higher education institutions planning to introduce project-based learning. It is advisable to initially implement PBL on a pilot basis in smaller-scale courses, which provides an opportunity to identify and address methodological and organizational challenges. At the same time, it is essential to provide methodological training and ongoing professional support for instructors, given that PBL requires new pedagogical roles and competencies.

To ensure effective implementation, it is recommended to design projects based on real-world problems, involving external partners where possible, which increases the relevance of the learning process and student motivation. It is also important to establish a clear and transparent assessment system that takes into account both individual and group performance, as well as the learning process and its outcomes.

Finally, the conscious promotion of student collaboration and reflective learning – for example, through the use of structured feedback and self-assessment tools – contributes to a deeper learning experience and the development of complex competencies. Together, these elements can facilitate the sustainable and effective integration of PBL into higher education practice.

Funding: The APC was funded by Széchenyi István University.

Ethics Committee Name: Scientific Advisory Board; Approval Code/Date: SZE/ETT-2/2025 (II.03.); 03 February 2025.

References

Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. *The Clearing House*, *83*(2), 39–43. https://doi.org/10.1080/00098650903505415

Doppelt, Y. (2003). Implementation and assessment of project-based learning in a flexible environment. *International Journal of Technology and Design Education*, *13*(3), 255–272. https://doi.org/10.1023/A:1026125427344

España, C., & Soosaar, R. (2022). A Novel Context for Project-Based Learning. *Interdisciplinary Journal of Problem-Based Learning*, *16*(1). https://doi.org/10.14434/IJPBL.V16I1.28785

Frank, M., Lavy, I., & Elata, D. (2003). Implementing the project-based learning approach in an academic engineering course. *International Journal of Technology and Design Education*, *13*(3), 273–288. https://doi.org/10.1023/A:1026192113732

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research*, *102*, 101586. https://doi.org/10.1016/j.ijer.2020.101586

Hartescu, I. (2020). Project-based learning and the development of students' professional identity [PhD, Lancaster University]. In *Lancaster University*. https://www.research.lancs.ac.uk/portal/en/publications/projectbased-learning-and-the-development-of-students-professional-identity(46dd6d01-4d38-4736-a068-8b51f7025ed9).html

Kovecses-Gosi, V. (2019). The pedagogical Project of Education for Sustainable Development in 3D virtual space. *10th IEEE International Conference on Cognitive Infocommunications, CogInfoCom 2019 - Proceedings*, 539–544. https://doi.org/10.1109/CogInfoCom47531.2019.9090000

Kövecsesné Gősi, V. (2023). *Kövecsesné Gősi Viktória Tanítás-tanulás a digitális korban Kihívások és módszertani megoldások*. Xante Librarium Kiadó. https://doi.org/10.15773/EKKE.HABIL.2023.004

Lancaster University. (2025). *Project Management Practice MSc*. https://www.lancaster.ac.uk/study/postgraduate/postgraduate-courses/project-management-practice-msc/2025/

Marnewick, C. (2023). Student experiences of project-based learning in agile project management education. *Project Leadership and Society*, *4*, 100096. https://doi.org/10.1016/j.plas.2023.100096

NHL Stenden University of Applied Sciences. (2025). *Learn by doing*. https://www.nhlstenden.com/en/study-at-nhl-stenden/home-of-the-originals/learn-by-doing

Phil Cocchiola. (2020). *Project-based Learning (PBL) in Oxford Academy – Oxford Academy*. https://oxfordacademy.net/about/oxford-blog/project-based-learning/

Polytechnic Institute of Cávado and Ave. (2025). *Pedagogical Innovation*. https://ipca.pt/en/pedagogical-innovation/

University of Edinburgh. (2025). *Placement-Based Learning | School of Social and Political Science*. https://www.sps.ed.ac.uk/students/development-hub/masters/placement-based-learning

Väänänen, M., Horelli, J., & Ylitalo, M. (2023). *New Project Learning Environment Integrates Company Based R&D-work and Studying*.

Zeppelin University. (2011). *Zeppelin-Project*. https://www.zeppelin-university.com/studying-lifelong-learning/educational-formats/research-based-learning/zeppelin-project.php

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, 2026 – Page 298-312
doi.org/10.54337/ojs.jpblhe.v14i1.11574

Design of a PBL-based Immersive Content Production Curriculum

Gum Young Kim * | Seowon University, Republic of Korea

Abstract

This case describes the design and implementation of a Problem-Based Learning (PBL) course in immersive content production and reports students' and experts' perceptions of it. Although the immersive content industry is expanding, systematic curricula are scarce. The 15-week course, "3D·VFX Content Production Practice," was taught to 29 third-year media content students. In weeks 1–7, students built skills in Substance Painter and Unreal Engine; in weeks 8–15, six teams responded to an ill-structured client scenario by producing interactive 3D videos of local sites in Chungbuk, Korea. Data were drawn from a survey, reflective journals, team artifacts and interviews with three industry experts. Students described growth in self-directed learning, creative design and team communication, and 62% reported being satisfied. Experts judged the workflow close to industry practice. Teamwork burden and problem complexity emerged as challenges, suggesting that problem scope should match students' skills and teams be formed deliberately.

Keywords: PBL; Immersive Content; Game Engine; Curriculum Design

* Corresponding author:
Gum Young Kim, Email: kimky_j@hotmail.com

Received 30 May 2026 | Accepted 28 October 2026 | Published 26 November 2026
© 2026 The Author. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

Introduction

With rapid digital development, the immersive content industry has emerged as a core growth driver in culture, healthcare, education, and defense (Kim & Park, 2023). Immersive content based on XR technologies–AR, VR, and MR–provides value differentiated from traditional media by maximizing user immersion and interactivity (Im, 2023). The Korean government supports production infrastructure and talent development through the 'Digital New Deal' and content industry policies, and the related market has recorded double-digit annual growth (Kim & Park, 2023). The sector thus functions as a catalyst for industrial convergence and digital transformation beyond mere consumer goods, and demand for professionals with creativity and technical competence is rapidly increasing. However, while research on immersive content utilization has been active, curriculum research remains lacking.

In prior research, Song and Ryou (2016) showed that VR/AR teaching materials are significant for students' learning; analyzing VR programs at institutions including Gyeonggi Content Agency, Youngsan University, Korea University of Media Arts, and Myongji College, they presented storytelling, audiovisual, and software track curricula. Nam et al. (2020) comparatively analyzed the educational effects of VR content production education for elementary and secondary students, arguing that VR curricula should enable students from elementary school to university to create subject content at each level. Nam and Kim (2018) analyzed that students or teachers need to directly create subject content rather than use company-provided VR content, and that research on teaching and learning methods is needed.

Currently, most immersive content classes are not run on independently established curricula; composition and instruction are entrusted to practitioners or VR production companies, and even universities depend on individual instructors' competence, so consistent educational quality is not guaranteed.

Prior research thus raises the need for curriculum research and for generalized teaching and learning methods rather than curricula shaped by instructors' backgrounds. Based on market expansion, the lack of curriculum research, and field demand, this study raises the need for research on curricula for training immersive content experts, aiming to develop a PBL-based curriculum that provides learners with reliable education of consistent quality.

To this end, the following research questions were established:

1. How should a PBL-based immersive content production curriculum be structured?

2. How did students and industry experts perceive and evaluate the PBL-based course?

For the first question, the researcher developed educational materials by directly producing immersive content, refined them with expert feedback, and applied them to the major course "3D·VFX Content Production Practice" as PBL-based instruction. The second was analyzed using learners' reflection journals, assignment plans, outputs, and survey data collected after 15 weeks of operation.

Theoretical background

Concept and Characteristics of Immersive Content

Immersive content provides users with an immersive experience in an environment similar to reality, implemented on eXtended Reality (XR) technologies such as AR, VR, and MR. Unlike traditional audiovisual-centered media, it enables real-time interaction reflecting user movements, gaze, and responses, and is characterized by sensory expansion, spatial experience, and participatory interaction (Kim & Park, 2023). Beyond enhancing visual effects, it maximizes 'presence' and 'immersion' by letting users intervene directly in the environment and form experiences within it — expanding it from an information delivery tool into a user–centered experience medium applicable in education, healthcare, culture and arts, tourism, and manufacturing (Koutsabasis et al., 2012).

Implementation converges multiple digital technologies: 3D modeling and animation, real–time rendering, location-based sensors, spatial audio, and UI/UX design, running on devices such as HMDs, AR glasses, mobile devices, and motion sensors (Kim, 2024). Real-time tracking of users' movements, gaze, and gestures with corresponding feedback implements personalized experiences, giving strengths in behavior-based or simulation learning (Ghaznavi et al., 2025).

Through high immersion and interactivity, immersive content enables learner-centered experiential learning, particularly effective in experimental, simulation, and collaboration-based learning (Kim et al., 2022). Applying its core technologies (Table 1) to education can overcome spatiotemporal constraints by virtually implementing hard-to-access environments, and it has been reported to simultaneously promote creative problem-solving, critical thinking, and collaborative competencies aligned with future competency-centered curricula (Jang, 2022). Project-based classes using immersive content

can thus induce deep learning by letting learners experience problem situations as if real and explore solutions directly.

The table below is a revised and updated version of Kim et al. (2022) on a 3D modeling curriculum for educationally disadvantaged learners.

Technology	Description
VR: Immersion Visualization	• VR immersive environments via projection, HMD, and video visualization software
VR: Realistic Interaction	• Five-sense user–system interaction; location tracking, motion simulators, tactile/haptic technology
VR: Virtual Environment Generation & Simulation	• 360-degree panoramic-based VR environments for scenario-based visualization/interaction; avatar-based communication
AR: Tracking and Sensing	• Precise positioning of virtual objects in real space via markers or visual SLAM
AR: Image Synthesis	• Representing virtual objects as if in real space; seamless synthesis with real-space imagery
AR: Real-time Interaction	• Real-time user interaction with virtual objects synthesized in real space

Table 1. Core Technologies of Immersive Content (adapted from Kim et al., 2022).

Literature review of Problem-Based Learning (PBL)

Problem-Based Learning (PBL) is a method in which learners set the direction of learning themselves in real-life-like problem situations, explore necessary knowledge, and derive solutions. First introduced at McMaster University School of Medicine in Canada in the late 1960s, it has spread across fields as a representative strategy in modern higher education (Jang, 2006). Its core lies not in one-way knowledge transfer but in comprehensively strengthening learners' self-directedness, problem-solving, collaboration, and critical thinking, so learners develop the ability to use knowledge in real contexts.

As shown in Figure 1, PBL generally proceeds through five stages: encountering and analyzing the problem, planning how to solve it (what learners know, what they need to know and how to find out), exploration and re-exploration, deriving solutions, and reflection and evaluation. Unlike traditional subject-centered classes, this encourages active participation while enhancing practical

skills and cognitive flexibility (Jang et al., 2020). Since immersive content classes focus on open-ended problems without a single correct answer, learners must attempt multifaceted approaches and design creative solutions — activities aligned with the essence of PBL and particularly effective in project-based production classes.

