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Editorial

Nineteenth Issue of the Journal of Problem Based Learning in Higher Education

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Bettina Dahl Søndergaard | Aalborg University, Denmark

Welcome to the first issue of the twelfth volume of the Journal of Problem Based Learning in Higher Education. This is our annual issue and contains 5 research papers and 3 case studies. The scope of the journal is nicely mirrored in the papers and cases, and the range of our mutual interest in the topic of PBL in Higher Education is showcased by the diversity of the papers and cases. Once again, our authors come from all over the world, Brazil, Denmark, Turkiye, Germany, Sweden, and the UK, and are focused on a variety of areas such as group assessment, supervision methods, organisational change, teacher training etc.

This issue also includes the first paper in our new series *Invited Author*. This series of papers is meant to give prominent researchers in the field of PBL a chance to write something from the heart. We hope that the initiative will work as an inspiration and spark reflections and discussions. Our first invited author is Professor John Mitchell at University College London. Professor Mitchell has been a leading figure in Engineering Education for many years and is a strong proponent of PBL. His paper is co-authored with Professor Emanuela Tilley also at UCL. In their paper, Professors Mitchell and Tilley discuss the role of PBL as a thread throughout a full curriculum, entangling the pedagogic of PBL not only

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in specific targeted activities, but as a continuous presence in shaping the curriculum and "*to enable programmes to connect theory, practice, societal context, values and skills as well as to break the mentality that comes with modularisation*". This is a valuable contribution to the discussions of the nature of PBL and the impact and involvement it has on programs and curriculums. We believe our new series, *Invited Author*, is off to a most promising start.

Over the years, our journal has developed from its core of Aalborg University researchers to an international forum for both authors and audience. Next year we launch a new initiative that enhances the international perspective of the journal. We will include a section in our annual issue that publishes papers and cases in Spanish. That all research is to be conducted and presented in English is no natural law, and a plurality of languages can have its advantages. Nuances and perspectives can get lost in translation, and the commonality of "research-English" has for decades, perhaps slightly unjust, benefited researchers with English as a natural language. Spanish is spoken by approximately 500 million people around the world, making it the second most spoken native language (after Mandarin Chinese). Spanish is also widely taught as a second or third language in many countries and areas of the world. To launch a Spanish section of the journal is an experiment, that we hope will be well received in the research community. All papers and cases in the Spanish section, will have an abstract in English, making their claims and ideas accessible for a larger audience. Although we encourage researchers to engage with a plurality of languages, we imagine that with modern technology, the Spanish content can be made readable with a minimum of effort. To edit our Spanish section, we have invited Associate Professor John Vergel from Universidad del Rosario in Bogota, Columbia, to be part of our editorial team. Welcome John!

A lo largo de los años, nuestra revista ha evolucionado desde su núcleo de investigadores en la Universidad de Aalborg hasta convertirse en un foro internacional, tanto para autores como para lectores. El próximo año reforzaremos la perspectiva internacional de la revista con una nueva iniciativa, una sección en nuestro número anual dedicada a publicar artículos y casos en español. Que toda la investigación deba ser realizada y presentada en inglés no es una ley natural, y la pluralidad de lenguajes puede tener sus ventajas. Los matices y las perspectivas a menudo se pierden en la traducción, y el predominio del inglés como idioma académico ha favorecido durante décadas, quizá de forma injusta, a quienes lo tienen como lengua materna. El español es hablado por aproximadamente 500 millones de personas en todo el mundo, lo que lo convierte en la segunda lengua materna más hablada (después del mandarín). Además, el español se enseña ampliamente como segunda o tercera lengua en muchos países y regiones del mundo. Incorporar una sección en español en la revista es una iniciativa que esperamos sea bien recibida por la comunidad académica y que contribuya, aunque sea de forma modesta, a promover una mayor diversidad lingüística en la investigación junto al

predominio del inglés. Todos los artículos y casos de la sección en español incluirán un resumen en inglés, lo que hará que sus propuestas e ideas sean accesibles a una audiencia más amplia. Aunque animamos a los investigadores a comprometerse con una pluralidad de lenguajes, imaginamos que, con la tecnología moderna, el contenido en español se podrá hacer legible con un esfuerzo mínimo. Para editar nuestra sección en español, hemos invitado al profesor John Vergel, de la Universidad del Rosario en Bogotá, Colombia, a formar parte de nuestro equipo editorial. ¡Bienvenido, John!