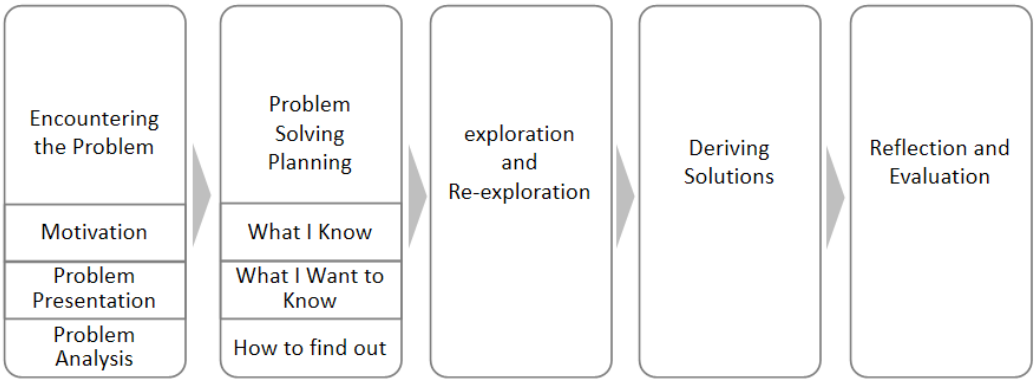


Figure 1. PBL Teaching and Learning Process.

Problem-based learning in its traditional form, as developed at McMaster University, centers on small groups that analyze an ill-structured problem and identify their own learning issues, with knowledge acquisition as the main goal (Barrows, 1996; Savery, 2006). Project-based learning, by contrast, is oriented toward producing an artifact, and learners often apply knowledge they already have (Helle et al., 2006). Between these lies the problem-oriented project work of the Aalborg model, in which teams formulate a problem and address it through an extended project (Kolmos & de Graaff, 2014). The course described here is closest to this hybrid. Weeks 1–7 build the technical skills the project requires. In weeks 8–15, teams receive an ill-structured client scenario, choose their own site and interpretation, and list facts, ideas and learning issues (Appendix A) before producing a video. This case therefore uses "PBL" in this broader, problem-oriented and project-based sense.

Curriculum design process

PBL-based Immersive Video Content Production Curriculum Course Overview

This course aims to foster convergent creative talent required by the immersive content industry. Adopting PBL as the central teaching strategy, it was structured so students perform the process from planning to production and presentation, divided into team and individual work, developing creativity and

collaboration while solving real problems in a practice-centered environment (see Table 2).

Item	Content
Course Name	3D·VFX Content Production Practice
Target Grade	Media Content Major 3rd Year
Class Time	1st Semester 15 Weeks (3 hours once a week)
Learning Method	Problem-Based Learning PBL + Project Production
Evaluation Method	Output Evaluation + Process Evaluation + Self/Peer Evaluation Combined

Table 2. 3D·VFX Content Production Practice: Course Overview.

Design of PBL-based Immersive Content Production Curriculum

Writing the problem (scenario writing) determines its presentation form, which should lead learners into the problem situation, allow actual participation, and consist of appropriate content and method. Here, an in-house email from a media production company was chosen, allowing various results through an unstructured scenario while including specific conditions by defining the content genre.

The problem scenario is as follows:

> "You are a video producer at a newly established content studio and have received a request from a Chungbuk tourism promotion company to produce a realistic short video under 3 minutes. It should represent the charm of a city or natural landscape so audiences feel as if at the actual site, evoking interest and travel desire for Chungbuk tourism resources. Under the theme 'Our Neighborhood with Four Seasons Project,' you will select a neighborhood containing Chungbuk regional culture and produce an exhibition video conveying a realistic atmosphere following visitors' footsteps, with interaction applied so audiences can walk around and appreciate the 3D space."

Development of PBL-based Immersive Content Production Curriculum

In weeks 1–7, students first learned technologies necessary for immersive content production –3D modeling, VR/AR implementation, interaction design, and game engines. As third-year students who took 'Maya' in their second year, they had a basic understanding of 3D programs; this class fully dealt with the Unreal game engine and Substance, a high-end texturing program.

The 15–week curriculum covered: orientation and program introduction (Week 1), Substance Painter basics and projects (Weeks 2–4), Unreal Engine fundamentals and advanced techniques (Weeks 5–6), mid-term evaluation (Week 7), PBL introduction and problem presentation (Week 8), team planning and individual project development (Weeks 9–11), post-production techniques (Week 12), team integration work (Week 13), feedback sessions (Week 14), and final presentations (Week 15). Details are in Table 3.

Week	Class Content
1	Orientation: course, game engine, PBL, Substance Painter
2–4	Substance Painter: interface; prop and character texturing
5–6	Unreal Engine: interface, materials, Blueprints, blockout, decals
7	Midterm review and submission
8	PBL introduction: team formation, problem scenario, project plan
9	Team planning: problem analysis, site, map, roles, schedule; blockout; journal
10–11	Individual work: modeling (Maya, Unreal), landscape, texturing (Substance); journal
12	Post-production in Unreal: Post Process Volume, Cine Camera, Movie Render Queue
13	Team integration: merging levels, post-processing, editing; journal
14	Project review and team feedback
15	Final presentation, PBL reflection, peer and self-evaluation

Table 3. 3D·VFX Content Production Practice: Weekly Course Plan.

Problem Presentation and Team Formation

In week 8, PBL and the team learning method were introduced, with a problem scenario inspired by the actual industrial field. Students formed teams of about five by region of interest and wrote task performance plans. Under the theme "Our Neighborhood with Four Seasons Project," the teams respectively selected 'Dongbu Warehouse,' 'Seowon University,' 'Seongan-gil,' 'Yukgeori Traditional Market,' 'Suamgol Mural Village,' and 'Ochang Miraegi Hanok Village' in Chungbuk, each preparing a project plan tailored to the scenario (Appendix A).

Information Search and Planning Concept

In week 9, each team conducted market research, technical analysis, and case studies, then wrote and presented content plans including storyboards, user flow diagrams, and technical application plans, using generative AI such as

ChatGPT and Midjourney in parallel for storyboards. Weekly reflection journals let students reflect on what they learned, their thoughts, and future plans (Appendix B).

Prototype Production and Implementation

From weeks 10 to 14, students developed immersive content prototypes by applying 3D modeling, VR/AR implementation, and interaction design step by step, while the instructor adjusted technical difficulty and work distribution through interim checks and mentoring. Students worked in divided team and individual tasks while learning production software weekly. Some projects were so large that finishing by the deadline was difficult when modeling each region and importing it into the game engine; weekly feedback and revisions therefore continued, such as reducing project scale and focusing on details. Figure 2 shows the class process (team meeting → project proposal → game engine production → final presentation).

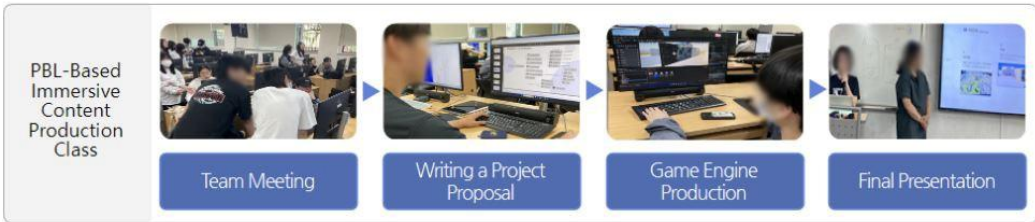


Figure 2. PBL-Based Immersive Content Production Class.

Presentation and Reflection

In the final week, each team presented their outputs, reflected feedback through actual user testing, and looked back on the learning process via self-reflection reports and peer evaluations. Six teams successfully completed immersive video projects showcasing different aspects of Chungbuk's regional culture and landscapes through interactive 3D environments (Table 4): Team A — Dongbu Warehouse; B — Seowon University; C — Seongan-gil; D — Yukgeori Traditional Market; E — Suamgol Mural Village; F — Ochang Miraegi Hanok Village (each with a demonstration video link).

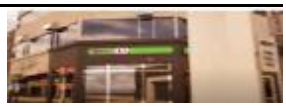
Team Name	Project Name	Image
A	· Dongbu Warehouse (https://www.youtube.com/watch?v=RSJCLikVhuA)	
B	· Seowon University (https://www.youtube.com/watch?v=_JkZtTsgRZE)	
C	· Seongan-gil (https://www.youtube.com/watch?v=HHPnQ656vVU)	
D	· Yukgeori Traditional Market (https://www.youtube.com/watch?v=Q2zatCO-ZQ4)	
E	· Suamgol Mural Village (https://www.youtube.com/watch?v=A_0AZ2g5Ijo)	
F	· Ochang Miraegi Hanok Village (https://www.youtube.com/watch?v=Tbe86G5LcX8)	

Table 4. 3D·VFX Content Production Practice: Class Outcomes.

Data Collection and Analysis

Four types of data were collected during and after the course. They were used to describe how the course unfolded and how participants perceived it, not to measure learning gains.

Survey. In week 15, all 29 enrolled students were invited to complete an anonymous online survey. It contained three items on prior familiarity with immersive content, class satisfaction and willingness to recommend the course, each rated on a five-point scale. All 29 students responded, and the results are reported descriptively as frequencies (Figure 3).

Reflective journals. Students wrote reflective journals in weeks 9, 10 and 13, answering seven open questions (Appendix B). 71 journals were collected. The author read them repeatedly and grouped recurring statements into themes such as technical difficulty, collaboration, local identity and career relevance.

Team artifacts. Project plans (Appendix A), storyboards and final videos (Table 4) were used to describe each team's process and outcomes, not to assess learning gains.

Expert interviews. Three practitioners (Table 5) reviewed the course plan, problem scenario and final outputs. Each was interviewed face-to-face or online

via video call for about 40 minutes in July 2025, and their responses were summarized by theme.

Ethics: At the start of the PBL phase in week 8, all students were informed of the purpose of this case report and gave verbal consent for their anonymized journals, survey responses and project outputs to be used. As the report is based on routine course activities, formal ethical review was not required by the institution. Participation did not affect course grades. Faces in Figure 2 have been blurred, all student names are pseudonyms, and the linked videos contain no faces or names of students.

Class Satisfaction and Curriculum Validity Verification

After one semester, a satisfaction survey was conducted with 29 students. As shown in Figure 3, 19 of 29 students (66%) reported low familiarity with immersive content before the course. Eighteen students (62%) were satisfied with the class. Willingness to recommend the course to other students was more mixed: 11 students answered positively, 12 were neutral and 6 answered negatively.