Translated from English to Spanish by John Vergel.

We also have other new members of the editorial team. Due to other commitments and engagements, both Associate Professor Frederik Hertel and long-time member of the team Associate Professor Lykke Brogaard Bertel have left us. To join in their place, we have this year welcomed Associate Professor Vibeke Andersson and welcomed back Associate Professor Jette Egelund Holgaard to the editorial team.

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

Kasper Sørensen
Lone Krogh
Stine Bylin Bundgaard
Giajenthiran Velmurugan
Carla Smink
Anne Mette Mørcke
Vibeke Andersson
Nicolaj Riise Clausen
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The Role of Project Based Learning at the Core of Curriculum Development

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Abstract

This paper will present the argument that while Problem Based Learning (PBL) (or its variant Project Based Learning, PjBL) provides significant benefits and advantages to student learning in of itself, the full benefit of PBL is only completely realised as part of an "integrated" curriculum that provides a variety of learning opportunities and instructional support. We propose that PBL should be more widely considered and used as the key integrative feature within a curriculum to enable programmes to connect theory, practice, societal context, values and skills as well as to break the mentality that comes with modularisation. To do this, we suggest that a coherent thread of PBL should be enacted that is stratified to progress students through increasingly open problems and projects, each connected to other aspects of the taught curriculum while enabling skills development and the formation of professional and responsible attitudes and attributes. We provide some examples from our own experience in Engineering but advocate that this approach is much more widely applicable within higher education.

Keywords: Problem Based Learning (PBL), Curriculum Design, Curriculum Development, Integrated Curricula.

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Introduction

Higher education has evolved significantly over the last decade, responding to external pressures as well as further rehearsing its on-going debate of the role of higher education in civilised society as espoused historically by Humboldt (Anderson 2004), Newman (1996) and more recently by the likes of Barnett (2011) and Marginson (2016). The emerging and complex landscape in which degree programmes are conceptualised include increased emphasis on quality assurance mechanisms, opportunities for blended and hybrid learning, as well as a reimagining of the disciplines and boundaries of disciplinary knowledge. Emerging topics such as AI and big data, as well as our necessary response to climate change and the climate emergency, cast a long shadow over the fundamental topics traditionally taught and are increasingly demanding a response from educators.

Perhaps most notably, in subjects such as science and engineering, the concept that learning should no longer be primarily based on the imparting of propositional knowledge but instead that such knowledge should sit within a much wider general context that is socially constructed and developed in a student-led environment (Goldberg & Somerville, 2023) has gained momentum. This has led to the development of curriculum frameworks, such as the Connected Curriculum (Fung, 2017) which aim to provide an outline of how relationships can be formed within the design of a curriculum to connect students with research, with the public, with the workplace and with each other across disciplines. Unfortunately, these desires for interconnectivity at times run counter to other developments in higher education, most notably that of modularisation. While neatly defined boxes of knowledge or educational activity, self-contained in terms of delivery and assessment, are convenient for university processes and accreditation bodies, they encourage compartmentalised thinking in both students and staff. All disciplines like to think of themselves as being hierarchical rather than encyclopaedic in terms of their knowledge structures, however, in STEM subjects this is often made starker with clear progressions of modules in a single subject spanning across years – for example in engineering, Thermodynamics I and II or Structures I and II or Electronic Circuits I and II, are all common disciplinary threads.

Set against this landscape we argue that a form of curriculum design is needed that is pragmatic, but also creates vehicles for flexibility and substantial change as new opportunities or requirements present themselves. Problem-Based Learning (PBL) has become a widely accepted pedagogy within many disciplines and particularly vocational disciplines such as engineering (Chen, Kolmos & Du, 2021) and medicine (Barrows, 1996). Alongside this, significant research has gone into evaluating the effectiveness of PBL as an instructional

tool at a variety of levels, from its implementation in schools (Dole, Bloom & Doss, 2017) to higher education (Guo et al., 2020). In this paper we are going to argue that a central core of problem (or project) based learning pervading all years within a degree program and structured as a progression of skills and technical depth is an ideal mechanism to create connections between elements of the curriculum and create a structure greater than the sum of its parts. We will draw on our experience in engineering, however, we suggest that for many disciplines a key curriculum design consideration should be to ensure that PBL experiences are structured with stages and not a series of unconnected activities. We propose that this approach is an ideal framework for revision of existing curricula – recognising the fact that the exact nature of the revision, for example the size of the PBL components, will be heavily dependent on the local context and legacy frameworks and that no single implementation could be prescribed. Instead, we suggest curriculum designers use our conceptualisation of a PBL core as an inspiration for their own models, acknowledging that the reuse of a considerable amount of the existing teaching activity will very often be necessary.

The authors are both engineering educators and educational researchers with leadership and Professorial positions in the UCL Faculty of Engineering Science, a research-intensive university in London, UK. Both have been involved in developing integrated programmes, most notably, UCL's Integrated Engineering Programme (IEP) (Mitchell, Nyamapfene, Roach & Tilley, 2021), where technical and transferable skills are combined within a curriculum centred around a core of Project Based Learning. They advise universities worldwide on strategies to review and adapt their curricula to incorporate active learning and to refocus their educational approaches to produce highly employable graduates for the modern workforce. This paper draws on these experiences of curriculum design and support of curriculum development in different contexts.

We will start by clarifying some definitions and describing the theoretical frameworks in which we propose our curriculum design.

What is the Curriculum and Curriculum Development?

It is common to consider the curriculum as having four elements (Bernstein, 2000) which involve different, although sometimes intersecting, groups within a university. Firstly, there is the *planned curriculum*, that which is designed, developed and ultimately validated through bureaucratic university processes. Secondly, there is the *delivered curriculum*, the manifestation of the designed curriculum when put into practice. Thirdly, there is the *received or perceived*

curriculum, acknowledging that the curriculum received by students may differ from that proposed or delivered by staff. Finally, and perhaps most crucially, but most often ignored, is the *hidden curriculum*, that which is not formally specified but tacitly transmitted thought the processes and cultures that are inherent in the educational organisation. For new programmes, the first element is typically driven by a programme lead or a visionary tasked with developing a new curriculum, perhaps supported by a small team. Once established, there may be periodic review by senior members staff, for example a Director of Studies. The remaining three elements are the sum of the inputs of many different actors who form the teaching 'team' that are responsible for all the separate elements of the programme. The coherency of this team and the extent to which there is a shared vision and understanding of the programme will contribute significantly to how and how far these elements diverge from the planned curriculum.

Typically, within each of these curriculum lenses discussions take place about what should be specified. The most common approaches have tended to focus on the content of the curriculum – the 'what' of the curriculum. For many years, documentation from accrediting bodies or government ministries specified, sometimes to minute detail, the specific knowledge a graduate engineer should acquire during their studies. Most recently an outcomes-based approach has been adopted in many parts of the world, reframing the requirement to be the knowledge and skills acquired by students by the completion of their studies. This has led to other aspects of professional practice to encroach and take priority in the act of curriculum design. This has been within the context of the shift to learning outcomes as the starting point of the development, which encourages the recognition of the importance of skill and competencies in graduates in addition to fundamental knowledge. We have also seen discussion of organisation processes, such programme level assessment and synoptic projects or synoptic assessment methods (synoptic - an element outside the modular structure that covers students' understanding of the links between the different elements of a subject). Although in many cases there is significant contextual constraints to making these changes, they demonstrate potentially significant shifts in pedagogy and assessment practices (Blackmore & Kandiko, 2012) that might be considered.

Despite engineering degrees often being considered as vocational, fitting with Short's (2000) definition of a 'practical' or 'mission-orientated' subject, the typical engineering curriculum, especially at top-ranking, research-intensive universities often has much in common with the 'Disciplinary Knowledge' model that Short would ascribe to philosophy or the sciences. In reality, this emphasis on knowledge over practice means that curriculum design becomes heavy on theory, with a focus on mathematics and science as the core, that leads

to engineering science theory and application of theory in later years – the math-science death march as characterised by Goldberg and Somerville (2014). A shift from this situation has been the centre of the majority of the curriculum development activities in recent years and in emerging calls for reshaping of engineering education (Habbal et al., 2024).