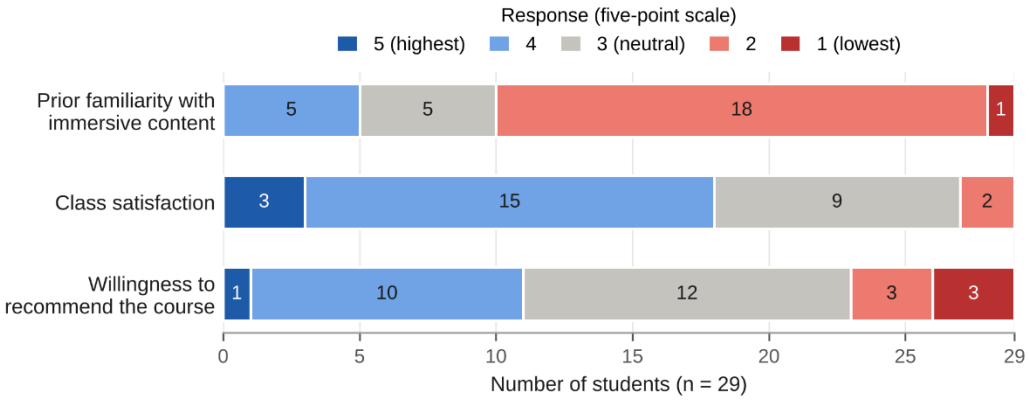


Figure 3. Student Survey Results.

Note. Responses were given on a five-point scale. For prior familiarity, 5 = very familiar and 1 = not at all familiar; for class satisfaction, 5 = very satisfied and 1 = very dissatisfied; for willingness to recommend, 5 = very willing and 1 = not at all willing.

Expert interviews were conducted with three professionals experienced in post-production (18+ years), university education (7+ years) and animation production (20+ years) (Table 5). The experts noted that team formation was a recurring problem and suggested identifying members' personalities and skill levels beforehand. They also considered the problem difficult to solve within

class time and recommended adjusting its complexity. Overall, however, they found the production process convincing: because industry practice proceeds in a similar way, they judged that the course helped students experience a professional environment and prepare for professional work.

Category	Company Category	Responsibilities	Experience
A	Post-production company	Post-production team manager	18+ years
B	University	Immersive media lectures	7+ years
C	Animation company	Production Supervisor	20+ years

Table 5. Expert Interview Participant Information.

Conclusion

This case described a one-semester course that applied PBL to immersive content production and reported how 29 third-year students and three industry experts perceived it. Three observations emerge from the case.

First, the course was structured in five stages: technology-based competence formation (Weeks 1–7), problem presentation and team formation (Week 8), information search and planning (Week 9), prototype production and implementation (Weeks 10–14), and presentation and reflection (Week 15). Building on students' prior experience with Maya, the first phase introduced Substance Painter and Unreal Engine, so the tools the project required were in place before the problem was presented. This sequence may serve as a modular model for similar production courses.

Second, the open-ended "Our Neighborhood with Four Seasons Project" gave students a production context resembling industry practice. They moved through problem definition, research, planning, production, post-production and presentation, and adjusted project scope to technical and time constraints. Students' reflective journals described communication, coordination and negotiation as necessary for completing the project, particularly through role distribution within teams (e.g., team leader, map production, modeling, level integration, presentation). At the same time, many students identified teamwork as a burden in the survey.

Third, the experts judged the assignment to be close to actual production workflows and valuable for previewing industry processes and standards.

However, they considered the problem too complex to solve within class time. This suggests adjusting problem difficulty to students' competence, forming teams more deliberately, and strengthening the instructor's role as a coach.

Taken together, the case suggests that a problem-oriented, project-based format can give students in technology-convergent fields such as immersive content an experience close to professional practice. Whether the format improves problem-solving, creativity or collaboration, however, cannot be determined from this case.

This case has several limitations. It did not measure learning gains, as there was no pre- and post-assessment and no comparison group. The findings are based on self-reports (a survey and reflective journals) from a single cohort of 29 students at one institution, together with the views of three experts, and cannot be generalized. Future studies could compare PBL implementations across majors and institutions, combine validated quantitative measures with qualitative data, and examine whether any learning effects persist over time.

References

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching and Learning, 1996*(68), 3–12. https://doi.org/10.1002/tl.37219966804

Ghaznavi, S., Haghparast, F., Pourahmad Ghalejough, A., & Sakian Mohamadi, H. (2025). Implementing user-centered design in architecture using virtual reality: A case study of a micro coworking space. *Design Studies, 99*, Article 101329. https://doi.org/10.1016/j.destud.2025.101329

Helle, L., Tynjälä, P., & Olkinuora, E. (2006). Project-based learning in post-secondary education – Theory, practice and rubber sling shots. *Higher Education, 51*(2), 287–314. https://doi.org/10.1007/s10734-004-6386-5

Im, K.-H. (2023). News analysis and visualization related to metaverse and realistic media. *The Journal of the Korea Contents Association, 23*(2), 372–378. https://doi.org/10.5392/JKCA.2023.23.02.372

Jang, H. J. (2022). *Development of virtual reality (VR) educational contents design framework* [Doctoral dissertation, Hanyang University].

Jang, J. A. (2006). A case study of problem design process for PBL. *The Journal of Yeolin Education, 14*(1), 65–92.

Jang, K. W., Choi, J. I., & Jang, S. Y. (2020). Development of design guidelines for PBL problem and implementation plan. *The Journal of Learner-*

Centered Curriculum and Instruction, 20(16), 569–594. https://doi.org/10.22251/jlcci.2020.20.16.569

Kim, G. Y. (2024). PBL based motion capture curriculum. *Journal of Digital Art Engineering and Multimedia, 11*(2), 243-252. https://doi.org/10.29056/jdaem.2024.06.09

Kim, H. A., Kim, J. W., Lee, Y. Y., Chae, Y. G., & Kim, D. H. (2022). A study on the 3D modeling curriculum for the education vulnerable. *Proceedings of the Korean Society of Computer Information Conference, 30*(2), 115–116.

Kim, J. H., & Park, J. C. (2023). *Survey on the current state of immersive content and mid- to long-term strategy research*. Ministry of Culture, Sports and Tourism; Korea Creative Content Agency.

Kolmos, A., & de Graaff, E. (2014). Problem-based and project-based learning in engineering education: Merging models. In A. Johri & B. M. Olds (Eds.), *Cambridge handbook of engineering education research* (pp. 141–160). Cambridge University Press. https://doi.org/10.1017/CBO9781139013451.012

Koutsabasis, P., Vosinakis, S., Malisova, K., & Paparounas, N. (2012). On the value of virtual worlds for collaborative design. *Design Studies, 33*(4), 357–390. https://doi.org/10.1016/j.destud.2011.11.004

Nam, C. M., & Kim, C. W. (2018). A comparative study of virtual reality content creation education by learner. *Journal of the Korean Association of Information Education, 22*(5), 585–592. https://doi.org/10.14352/jkaie.2018.22.5.585

Nam, C. M., Kim, C. W., Hong, K. S., Cho, C., & Hong, J. H. (2020). A study on the learner characteristics in virtual reality by a school level curriculum. *Journal of the Korean Association of Information Education, 24*(1), 71–78. https://doi.org/10.14352/jkaie.2020.24.1.71

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning, 1*(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Song, P.-J., & Ryou, H.-S. (2016). A study on VR curriculum. *Journal of the Korea Internet of Things Society, 2*(4), 21–25. https://doi.org/10.20465/kiots.2016.2.4.021

Appendix A

Team Name:	*Team C*	***Date:***	*May. 8. 2025*
Ideas	Facts	Learning Issues	Action Plan
- Created an immersive video exhibition capturing the essence of autumn, centered around the alleys of Seongan-gil in Cheongju - Conveys a sense of realism by utilizing perspectives and sounds that make viewers feel as if they are actually walking through the alleys - Designed to allow visitors to freely explore every corner of the alleys through 3D interactions, enabling them to experience the culture and atmosphere of Cheongju - Maximizes visual appeal by incorporating representative seasonal elements into the video	- Seongan-gil is Cheongju's premier commercial district and cultural alley, home to a concentration of small businesses and art spaces - The alley is a space where retro charm and modern elements coexist - Cheongju is a region with distinct four seasons, and the scenery and atmosphere of the alley change significantly with the seasons - Interactive exhibitions are gaining attention as a content format that enhances visitor engagement and the quality of the experience -Video content should be planned to leave a strong impression, despite its short format of less than one minute	- Whether filming is permitted in the alley - Selection of a technical platform for implementing interactive exhibits (e.g., Unity, Unreal, WebGL, etc.) -Availability of materials such as local sounds, interviews, and Foley sounds to be used in the video -Need for specific research on representative seasonal events and locations -Analysis of the age groups, interests, and movement patterns of the primary target audience visiting Seongan-gil -A structure that allows for effective storytelling within one minute -Verification of data from public institutions	- Select specific alleys and main pathways along Seongan-gil to include in the project Identify areas suitable for filming and implementing interactions on a map - Conduct preliminary site visits to collect imagery - Create 3D models of buildings, signs, and streets in the selected alley areas - Design camera angles, cinematic effects (lighting, color palette, etc.), and interaction points - Prepare demonstration videos and 3D interactive experience materials

Table A1. Project Plan of Team C.

Appendix B

Student Name:	*Student A*
Question	Answer (summarized by the author)
1. What did you learn from this lesson?	Beyond producing video, I reflected on incorporating local character and realism into Seongan-gil-based content, and my first experience integrating 3D spatial design with interactive elements taught me about content scalability.
2. What activities did you find difficult in class?	Creating the 3D map and interactions in Unreal Engine, a completely new tool; balancing realism with performance was hard, but repeated revisions and teammate feedback gradually improved quality.
3. What would you like to learn next?	VR/AR exhibition content technologies — sound design, lighting effects, and UX-prioritized spatial design for content that lets audiences "walk through a space."
4. How can you apply it?	Local-theme video planning applies to travel vlogs, tourism promotion, and exhibition design; I gained a foundation for planning content that lets audiences "experience," not just "see."
5. What are your weaknesses in this class?	Lack of 3D modeling and game engine skills, which limited communication and implementation; continuous technical study is needed.
6. What did you feel while going through this course?	Content planning means understanding a subject's essence so audiences can "experience" it; production is a complex creative process where research, field surveys, spatial design, and audiovisual composition must interconnect organically.
7. Please feel free to share any other thoughts.	The project deepened my affection for my neighborhood and showed the power of local content; collaborating taught me the joy of co-creation and how I want to create content in the future.

Table B1. PBL Reflection Journal of a Student.

Note: Answers were summarized by the author from the student's original journal, written in Korean and translated into English.