Although often implicit and highly contextualised, institutional structures, including ways of working and culture, are rarely articulated clearly, thus we deem interrogation of the organisation processes of the curriculum an important starting point to any design. Most faculty assume they work within a set of organisational constraints that are 'normal' (i.e. the same everywhere) despite huge variation occurring between countries and even between institutions within the same country. For example, in the UK and Canada, as well as many Nordic countries, the concept of a curriculum can take on a fairly rigid structure, with precisely described modules in a predefined order certainly not uncommon in the first two years if not further into the programme, especially in Science and Engineering. In contrast, in the USA, Egypt, and certain parts of Europe the curriculum is often far less structured, with credit-hour systems that allow considerable free choice in the modules taken (as long as the subject hours add up), when they are taken and in some cases even in the order in which they are taken (although pre-requisites exist). The differences in these fundamental structures mean that the level of curriculum 'design' that is possible can be very different depending on the context. In the Integrated Engineering Programme (IEP) at UCL, all bar one module of the first two years is pre-determined in both content and order for each discipline allowing the possibility of a programme level curriculum design to a high-level of detail creating a complex web of interconnections to be formed between modules and interconnecting activities (Mitchell et al., 2021). In contrast, the New Engineering Education Transformation (NEET) at MIT had to introduce far more structure than typical to provide coherent threads of modules within their degree programmes (Crawley & Hosoi, 2019).

Taking this concept of the curriculum, one which considers the knowledge and skills but also the academic process, pedagogy and assessment, we define curriculum design as: *the systematic process that defines what will be taught, who are the teachers, who will be taught, and how they will be taught within an engineering education.* We define curriculum development as: *involving the planned, purposeful, progressive, and holistic process to create positive improvements in an education system so that graduates are best prepared to maximise their future*. As such both draw together threads of knowledge and transferable skills and pedagogic approaches to create an amalgamated set of learning experiences to meet the intended programme level outcomes.

The desire to have Programme level outcomes stems from a shift in thinking towards Outcome-based education (OBE) (Premalatha, 2019) which (in engineering at least) has, in part, been led by accreditation as well as by other quality assurance mechanisms within the academy, included a recent emphasis on the skills and employability of graduates. OBE "means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences." (Spady, 1994, p11). This is a central conceptualisation of our approach to curriculum design, where the elements within the curriculum are all intended, in one way or another, to progress the student towards the ultimate programme level goals (Premalatha, 2019). It is highly likely that these stages themselves will also be expressed as having goals – often expressed as module level learning outcomes, but the key consideration is that they do not occur in isolation but as stages in a longer journey towards successful degree completion. It is also important to note that there is a multiplicity of programme level outcomes and although many may interrelate and support each other this is not always necessary.

Perhaps the most common example of this can be seen in accreditation documents that specify the graduate attributes and competencies. For example, in the UK Engineering Accreditation documentation one such outcome is "Analyse broadly-defined problems reaching substantiated conclusions using first principles of mathematics, statistics, natural science and engineering principles." (Engineering Council, 2020, p28). This demonstrates how outcomes may provide overarching coverage of skills – in this case analytical skills – with knowledge – mathematics, statistics, natural science and engineering principles. A key feature is that they are the product of multiple, interconnected learning elements within the curriculum rather than one single class, module or activity. Such statements can be seen in many disciplines, for example, Law "The ability to demonstrate knowledge and understanding of a wide range of legal concepts, values, principles and rules of English law and to explain the relationship between them in a number of particular areas" (SRA, 2014, Appendix A) or Medicine "recognise the complex medical needs, goals and priorities of patients, the factors that can affect a patient's health and wellbeing and how these interact. These include psychological and sociological considerations that can also affect patients' health" (GMC, 2018, p11).

What these definitions of curriculum development and design seek to highlight is that the curriculum is the drawing together of threads, some relating to technical content, some relating to transferable skills and purposely proposes to connect them in the students' understanding of the discipline within the context of the institutional vision, values and strengths. In our conceptualisation of this prevalent curriculum model, which exists within

many higher education institutions, it is then Problem (or Project) Based Learning that then becomes the central mechanism around which the rest of the curriculum is structured. It becomes the vehicle for skills to be developed and the place where core technical content is applied. It is where connections are made, and an opportunity presented for all these elements to be integrated through authentic experiences. However, it can also be the place where new knowledge is created. All open-ended projects offer that opportunity, and while not all students will achieve this it is paramount that intellectual space is available for new areas to be explored. It should, however, also be noted that preparation is needed. Isolated PBL without providing students with support or basic training in the skills required for success in that environment can be counterproductive. Any design should consider how students build and development communications skills, teamwork skills and critical thinking skills both inside and outside the PBL environment so they are prepared to get maximum value out of the project experience.

Problem and Project Based Learning

We have placed PBL at the heart of our curriculum, but why? Well firstly we should include our definition of PBL as it is quite evident from the literature that PBL covers a vast array of student-centred activities and forms. PBL is generally characterised as a constructivist, active learning technique built on the use of ill-structured problems (Savery & Duffy, 1995; Barrows, 1996) which form the core stimulus for the learning process (Savin-Baden & Major, 2004). It is typically undertaken within groups or teams. We further define Project Based Learning in a broad category that can be encapsulated after Hanney and Savin-Baden (2013, p8) as:

> "A time-bounded activity which is directed by the project participants or team, who determine the course of the project and the final output in response to a brief of some description."

For many years, the argument has raged (although this is perhaps putting it too strongly) as to where particular instructional models sit in the taxonomy landscape that surrounds PBL - this was even before the new entrances of Challenge-Based Learning (CBL) (Gallagher & Savage, 2023), Design-Based Learning (DBL) (Davis, 1998), Team-Based Learning (TBL) (Hrynchak & Batty, 2012) etc. where invented and created an even more confusing alphabet soup. We take the stance that in the evolutionary tree of these approaches, PBL is the central ancestor and most fundamental description of the genre. Although we also note that there are many lists of characteristics that are subscribed to PBL. For example, Savery (2015, p7) in *Essential Readings in Problem-based Learning* described PBL as "an instruction (and curricular) learner-centred approach that

empowers learners to conduct research, integrate theory and practice, and apply knowledge and skill to develop a viable solution to a defined problem. Critical to the success of the approach is the selection of ill-defined problems (often interdisciplinary) and a tutor who guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience".

This definition covers many of the elements typically attributed to PBL. There is, however, an important omission here, often present in other definitions. That is for the need of the problems to be authentic to the discipline or interdisciplinary context in which the problem exists. We suggest that this is critical to the success of PjBL activities and to the engagement of students (Roach, Tilley, & Mitchell, 2018). It is because of this that we believe in many subjects the difference between PBL and PjBL is at best blurred and in practice, in engineering at least, it is almost non-existent as projects are recognised as a unit of work associated with the profession and thus inherently align with our authentic learning argument (Lahiff et al., 2019). Hence, in our experience of engineering education, we have most commonly implemented what we would consider to be Project Based Learning. While we will typically use the PBL nomenclature in the rest of this paper, there is no reason that in an appropriate context, the other approaches mentioned above could not replace anything discussed here.

It should be noted that Boud and Felettir (1997) caution against confusing PBL as an approach to curriculum design with the teaching of problem solving. This is something with which we strongly agree – PBL is educational tool that can be called upon within a curriculum design – not a starting point (e.g. we must have 50% PBL) around which a design should be based. While we are strongly advocating for the inclusion of a significant element of PBL, it is precisely because of its features of authenticity, its ability to encourage students to integrate theory and practice, and its appropriateness as a vehicle to allow students to apply skills within context, rather than any predetermined institutional ideology concerning its role as a transformative or reforming pedagogy. For example, in our own curriculum design experience, PBL as an active learning philosophy (Christie & de Graaff, 2017) was used as a central theme connecting the curriculum, rather than as an all-encompassing ideology. However, it is not uncommon that PBL and its variants are the centrepiece of a redefined curriculum when an institution is championing significant educational change where they are looking for what Kolmos (2017, p2) described as a 'mode 1' academic university where the emphasis is on theoretical learning, to 'mode 3', a hybrid institution with greater focus on social progress.

Creating a Spine of PBL in an Integrated Curriculum

Far too often curriculum development and revision is framed as a battleground. On the one side, the traditionalist clinging onto the methods of the past – the (large) lecture or prescriptive laboratory, while the other side is characterised as the evangelists of active learning, espousing student-centred approaches such as PBL as the only effective method of instruction. Of course, this polarised scenario poorly reflects the true landscape. As engineers, unsurprisingly, we have taken a very pragmatic, somewhat 'engineering' approach to our curriculum design – that of selecting the right tool for the job. Curriculum design at a programme level allows for the consideration of the wide variety of different learning outcomes that are to be achieved and the stages that students must progress through to eventually achieve those outcomes. Of course, it is surprising to see the lecture chosen as the predominantly form of instruction as traditionally may have been the case, but it would be equally surprising to have PBL as the only alternative. Controlled variety is key, with lectures as well as supporting tutorials, interactive workshops and inspiring seminars, explorative laboratories and project-based learning activities that interconnect and build into a coherent and connected learning journey for the students.