Journal of
Problem Based Learning
in Higher Education

VOL 14 • 1

Vol 14, No. 1, Page 313-332
doi.org/10.54337/ojs.jpblhe.v14i1.10531

Project-Based Learning for Sustainable Design in a Heat Transfer Course

Aprendizaje Basado en Proyectos para el Diseño Sostenible en un Curso de Transferencia de Calor

Juan Sandoval Herrera * | Universidad de América, Colombia

Abstract

Training engineers to meet the challenges of sustainable development requires integrating sustainability into technical education through applied approaches. Although Project-Based Learning (PBL) has proven effective in engineering education, its explicit alignment with the Sustainable Development Goals (SDGs) remains limited in courses such as heat transfer. This case study implemented a PBL strategy in a Heat Transfer II course, focused on the sustainable design of real thermal equipment, aiming to enhance disciplinary understanding and promote environmental awareness. Eighty-three engineering students participated, designing heat exchangers based on thermal, hydraulic, and sustainability criteria linked to specific SDGs. Projects were evaluated through technical and sustainability rubrics, a student perception survey, and comparison with a previous semester. The results revealed that the

* Corresponding author:
Juan Sandoval Herrera, Email: juan.sandoval@uamerica.edu.co

Received 20 June 2025 | Accepted 24 February 2026 | Available online in Early View 24 April 2026 | Published 26 November 2026
© 2026 The Author. This is an Open Access article published by Aalborg University Open Publishing under a CC BY license (http://creativecommons.org/licenses/by/4.0/)

percentage of students rated at the "Very Good" level increased by 22 percentage points compared to the non-PBL semester. Moreover, 94% of students found the allotted project time adequate, and 72% reported a deep understanding of the connection between heat transfer and sustainability. These findings indicate that PBL, when framed around real technical challenges and aligned with the SDGs, is an effective pedagogical tool for fostering deep learning, transversal competencies, and the education of engineers who are aware of and committed to addressing global sustainability challenges.

Keywords: Project-based learning; heat transfer; sustainability; SDG; thermal engineering

Resumen

Formar ingenieros capaces de afrontar los desafíos del desarrollo sostenible implica integrar la sostenibilidad en cursos técnicos desde una perspectiva aplicada. Si bien el Aprendizaje Basado en Proyectos (ABP) ha mostrado efectividad en la enseñanza de la ingeniería, aún es escasa su articulación explícita con los Objetivos de Desarrollo Sostenible (ODS) en asignaturas como la transferencia de calor. Este estudio de caso implementó un ABP en el curso de Transferencia de Calor II, centrado en el diseño sostenible de equipos térmicos reales, con el fin de mejorar la comprensión disciplinar y fomentar la conciencia ambiental. Participaron 83 estudiantes de ingeniería, quienes diseñaron intercambiadores de calor considerando criterios térmicos, hidráulicos y de sostenibilidad asociados a los ODS. Los resultados fueron evaluados mediante rúbricas técnicas y de sostenibilidad, encuestas de percepción y análisis comparativo con el semestre anterior. Se evidenció que el porcentaje de estudiantes en nivel "Muy bueno" aumentó 22 puntos porcentuales respecto al semestre sin ABP. Además, el 94 % de los estudiantes consideró adecuado el tiempo asignado y el 72 % afirmó haber comprendido profundamente la relación entre transferencia de calor y sostenibilidad. Los hallazgos sugieren que el ABP orientado a problemas técnicos reales y contextualizado con los ODS es una estrategia pedagógica efectiva para fortalecer el aprendizaje profundo, las competencias transversales y la formación de ingenieros comprometidos con los retos globales.

Palabras clave: Aprendizaje Basado en Proyectos; transferencia de calor; sostenibilidad; ODS; ingeniería térmica.

Introducción

La importancia de entender y aplicar el desarrollo sostenible es cada vez mayor ante la evidencia del deterioro ambiental, el agotamiento de recursos y la necesidad de un cambio en el modelo actual. La Agenda 2030 de las Naciones Unidas y sus 17 Objetivos de Desarrollo Sostenible (ODS) proporcionan un marco para abordar estos desafíos (Iturralde Durán, 2017). Las universidades tienen la responsabilidad de integrar la sostenibilidad en sus currículos y formar a los futuros profesionales, especialmente ingenieros, para que puedan contribuir a resolver estos problemas globales (Blanco et al., 2021; Calvo et al., 2022).

Particularmente, la reducción y optimización del gasto energético se presenta como un ejemplo tangible y de gran relevancia de este problema central, debido a su impacto directo tanto en la sostenibilidad medioambiental (reducción de emisiones de CO_2 y gases de efecto invernadero, eliminación de la dependencia de combustibles fósiles) como en la sostenibilidad económica (reducción de costes). De tal forma que, el diseño sostenible de equipos de transferencia de calor responde directamente a los ODS 7: Energía asequible y no contaminante; ODS 11: Ciudades y comunidades sostenibles; ODS 12: Producción y consumo responsable; ODS 13: Acción por el clima.

Ahora bien, con el fin de desarrollar el proceso de enseñanza – aprendizaje del diseño sostenible se pueden implementar diversas metodologías, siendo de gran interés en la actualidad las metodologías activas, como el Aprendizaje Basado en Proyectos (ABP), porque plantea a los estudiantes un problema real y cercano, como podría ser la optimización del confort térmico y la reducción del gasto energético en el propio edificio de la universidad (Calvo et al., 2022; Guerra et al., 2017; Sanchis et al., 2020). Los estudiantes aplican conocimientos, diseñan, implementan y analizan datos, por ejemplo, con la reducción del gasto energético a través de proyectos que integran elementos de diversas asignaturas de su currículo.

De igual manera, el abordaje de este problema mediante metodologías activas contribuye al desarrollo de competencias específicas y transversales como el autoaprendizaje, el trabajo en equipo, el pensamiento crítico, la capacidad de análisis, la resolución de problemas, la capacidad de innovar y la concienciación sobre la sostenibilidad (Kricsfalusy et al., 2018; Sanchis et al., 2020). Caso particular el descrito por Rodríguez-Sandoval y Cortés-Rodríguez (2010) en el que usaron aprendizaje basado en proyectos (ABPr) en diferentes cursos teórico-prácticos del programa de Ingeniería Agrícola.

Los proyectos se han venido aplicando en cursos de ingeniería como método para enriquecer el proceso de enseñanza aprendizaje por competencias desde hace varios años (Castellanos y Hernández, 2010; Puenayán et al., 2024) y se han venido perfeccionando, con especial énfasis en los métodos de evaluación, orientados a resolver problemas reales de la ingeniería (Caicedo, 2020; Viáfara, 2020); pero, en la revisión realizada para este trabajo, no fue hallado suficiente material que combinara ABP en ingeniería con la inclusión del desarrollo sostenible. Solo de manera tangencial, Garrido de la Torre et al. (2020), mostraron cómo el ABP, aplicado en dos cursos consecutivos de ingeniería, permite abordar contextos reales que, de forma inherente, requieren considerar criterios sociales, éticos y ambientales, aunque no evaluaron explícitamente la sostenibilidad.

Ya enfocado en los ODS, Blanco et al. (2021) demostraron la posibilidad de integrarlos en cursos técnicos de ingeniería informática mediante metodologías activas como el ABP. En su caso, el enfoque estuvo orientado al desarrollo de productos comunicativos —sitios web— para promover la reflexión ética y social sobre los ODS entre estudiantes de ingeniería informática.

Inspirado en esta lógica, y buscando responder a la pregunta de investigación: "¿De qué forma se pueden integrar los ODS en un curso de ingeniería enfocado en el diseño de equipos de transferencia de calor y evaluado de forma cualitativa empleando resultados de aprendizaje?", el presente trabajo implementa el ABP en el curso de Transferencia de Calor II, con un enfoque centrado en el diseño sostenible de equipos térmicos reales. A diferencia de trabajos similares que pudieran encontrarse, aquí los estudiantes trabajaron con variables de proceso, realizaron cálculos térmicos e hidráulicos, midieron y discutieron los indicadores ODS vinculados a sus diseños, con los siguientes propósitos educativos: (1). Comprender la relevancia del problema central de la sostenibilidad y los ODS. (2). Aplicar y conectar conocimientos de diversas disciplinas para abordar un problema real y complejo. (3). Desarrollar soluciones concretas a problemas reales. Y (4). Formar competencias necesarias para ser futuros ingenieros responsables y conscientes de los desafíos globales.

Metodología

Diseño

El método para esta investigación fue de tipo experimental en dos unidades de estudio, correspondientes a sendos grupos de clase de Transferencia de Calor II, durante un semestre. Las características de este estudio de casos son:

longitudinal, cuantitativo, con enfoque constructivista por la metodología activa empleada y descriptivo (Ordoñez-Pacheco, 2025).

El uso de metodologías activas como el ABP facilita la adquisición de conocimientos técnicos, además de que es fundamental para el desarrollo de competencias transversales. Diversos autores han demostrado su impacto positivo en el pensamiento crítico (Guerra, 2017; Requies et al., 2024), el trabajo en equipo a través del aprendizaje cooperativo (Navaridas-Nalda et al., 2020; Sanchis et al., 2020) y la capacidad de innovación al enfrentarse a desafíos de diseño real (Kricsfalusy et al., 2018; Martínez Casanovas et al., 2022; Rodríguez-Sandoval y Cortés-Rodríguez, 2010). El origen de los proyectos podía provenir de la solución de problemas reales o contextualizados, identificados por los propios estudiantes; pero, en general, se buscaba que los estudiantes respondieran a la pregunta guía "¿Cómo integrar elementos técnicos y de sostenibilidad para diseñar un equipo de transferencia de calor que solucione una problemática en particular?".

Los criterios técnicos que debían guiar sus diseños fueron: buen desempeño térmico con ahorro en consumo de potencia de bombeo; factor de limpieza, relacionado con la frecuencia de mantenimiento, no menor a 0,7; factor de sobrediseño no superior a 40 % (Kakaç & Liu, 2012; Lee, 2020); y en cuanto a la sostenibilidad, se debía evidenciar la evaluación de por lo menos un indicador de cada reto correspondiente a los ODS identificados en sus equipos de transferencia de calor.

Participantes

El proceso ABP se aplicó a un total de 83 estudiantes de los tres grupos de transferencia de calor II del segundo semestre de 2024 en los programas de ingeniería química, ingeniería mecánica e ingeniería en energías, quienes estaban cursando entre quinto y octavo semestre de su respectivo programa. Las diferencias se dan por los currículos de cada ingeniería y por irregularidades en la trayectoria académica, es decir, por repitencia o adelanto de asignaturas. Sus edades, en general, estaban entre 19 y 23 años. Al final del proceso de ABP, la encuesta de evaluación de la estrategia la respondieron de forma voluntaria 50 estudiantes, es decir, el 60 % del total de participantes.