There are many different approaches to the implementation of PBL within the curriculum. Kolmos, De Graff and Du (2009) expertly dissect the differences between these models and draw on the five models of PBL developed by Savin-Baden (2000). The models provide a useful characterisation against which to evaluate each PBL approach and while we will make use of them here, we apply a slightly different framing to that explicitly adopted by Savin-Baden and implicitly by Kolmos, De Graff and Du. That is, rather than seeing them as a spectrum of approaches based on the quality of PBL that range from minimal engagement with PBL in 'model I' to the self-confessed utopia of 'model V', we see them in the context of a student journey – from a highly structured and broadly familiar approach strongly rooted in their disciplinary knowledge in 'model I' to wicked and open problems in 'model V'. As Savin-Baden describes it, a model where knowledge is "contingent, contextual and constructed" (2000, p127).

This framing leads us to the view of a curriculum that builds and develops and is often referred to as a spiral curriculum (Harden & Stamper, 1999), where there is an opportunity for iteration and the revisiting of important elements of learning – for example, key skills, throughout the curriculum. Originally conceived by Bruner (1960), it encourages reinforcement and integration of knowledge through an aligned process of building new learning that is connected to previous learning. In our curriculum model, we propose that PBL is the core mechanism of that spiral which provides the continuity – as shown

pictorially in Figure 1. Despite being central, it is important to note that it also needs to be fed and supported by the other elements and aspects of the curriculum creating a symbiotic relationship between the theory, skills and practice. These are shown as the parallel threads, with the spiral indicating the building nature of the curriculum as student connect these threads together via the PBL core.

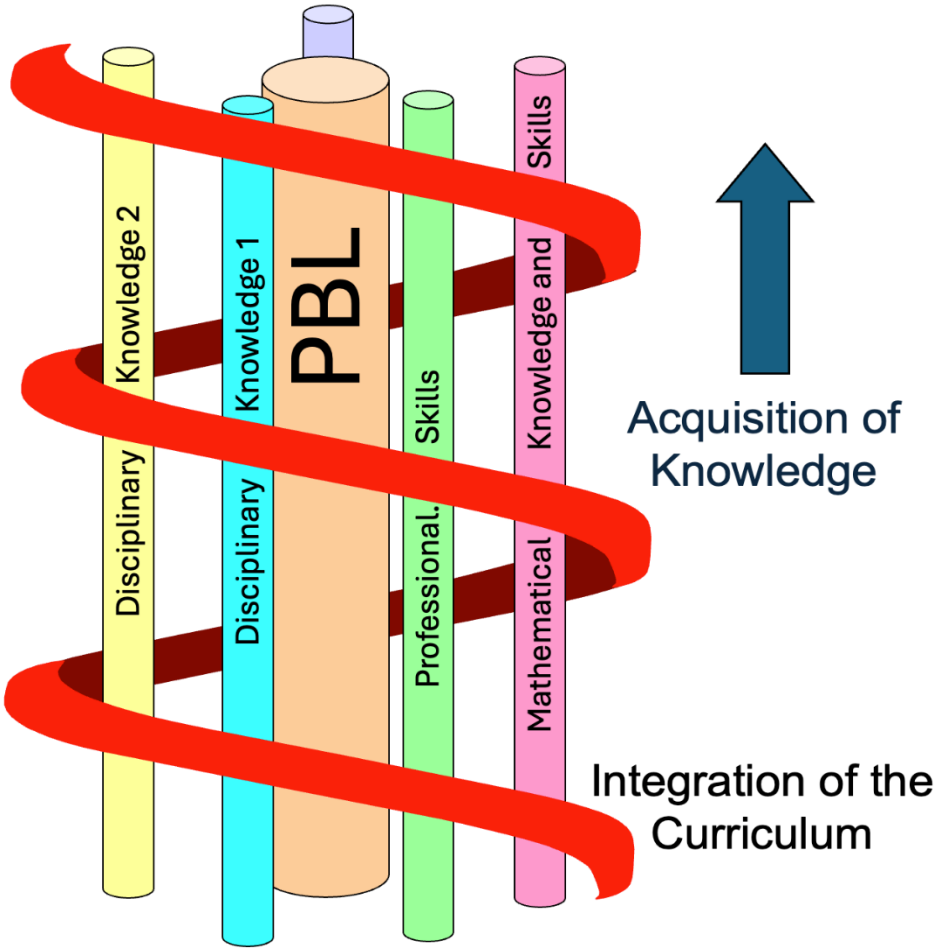

Figure 1. Example of PBL at the heart of a spiral curriculum.