Instrumentos

Para evaluar los proyectos presentados por los grupos de estudiantes, se comparte con Herrera (2017) el uso de rúbricas de heteroevaluación y de autoevaluación al final del proceso académico para ABP. Barrera et al. (2022) también aplicaron el ABP como estrategia didáctica activa y experiencial. Las

rúbricas, así como los resultados en bruto de la encuesta y material adicional, se comparten a los lectores interesados.

Al final del semestre se envió una encuesta a los estudiantes, en formulario Google online, con el fin de conocer su percepción sobre la estrategia implementada (Blanco et al., 2021; Grau et al., 2020; Intriago-Zambrano et al., 2025), así como sobre diferentes aspectos de la relación entre la asignatura y la sostenibilidad (Grau et al., 2020: Blanco et al., 2021). En la tabla 1 se presentan las preguntas de la encuesta final del ABP.

Ítem	Tipo	Aspecto / Pregunta	Escala
1	Cuantitativo	Relación entre los contenidos del curso y la sostenibilidad: ¿En qué medida cree que le ayudó este proyecto a entender la relación entre transferencia de calor y sostenibilidad?	1: nada; 3: indiferente; 5: mucho
2	Cuantitativo	Relación entre los contenidos del curso y el desarrollo del proyecto: ¿En qué medida siente que los contenidos teóricos, laboratorios y visita al CEPIIS le ayudaron a la realización de este proyecto?	1: nada; 3: indiferente; 5: mucho
3	Cuantitativo	Aplicación del proyecto a su ejercicio profesional: ¿En qué medida cree que realización de este proyecto le hará cambiar su conocimiento sobre la aplicación de la sostenibilidad en el diseño de equipos, procesos o productos?	1: nada; 3: indiferente; 5: mucho
4	Cuantitativo	Aplicación del proyecto a su desarrollo personal: ¿En qué medida cree que realización de este proyecto le hará cambiar su perspectiva sobre la importancia de la sostenibilidad para su vida?	1: nada; 3: indiferente; 5: mucho
5	Cuantitativo	Considera que el tiempo asignado a la realización del proyecto es:	Insuficiente. Adecuado. Excesivo.
6	Cualitativo	Agregue comentarios que contribuyan a la mejora de esta estrategia didáctica en próximos semestres. Muchas gracias.	

Tabla 1. Encuesta de evaluación del ABP por parte de los estudiantes.

Nota: Preguntas de la encuesta aplicada.

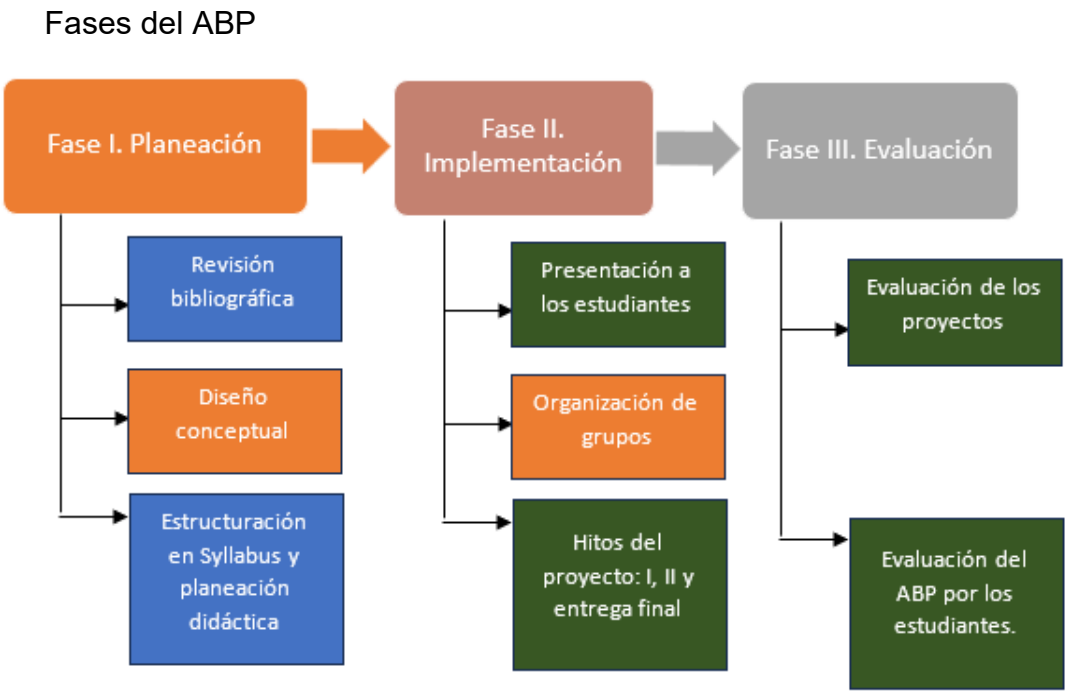


Imagen 1. Diagrama de fases del proceso ABP aplicado en Diseño sostenible de equipos de transferencia de calor.

Planeación. La primera fase correspondió a la planeación, cuyo tiempo, que no se muestra en la Imagen I, es el asignado a los docentes como parte de su preparación de clases. Dentro de esa fase, la **revisión bibliográfica** se enfocó en las palabras clave: "Diseño", "Equipos de transferencia de calor", "Sostenibilidad", "Aprendizaje basado en proyectos", en las bases de datos Science direct; Springerlink y Google scholar. El área temática fue "Ciencias sociales", subtema "Educación". No se limitó a los últimos cinco años, porque se quería ver desde qué año se emplea esta estrategia en la intersección de estos temas. La segunda parte de esta fase fue el **diseño conceptual** de la estrategia que se iba a implementar en el curso, en la que se definió el momento específico del curso para aplicarla; los conocimientos previos; las rúbricas de evaluación; los entregables en cada hito del ABP; los canales de comunicación e interacción; y la bibliografía complementaria de apoyo a los estudiantes. Luego, esta información se llevó de forma concreta al **syllabus** del curso y de manera detallada a la **planeación didáctica**, el documento que pueden seguir los estudiantes para saber el desarrollo de la asignatura por cada una de las 16 semanas de clase.

Implementación. El ABP se explicó en una **presentación** que incluía los objetivos, los hitos evaluativos con sus correspondientes entregables, las rúbricas de evaluación final y la bibliografía complementaria. Una parte de la presentación del ABP consistió en introducir el desafío, dando a conocer las

opciones de problemas reales o ficticios en los que podían trabajar. Luego, formaron **grupos** de forma libre, de dos, tres o cuatro estudiantes, para evitar conflictos debido a que los cursos son transversales a las ingenierías y muchos no se conocen, con la libertad de cambiarse de grupo si durante el desarrollo del proyecto tenían inconvenientes. Los canales de comunicación fueron el correo electrónico, el aula virtual y las tutorías presenciales, tres horas a la semana. Las fechas de entrega de cada uno de los **hitos de evaluación** fueron cada dos semanas. En total fueron tres entregas: avance I, a las dos semanas, avance II, a las cuatro semanas; y entrega final, a las seis semanas desde el inicio del ABP. El Avance I (semana 2), se centró en la definición técnica y los cálculos preliminares de transferencia de calor; y el Avance II (semana 4), permitió que los estudiantes presentaran la selección final del tipo de equipo, de los materiales y la justificación técnica de los ODS vinculados al diseño. Estos entregables permitieron realizar una retroalimentación formativa antes de la entrega del diseño final. En todo momento, el rol del docente fue de facilitador y guía durante las tutorías presenciales, respondiendo dudas por medio de los canales de comunicación y proporcionando retroalimentación en los hitos de control.

Evaluación. La evaluación cualitativa de los proyectos aplicó dos rúbricas: una de heteroevaluación, realizada por el docente para evaluar la calidad del informe técnico final de cada grupo y conocida por los estudiantes. En la Imagen 2 se muestran los criterios técnicos del diseño y de sostenibilidad con sus respectivos niveles de evaluación cualitativa Insuficiente, Aceptable, Bueno, Muy bueno y Sobresaliente (Navarrete-Artime y Belver Domínguez, 2022; Cedeño et al., 2023).

CATEGORIA	Insuficiente	Aceptable	Bueno	Muy bueno	Sobresaliente
1. Presentación, Organización y Estructura	El informe escrito está desordenado, no tiene un formato uniforme y no cumple con la estructura mínima requerida. No cita ni referencia la información.	El informe escrito está desordenado, o no tiene un formato uniforme o no cumple con la estructura mínima requerida. No cita o no referencia la información citada.	El informe escrito está ordenado y tiene un formato uniforme, pero no cumple con la estructura mínima requerida. No cita bien la información ni usa bien el sistema de referencias.	El informe escrito está ordenado, pero no cumple con la estructura mínima requerida o no tiene un formato uniforme. Cita la información o usa bien el sistema de referencias	El informe escrito está ordenado, cumple con la estructura mínima requerida y tiene un formato uniforme. Cita la información y usa bien el sistema de referencias.
2. Aplicación de conceptos de transferencia de calor al diseño del equipo	El proyecto demuestra vacíos importantes de conocimiento y comprensión del tema de intercambiador de calor coraza y tubos. La información presentada no es precisa ni relevante.	El proyecto demuestra algún conocimiento y comprensión del tema de intercambiador de calor coraza y tubos. La información presentada a veces no es precisa o no es relevante.	El proyecto demuestra buen conocimiento y comprensión del tema de intercambiador de calor coraza y tubos. La información presentada a veces es precisa y relevante.	El proyecto demuestra muy buen conocimiento y comprensión del tema de intercambiador de calor coraza y tubos. La información presentada es precisa y relevante.	El proyecto demuestra un profundo conocimiento y comprensión del tema de intercambiador de calor coraza y tubos. La información presentada es precisa y relevante.
3. Integración de la sostenibilidad en el diseño	El proyecto demuestra vacíos importantes en la integración y en la medición de los indicadores de sostenibilidad relacionados con los ODS.	El proyecto demuestra vacíos importantes en la integración o en la medición de los indicadores de sostenibilidad relacionados con los ODS.	El proyecto presenta algunos fallos en la integración y en la medición de los indicadores de sostenibilidad relacionados con los ODS.	El proyecto presenta algunos fallos en la integración o en la medición de los indicadores de sostenibilidad relacionados con los ODS.	El proyecto demuestra gran integración y adecuada medición de los indicadores de sostenibilidad relacionados con los ODS.

Imagen 2. Rúbrica de heteroevaluación. Autor.

Por otro lado, en la Imagen 3 se muestra la rúbrica de coevaluación aplicada a la presentación de los grupos, donde sus compañeros evaluaron a los distintos grupos conforme a criterios de dominio del tema, expresión oral, manejo del tiempo y recursos audiovisuales (Navarrete-Artime y Belver Domínguez, 2022). La importancia de la coevaluación, en un esquema de ABP, radica en que contribuye a fortalecer el proceso de evaluación formativa fomentando un espíritu crítico en el alumnado (Mendoza et al., 2025).