In practice, we understand that this will take many forms and be dependent on the subject as well as the local context. However, what is critical is the integration and the interconnections that are formed between the central elements and the knowledge development in the outer threads, connected together via the spiral. This requires a multi-dimensional approach to curriculum design, considering the hierarchy of discipline specific knowledge as well as the points of interconnection to the PBL core and how the projects can be used a vehicle to develop skills and practice. This approach provides many advantages, one critical element being the future-proofing that these context

rich experiences provide for the programme and the opportunity they present to enable continued innovation and rapid curriculum development. For example, a recent change in the accreditation requirements for engineering programmes in the UK has brought an increased emphasis on contextual topics. In a more traditional curriculum, such changes might require a new compulsory module or significant change to existing modules. In the curriculum we describe here, there is ample opportunity with this PBL core to embed sustainability into the authenticity of the projects, or bring ethics into the student's learning including coverage of wider social and global responsibilities central to the modern profession.

Such an approach is not without risks. Most notably, it can create a separation of the curriculum and scourge of 'someone else's problem' where key non-technical elements of the curriculum are segregated, forming ghettos of instruction, where everything outside of the traditional fundamentals of the discipline are dumped. Drawing on our experience of engineering education development in different disciplinary and institutional contexts, we have seen that in response to pressure from accrediting bodies to increase the teaching of design in the engineering curriculum in the early 2000's, it was not uncommon for traditional engineering programmes to introduce a design thread, often a series of design modules across the years where project-based design activities are undertaken. On paper, this might appear to look exactly like the sort of PBL thread that we are advocating here. And in many cases, they are. However, this is not always the case. If implemented solely out of pressure from accreditation without holistic curriculum design, they can become their own silo; separated and distinct from the rest of the curriculum. This approach creates projects/problems disconnected from the content of the programme, which risks this representation of the profession distracting students from what they perceive as their core learning. While they achieve many good things regardless of their segregation, valuable opportunities for greater integrative learning are missed and they can also become the sole repository for all 'non-technical' elements of the curriculum, reinforcing in students minds the separation between the mathematics, the science and the technical engineering and considerations of design, sustainability, ethics, user requirements etc.

While it might initially seem that such an approach requires wholesale curriculum revision which is hugely disruptive and likely to be met with significant resistance from staff, in fact, we suggest that it can be implemented in a far more pragmatic fashion. In such an approach, all elements of the curriculum should be reviewed but although some space is needed to be fashioned in the core, the vast majority of the programme can remain, with relatively minor disruption. This approach, while leveraging many advantages, also allows for continuous regeneration of the curriculum rather than a

momentous revolution to suit the constraints of traditional universities. In our experience of the Integrated Engineering Programme at UCL (Mitchell et al., 2021), approximately 20% of the entire curriculum saw major revision, while the rest experienced much more modest refinement to fit within the new approach. Ten years on, we see that this programme has continued to evolve. In some cases, this was driven by the leadership team consciously developing the planned curriculum, but in others it is driven by the teaching team evolving the delivered curriculum by both further developing the new content, but also expanding their reach further across the programme. While some have rightly questioned diffusion models of innovation in higher education (Smith, 2012), it seems that if a critical mass of innovation is achieved, the resulting culture change promotes further developments.

What is important if such an approach is adopted, is that consideration is given not only to the planned curriculum but also to the perceived curriculum. The critical question is "How do students see the curriculum?". Do they still see the compartmentalised progression of technical modules as the main instructional element of the curriculum or do they now see the projects/problems as core, with the theoretical learning supporting these experiences. This shift in mindset is critical. In designing and evaluating such a programme, we must remember the mode in which students experience the curriculum. As educators we often take a bird's eye view of the curriculum – looking down on it as it is laid out across the years. Students, of course, rarely share this perspective. They approach the curriculum in a linear fashion from start to finish and hence it is an understanding of this journey through the educational landscape and the combination of the delivered curriculum and the hidden curriculum that is fundamental to how the curriculum is perceived. Approaches such as modelling the student journey can provide hugely valuable insight into the impact of any reform.