CATEGORIA	Insuficiente	Aceptable	Bueno	Muy Bueno	Sobresaliente
1. Conocimiento y preparación del tema.	Poco conocimiento del tema e información poco relevante.	Demuestra poca confianza y escasa información relevante.	Demuestra confianza, pero falla algunas veces presentando la información precisa del tema.	Demuestra confianza, presentando la información precisa del tema.	Demuestra solvencia y confianza, presentando la información precisa y pertinente del tema.
2. Expresión oral.	Escaso manejo lingüístico, falla en tono de voz y no indica información en pantalla.	Demuestra poco dominio lingüístico y falla tono de voz o no muestra información en pantalla.	Demuestra dominio lingüístico, pero falla su tono de voz y no muestra la información en pantalla.	Demuestra dominio lingüístico, pero falla su tono de voz o no muestra información en pantalla	Demuestra dominio lingüístico, buen tono de voz e indicación de información en pantalla.
3. Estructura y orden.	No tiene orden, no respetan tiempo y dificultan el proceso de comprensión del tema.	Presenta poco orden, sin respetar en forma general los tiempos y dificulta la comprensión del tema de principio a fin.	Presenta alto orden, pero no respetan los tiempos y dificultan la comprensión del tema de principio a fin.	Presenta alto orden, respetando en forma general los tiempos y facilitando la comprensión del tema de principio a fin.	Presenta alto orden, respetando los tiempos y facilitando la comprensión del tema de principio a fin.

Imagen 3. Rúbrica de Coevaluación. Autor.

Análisis de datos

Desempeño técnico de los diseños estudiantiles. Se analizaron los informes técnicos finales para verificar la precisión de los balances de energía y el dimensionamiento térmico e hidráulico de los equipos. Estos datos se sometieron a un proceso de heteroevaluación, comparando los cálculos realizados por los estudiantes con los criterios técnicos y de sostenibilidad establecidos como referencia de acuerdo con la literatura y explicados en clases previas (Kakaç & Liu, 2012; Lee, 2020).

Evaluación de sostenibilidad. Los estudiantes identificaron los Objetivos de Desarrollo Sostenible (ODS) pertinentes y aplicaron indicadores específicos según la bibliografía (Calvo et al., 2021; Grau et al., 2020). La evaluación por parte del docente consistió en verificar la coherencia entre el diseño técnico, el contexto empresarial y la métrica del indicador propuesto.

Análisis comparativo del impacto del ABP y percepciones estudiantiles. Para medir la eficacia de la estrategia, se realizó un análisis comparativo de los promedios de rendimiento académico entre el semestre con ABP (2024-B, n=3 grupos) y el semestre previo bajo enseñanza tradicional (2024-A, n=3 grupos). Por otra parte, los datos de la encuesta de percepción se analizaron mediante estadística descriptiva (frecuencias y promedios) para las escalas Likert. Finalmente, las respuestas abiertas fueron sometidas a un análisis temático cualitativo; estas se transcribieron y codificaron en categorías emergentes que se agruparon en dos dimensiones: "Comentarios positivos" y "Aspectos susceptibles de mejora". Finalmente, los comentarios de la pregunta abierta de la encuesta fueron sometidos a un análisis temático. Las respuestas se transcribieron, se leyeron repetidamente para identificar patrones y se codificaron en categorías emergentes. Estas categorías se agruparon finalmente en dos grandes temas: "Comentarios Positivos" y "Aspectos Susceptibles de Mejora".

Resultados

A continuación, se presentan los resultados, donde los dos primeros componentes (técnico y sostenibilidad) se detallan mediante los hallazgos de la heteroevaluación y coevaluación, mientras que el tercer componente se aborda a través de los datos de rendimiento académico y percepción estudiantil.

Desempeño técnico de los diseños estudiantiles y evaluación de sostenibilidad

En la Tabla 2 se presentan los resultados académicos cualitativos del diseño, discriminados en la heteroevaluación realizada por el docente y la coevaluación por los compañeros.

Nivel cualitativo	Informe del Diseño sostenible	Exposición del diseño	Asignatura	2024 A
	Heteroevaluación	Coevaluación	Promedio de las 16 semanas	Promedio de las 16 semanas
Sobresaliente	25,3 %	4,60%	5,75%	9,09%
Muy bueno	33,3 %	70,11%	63,22%	41,8%
Bueno	25,3%	18,39%	17,24%	32,73%
Aceptable	8,05%	0,00%	11,49%	14,55%
Regular	8,05%	0,00%	1,15%	0,00%
No acreditable	0,00%	6,90%	1,15%	1,82%

Tabla 2. Resultados académicos en el período de estudio.

En comparación con el semestre inmediatamente anterior, el 2024 A, se observa que el porcentaje de estudiantes que alcanzó nivel Sobresaliente cayó en 4 puntos porcentuales; así como en Aceptable, con 3 puntos porcentuales; y en Bueno, con casi 14 puntos porcentuales; pero aumentó el porcentaje de estudiantes en Muy bueno en 22 puntos porcentuales.

Percepciones estudiantiles

En primer lugar, se muestran los resultados de las respuestas cuantitativas, de la 1 a la 5.

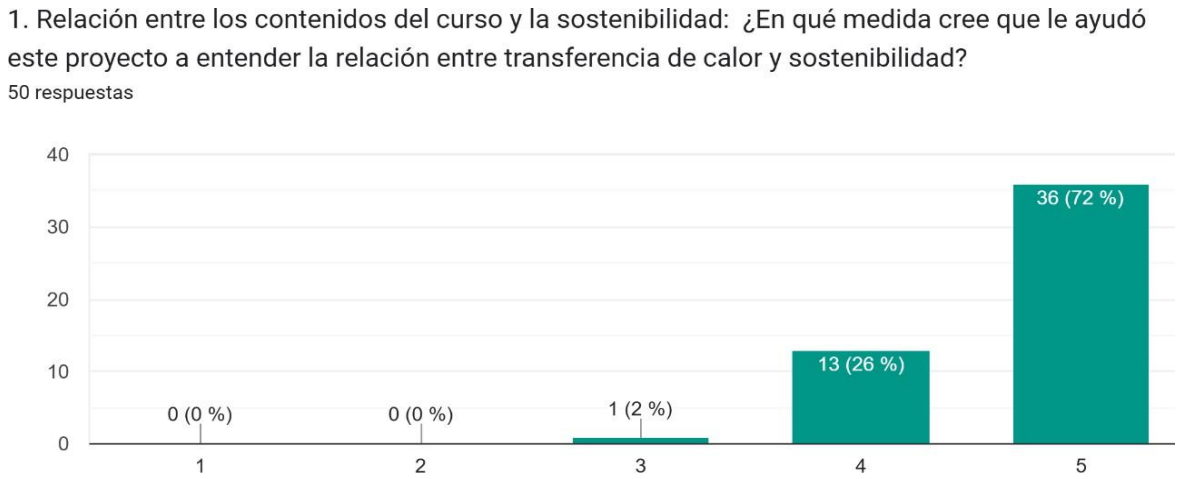


Imagen 4. Resultados de la pregunta 1 de la encuesta de percepción. Autor.

Los resultados de la pregunta 1 (Imagen 4) mostraron un promedio de valoración de 4,52. Promediando entre quienes respondieron 4 y 5, 49 encuestados, es decir, el 72% considera que la realización del proyecto de diseño sostenible le ayudó a entender mucho la relación entre la transferencia de calor y la sostenibilidad. En cuanto a la pregunta 2, como se observa en la

imagen 5, el 96% de los encuestados asignaron 4 y 5 como valor a la relación entre los contenidos del curso y el desarrollo del proyecto, es decir, consideraron que los contenidos teóricos y prácticos de la asignatura ayudaron mucho a la realización del proyecto de diseño sostenible. El promedio de valoración de este aspecto corresponde a un 4,72.

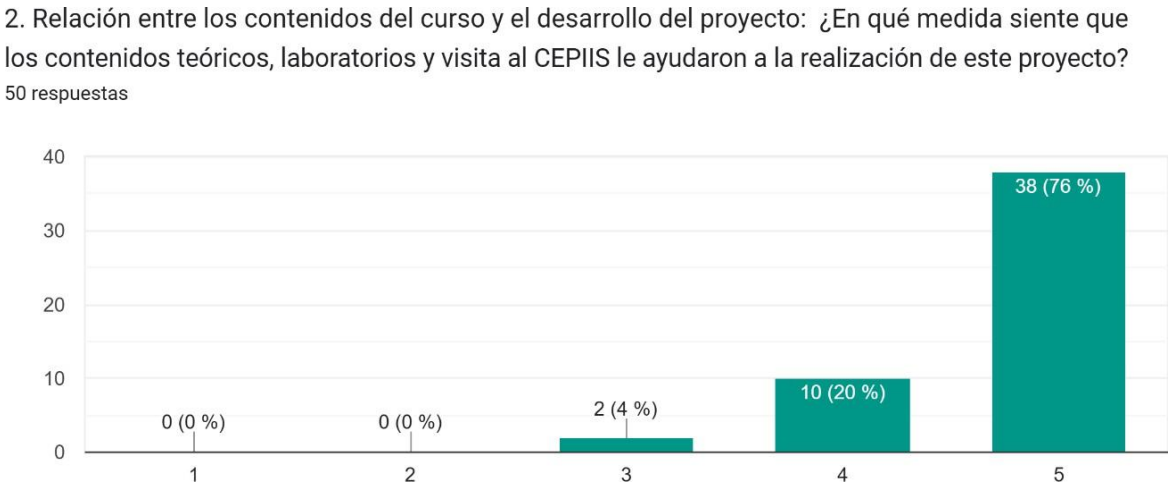


Imagen 5. Resultados de la pregunta 2 de la encuesta de percepción. Autor.

En las respuestas a la pregunta 3, mostradas en la imagen 6, se observa una disminución en la valoración, porque presenta un promedio de 4,52 comparado con los promedios de las preguntas anteriores. Sobre todo, se ve una disminución de 10 puntos porcentuales en la mayor valoración del ítem con respecto a la pregunta 2, y de 6 puntos porcentuales con respecto a la pregunta 1; así como un aumento de 2% a 6% en la valoración 3 para el ítem con relación a la pregunta 1, y de 2 puntos porcentuales con relación a la pregunta 2.

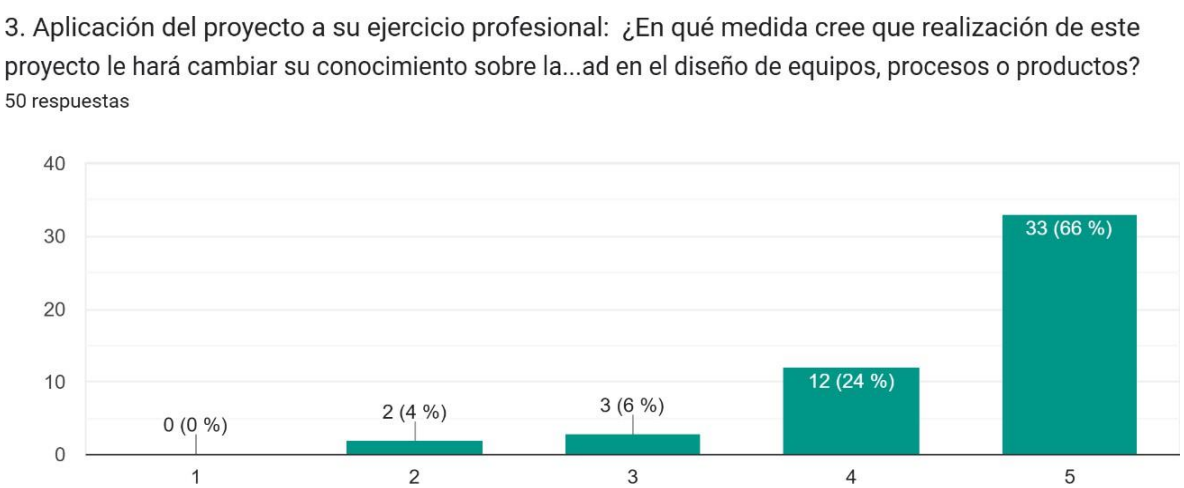


Imagen 6. Resultados de la pregunta 3 de la encuesta de percepción. Autor.

En cuanto a la pregunta 4, la valoración máxima del ítem presenta una reducción de 8 puntos porcentuales con respecto a la pregunta 3, 18 puntos con respecto a la pregunta 2 y 14 puntos con respecto a la pregunta 1. Sin embargo, aumenta el porcentaje de quienes valoran con 4 este ítem, en otras palabras, consideran importante el aporte del proyecto a su desarrollo personal,

pero no tanto con respecto a la relación entre la parte teórica y práctica del curso y el proyecto, así como a la aplicación de la sostenibilidad en el diseño de equipos (Imagen 7).

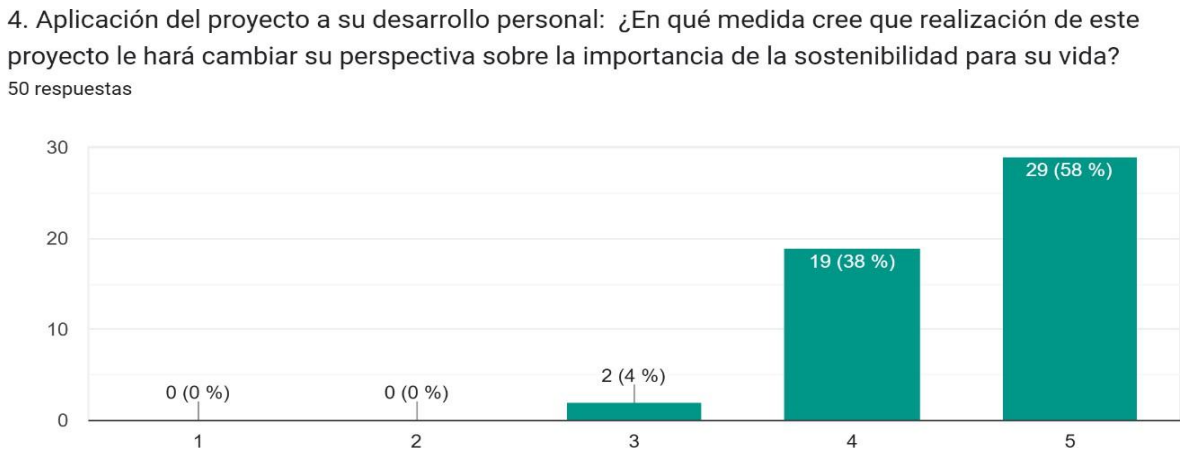


Imagen 7. Resultados de la pregunta 4 de la encuesta de percepción. Autor.

Para terminar el estudio cuantitativo, como se evidencia en la Imagen 8, el 94% considera que el tiempo asignado a la realización del proyecto fue suficiente, o adecuado. Mientras que un 6% lo consideró insuficiente (Imagen 8).



Imagen 8. Resultados de la pregunta 5 de la encuesta de percepción. Autor.

Los comentarios dados de forma anónima, y que se tomaron en cuenta para analizar los resultados de esta investigación, se muestran, clasificados subjetivamente, como "positivos" o "susceptibles de mejora" en la Tabla 3.

Positivos	Susceptibles de mejora
Fue una materia excelente, con contenidos importantes para el desarrollo profesional y personal.	El tiempo para la realización del proyecto debe ser más extensa.
La verdad no tengo mucho que comentar, el profesor ofreció todas las herramientas necesarias para realizar el proyecto de manera amena, al igual que su apoyo al resolver las dudas que se van generando.	Sería bueno realizar visitas a campo para ver diferentes formas de como se aplica en la industria.
Me pareció el tiempo justo y con la tutoría necesaria para resolver dudas.	Tener al menos 2 clases dedicadas únicamente al proyecto, para resolver dudas a tiempo y entregar el trabajo de manera correcta.
No tengo nada que agregar, más que un agradecimiento enorme a su clase profe, el semestre fue muy fructífero y grato respecto a su materia.	Me gustaría que la materia fuera más didáctica, es decir mejores laboratorios no sólo informes, sino donde uno este más tiempo metido en el papel de Ing químico y poder controlar unos solo las variables, ya que el profesor nos decia que poner, sino que uno mismo lo piense y lo desarrolle.
Me parece que así estuvo bien, las clases fueron muy claras.	Trabajar más en lo indicadores para el cumplimiento de los ODS.
Sin comentarios adicionales me parece una buena estrategia didáctica.	Gracias. Como único cometario sería bueno el tener un espacio durante la clase en el cual se puedan resolver dudas del proyecto, esto debido a que muchas veces no se podía ingresar a tutorías por temas de tiempo o se cruzaba horarios académicos.
Considero que las temáticas se manejan de una manera muy correcta, al igual que el modo de dictar la asignatura, además yo que ya vi, diseño de procesos, me consta que todo lo aprendido es súper efectivo y adecuado, además el profesor es excelente, y además de ser buen profesional es buena persona y eso resalta mucho.	Parámetros mas claros desde la primera entrega
	Más ejercicios
	El proyecto se encuentra bien estructurado, sin embargo, sugeriría abrir un espacio de tutorías enfocado en solo resolver inquietudes del mismo
	Seria bueno realizar visitas a campo para ver diferentes formas de como se aplica en la industria

Tabla 3. Comentarios recibidos por parte de los estudiantes.

Nota: Comentarios transcritos literalmente del formulario de encuesta en línea.

Discusión

Se analiza la efectividad de la estrategia de Aprendizaje Basado en Proyectos (ABP) para la enseñanza de la transferencia de calor con un enfoque de diseño sostenible. El análisis se articula en torno a tres ejes fundamentales: (1) el rendimiento académico y la adquisición de competencias técnicas y de sostenibilidad; (2) las percepciones estudiantiles acerca del impacto de la metodología aplicada; y (3) una reflexión pedagógica sobre la implementación de la sostenibilidad en un curso de ingeniería.

Rendimiento académico y adquisición de competencias individuales

Como se muestra en la Tabla 2, el aumento de 22 puntos porcentuales en la categoría "Muy bueno" respecto al semestre previo sugiere que la metodología aporta una mayor consistencia en el rendimiento académico (Calvo et al., 2022). Este hallazgo es congruente con la literatura que afirma que las metodologías activas resultan en un aprendizaje más profundo y una mejor capacidad para resolver problemas reales (Barrera Arcaya et al., 2022; Guerra, 2017).

Un aspecto distintivo de esta implementación fue la evaluación explícita de la sostenibilidad mediante indicadores técnicos cuantificables, como aumento de la eficiencia energética, kg de CO_2 evitados o ahorro de agua y/o de vapor, vinculados con los ODS 7, 13 y 12, respectivamente. Representa un avance respecto a estudios previos en ingeniería, como el de Garrido de la Torre et al. (2020), en el que no se integraba este componente en el diseño y una aplicación de los ODS a la ingeniería térmica, a diferencia de lo realizado por Blanco (2021) quienes lo aplicaron en ingeniería de sistemas. La capacidad de los estudiantes para justificar sus diseños desde una perspectiva de sostenibilidad valida el ABP como un vehículo eficaz para el desarrollo de competencias transversales como el pensamiento crítico y la toma de decisiones (Herrera-Castrillo, 2025; Sanchis et al., 2020).

Complementariamente, el proceso de coevaluación permitió valorar competencias transversales fundamentales para el ejercicio profesional, como el dominio del tema, la expresión oral y el manejo de recursos (Navarrete-Artime y Belver Domínguez, 2022). El alto porcentaje de estudiantes en el nivel "Muy bueno" indica que la mayoría logró comunicar eficazmente sus hallazgos ante sus compañeros, fortaleciendo el trabajo en equipo y la capacidad de análisis crítico (Herrera-Castrillo, 2025; Sanchis et al., 2020). No obstante, el menor porcentaje en el nivel "Sobresaliente" en esta área sugiere una oportunidad para fortalecer las habilidades de oratoria o ajustar las expectativas de la rúbrica para estas competencias específicas (Kricsfalusy et al., 2018).

Percepciones estudiantiles sobre la estrategia ABP

Un promedio de 4,58 en las respuestas 1 a 4 (Figuras 4 a 7) indica que la mayoría de los estudiantes consideró que el proyecto se relacionó “mucho” o “bastante” con los contenidos del curso; y que, a su vez, los contenidos del curso se pudieron integrar con los principios de la sostenibilidad. Por último, su conocimiento sobre la aplicación de la sostenibilidad al diseño se

mejoró “mucho” o “bastante”; así como su perspectiva sobre la importancia de la sostenibilidad para la vida, lo que favorece el desarrollo de competencias sociales y éticas en los estudiantes (Blanco et al., 2021; Calvo et al., 2022).

Sin embargo, se observó una brecha entre la aplicación profesional y la personal de los principios de la sostenibilidad, analizando los resultados específicos de las preguntas 3 y 4; como indican Intriago-Zambrano et al. (2025), la transferencia de aprendizajes técnicos a la esfera personal requiere procesos reflexivos más prolongados.

Por otro lado, varios estudiantes utilizaron el espacio de comentarios para referirse a aspectos generales del curso, más allá del proyecto de diseño sostenible. Esto indica que el instrumento de evaluación podría beneficiarse de una formulación más precisa que delimite claramente el objetivo de cada pregunta, como recomiendan Navarrete-Artime y Belver Domínguez (2022).

Respecto al tiempo asignado para la realización del proyecto, la discrepancia entre algunos comentarios cualitativos con relación a los resultados cuantitativos de la quinta pregunta permite inferir que hubiera sido necesarias más sesiones exclusivas al proyecto. Esta diferencia entre datos cuantitativos y cualitativos refleja la importancia de aplicar métodos mixtos para evaluar estrategias educativas, permitiendo captar matices que no son evidentes en una sola fuente de información (Navaridas-Nalda et al., 2020).

Reflexión pedagógica e implicaciones para la práctica educativa.

En síntesis, los hallazgos de este estudio, tomados en conjunto, proveen evidencia robusta para responder a la pregunta de investigación. La estrategia de ABP demostró ser un vehículo pedagógico eficaz, porque logró una mejora medible en el rendimiento académico (el aumento de 22 puntos en la categoría 'Muy bueno') y se validó la conexión explícita con la sostenibilidad, como lo demuestra la alta percepción de los estudiantes (promedio de 4,58) y, fundamentalmente, la capacidad de aplicar la teoría a problemas reales, un pilar del aprendizaje profundo (Barrera Arcaya et al., 2022).

Por su parte, en contraste con los resultados cuantitativos positivos en relación con el tiempo adecuado, en los comentarios algunos estudiantes muestran que, aunque se les brindaron herramientas adecuadas, faltó más tiempo para el desarrollo del proyecto, o que faltó un espacio adicional para resolver dudas. No obstante, se observa que varios comentarios se orientaron hacia la clase, no solo hacia el objetivo real de la encuesta, que era el proyecto de diseño sostenible.

A la luz de los comentarios de los estudiantes sobre la necesidad de ampliar los espacios para solución de dudas, con clases exclusivas para los aspectos del proyecto, se considera como un aspecto de mejora para próximas implementaciones de esta estrategia. Y en un futuro, si los resultados así lo indican, se podría extender a otras asignaturas. En todo caso, hace falta replicar estas experiencias y, sobre todo, recibir mayor apoyo y formación para que los docentes se atrevan a realizar ABP orientado a la sostenibilidad, pues, tal como advierten Blanco et al. (2021)

y Sánchez-Carracedo et al. (2020), para consolidar estas estrategias es fundamental fortalecer la formación docente en el uso pedagógico de los ODS y metodologías activas, y contar con el respaldo institucional que facilite su implementación sistemática.

Para futuras implementaciones, se recomienda ampliar los espacios de tutoría exclusivos y asegurar el respaldo institucional para la formación docente en el uso pedagógico de los ODS (Blanco et al., 2021; Sánchez-Carracedo et al., 2020). En conclusión, el ABP aplicado en el curso de transferencia de calor, con enfoque en diseño sostenible, no solo mejora el rendimiento académico, sino que fomenta una responsabilidad social indispensable para la ingeniería contemporánea (Requies et al., 2024).

Referencias

Barrera Arcaya, F., Venegas-Muggli, J. I., & Ibacache Plaza, L. (2022). El efecto del Aprendizaje Basado en Proyectos en el rendimiento académico de los estudiantes. *Revista de estudios y experiencias en educación*, *21*(46), 277-291. http://doi.org/10.21703/0718-5162.v21.n46.2022.015.

Blanco, J. M., Arruabarrena, R., Bermejo, M., Usandizaga, I., & Jaime, A. (2021). Una experiencia de inclusión de los Objetivos de Desarrollo Sostenible en la asignatura Gestión de Proyectos. *Actas de las Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI), 6*, 251–258.

Caicedo, J. (2020). Proyectos de diseño mecánico como herramienta para el desarrollo de competencias transversales en los ingenieros. *Revista Educación en Ingeniería, 15*(30), 60-73. https://doi.org/10.26507/rei.v15n30.1127

Calvo, I., Gil-García, J. M., Carrascal, E., Armentia, A., Barambones, Ó., Basogain Olabe, X., ... & Apiñaniz, E. (2022). Introduciendo sostenibilidad y multidisciplinaridad en los grados de ingeniería. *XLIII Jornadas de Automática* (pp. 262-269). Universidade da Coruña. Servizo de Publicacións. https://doi.org/10.17979/spudc.9788497498418.0262

Castellanos, L. M., & Hernández, A. A. (2010). Una alternativa metodológica innovadora para formar y evaluar competencias a través de proyectos de curso en las carreras de ingeniería. *Revista Educación en ingeniería*, *5*(10), 37-48.

Cedeño, E. I. B., Loor, J. S. L., Garófalo, A. R. B., & Almeida, J. J. M. (2023). La evaluación formativa en la práctica pedagógica de la Educación Superior: Revisión Sistemática. *Ciencia Latina Revista Científica Multidisciplinar*, *7*(3), 1464-1476. https://doi.org/10.37811/cl_rcm.v7i3.6289

Garrido de la Torre, M. E., Pérez-Zuriaga, A. M., Martínez-Ibáñez, V., López Maldonado, G., & Cuadrado Tarodo, Á. (2020, December). PIME Aprendizaje Basado en Proyectos: Ingeniería de Carreteras e Ingeniería Geotécnica. In *IN-RED 2020: VI Congreso de Innovación Educativa y Docencia en Red* (pp. 293-306). Editorial Universitat Politècnica de València. https://doi.org/10.4995/INRED2020.2020.11929

Grau, S. O., Gimeno, F., Chilet, S. S., Altozano, P. G., Peralta, I. B., Estevan, C. V. P., ... & Aparisi, A. E. (2020). Instalación Fotovoltaica con Almacenamiento en Baterías de Litio para la Inclusión de los Objetivos de Desarrollo Sostenibles en las Ingenierías. In *XIV Congreso de Tecnologías Aplicadas a la Enseñanza de la Electrónica: Proceedings TAEE 2020= XIV Conferência em Tecnologias Aplicadas ao Ensino da Eletrónica= XIV Conference on Technology, Teaching and Learning of Electronics* (pp. 153-160). Instituto Superior de Engenharia do Porto.

Guerra, A. (2017). Integration of sustainability in engineering education: Why is PBL an answer? *International Journal of Sustainability in Higher Education, 18*(3), 436-454. https://doi.org/10.1108/IJSHE-02-2016-0022

Requies, J., Barrio, V. L., Acha, E., Agirre, I., Viar, N., & Gandarias, I. (2024). Integration of sustainable development goals in the field of process engineering through active learning methodologies. *Education for Chemical Engineers, 49*, 26-34. https://doi.org/10.1016/j.ece.2024.05.003

Herrera, R. F. (2017). Collaborative project-based learning of environments programming from civil engineering projects. *Revista Electrónica Educare*, *21*(2), 205-222. http://dx.doi.org/10.15359/ree.21-2.10

Herrera-Castrillo, C. (2025). Metodología para el aprendizaje por competencias de JeHe en física y matemáticas. *Revista Digital de Investigación en Docencia Universitaria, 19*(1), e1759. https://doi.org/10.19083/ridu.2024.1759

Iturralde Durán, C. (2019). Los paradigmas del desarrollo y su evolución: Del enfoque económico al multidisciplinario. *RETOS. Revista de Ciencias de la Administración y Economía*, *9*(17), 7-23. https://doi.org/10.17163/ret.n17.2019.01

Intriago-Zambrano, D. A., Huatatoca-Chimbo, L., Vasconcellos, N., & Pérez, O. M. (2025). ABP como fortalecedor del conocimiento en materias básicas de la Unidad Educativa Básica Eloy Alfaro. *Revista Panamericana de Pedagogía*, *40*. http://doi.org/10.21555/rpp.3367

Kakaç, S., Liu, H., & Pramuanjaroenkij, A. (2012). *Heat exchangers: selection, rating, and thermal design*. *Third edition*. CRC press.

Kricsfalusy, V., George, C., & Reed, M. G. (2018). Integrating problem-and project-based learning opportunities: Assessing outcomes of a field course in environment and sustainability. *Environmental education research, 24*(4), 593-610. https://doi.org/10.1080/13504622.2016.1269874

Lee, H. (2022). *Thermal design: heat sinks, thermoelectrics, heat pipes, compact heat exchangers, and solar cells*. John Wiley & Sons. https://doi.org/10.1002/9781119686040

Mendoza, C. E., Game-Varas, C., & Alcívar, A. (2025). Estrategias efectivas de retroalimentación en el Aprendizaje Basado en Proyectos para mejorar la calidad de Educación Superior. *Revista Científica Arbitrada Multidisciplinaria PENTACIENCIAS*, *7*(2), 280-300. https://doi.org/10.59169/pentaciencias.v17i2.1442

Navaridas-Nalda, F., González-Marcos, A., & Alba-Elías, F. (2020). Evaluación online orientada al aprendizaje universitario: Impacto del feedback en los resultados de los estudiantes. *Revista Interuniversitaria de Formación del Profesorado, 34*(2), 101-120. https://doi.org/10.47553/rifop.v34i2.77697

Navarrete-Artime, C., & Belver Domínguez, J. (2022). Evaluar con rúbricas. Una propuesta exitosa dentro del ABP. *Revista Iberoamericana de Evaluación Educativa*, *15*(1), 101-120. https://doi.org/10.15366/riee2022.15.1.006

Ordoñez-Pacheco, Á. F. (2025). Metodología de la Investigación Metodología académica con aplicación a las investigaciones sociales: enfoques, tipos, métodos y diseños. *Sociedad & Tecnología*, *8*(2), 335-357. https://doi.org/10.51247/st.v8i2.484

Puenayán, M. R., Suárez, M. G. E., Sampedro, N. M. V., Almachi, L. P. A., & Jiménez, N. I. A. (2024). El Aprendizaje Basado en Proyectos (ABP) como Estrategia Didáctica para Mejorar el Rendimiento Académico. *Ciencia Latina: Revista Multidisciplinar*, *8*(4), 10447-10459. https://doi.org/10.37811/cl_rcm.v8i4.13186

Rodríguez-Sandoval, E., & Cortés-Rodriguez, M. (2010). Evaluación de la estrategia pedagógica" aprendizaje basado en proyectos": percepción de los estudiantes. *Avaliação: Revista da Avaliação da Educação Superior (Campinas)*, *15*(1), 143-158. https://doi.org/10.1590/S1414-40772010000100008

Sanchis, R., Mula, J., Cantó, B., García-Sanoguera, D., & Torregrosa, J. I. (2020). Incorporación del aprendizaje basado en proyectos en las titulaciones de grado del Campus de Alcoy de la Universitat Politècnica de València. En *IN-RED 2020: VI Congreso de Innovación Educativa y Docencia en Red* (pp. 366-376). Editorial Universitat Politècnica de València. https://doi.org/10.4995/INRED2020.2020.12030

Viáfara, C. (2020). Desarrollo de proyectos colaborativos con la industria como estrategia de educación en ingeniería. *Revista Educacion en Ingenieria*, *15*(29), 1-12. https://doi.org/10.26507/rei.v15n29.1030