One advantage of adopting such an approach centred on PBL is that we can maintain the strong disciplinary presence that will be, in the majority of cases, the most recognisable feature of the existing degree, but augment and connect it through a core of PBL with associated supporting instruction. This forms a discipline specific programme that draws on interdisciplinary learning to provide the breadth of experience that students and employers are calling for. There are many ways these connections, which emphasise the relationship between disciplines, can be formed. The project core can contain separate projects, mapped to build and progress or may contain vertically integrated projects (Coyle, Allebach & Krueger, 2006) – a single long-term project that spans multiple year groups. Figure 2 shows an example of the sort of connections that might be developed with such a curriculum, with a central spine of project activities that build skills and provide a vehicle for practice and

integration of learning, supported by not only the discipline specific material but also by a thread of instruction to ensure that student have the necessary skills to perform well within this project element.

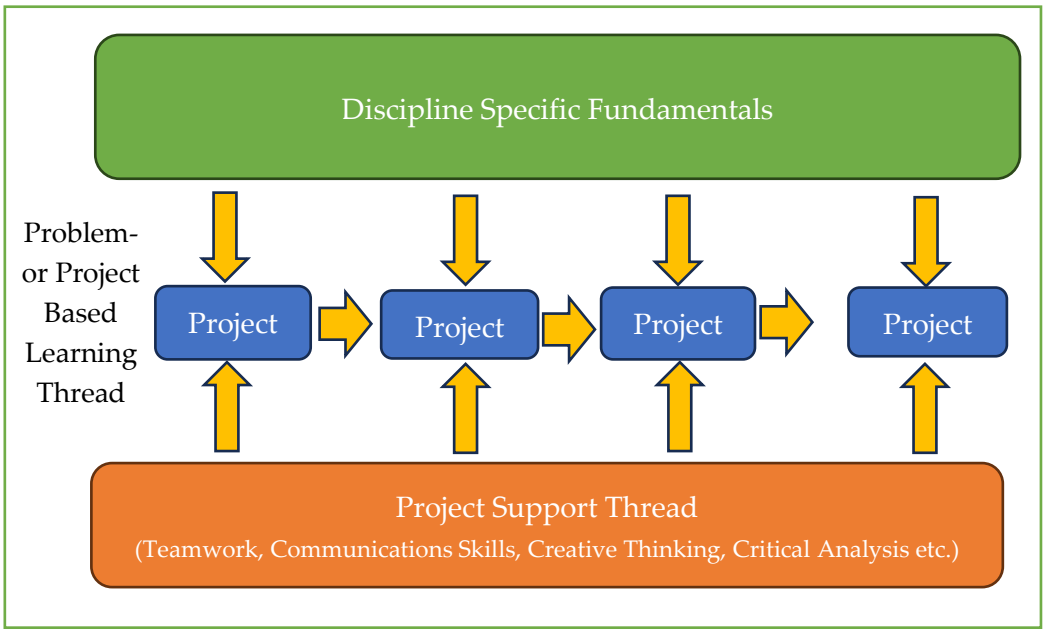

Figure 2. Example of the connections between elements of the curriculum.

This final area is one which is often missing, borne out of the mistaken assumption, for example, that putting students in teams will naturally teach teamwork through some form of self-discovery or osmosis.

Conclusions

In this position paper we argue for a model of curriculum development that uses problem- or project-based learning as its core to promote connections between all other elements of the curriculum. We suggest that a model of curriculum design that actively encourages the interconnection to modules and learning threads within the programme via a problem/project-based learning core is an excellent approach to curriculum development that can be undertaken as part of a curriculum reform within an established programme to create a significant shift in the emphasis of the educational experience that students perceive without the pain that is often considered to be associated with wholescale curriculum revision. We advocate for a revised programme structure, promoting skills development and authentic practice within students, that pragmatically overcomes some of the key disadvantages of modularisation and addresses the calls for an increased emphasis on

developing rounded graduates, with a high-level of social awareness and considerable practice in key employability skills.

References

Anderson, R. D., (2004). Germany and the Humboldtian Model. In *European Universities from the Enlightenment to 1914*. Oxford.

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

Barnett, Ronald (2011). *Being a University*. New York: Routledge. https://doi.org/10.4324/9780203842485

Bernstein, B. (2000). *Pedagogy, Symbolic Control and Identity*. Revised ed. New York: Rowman and Littlefield.

Blackmore, P., & Kandiko, C.B. (2012). *Strategic Curriculum Change in Universities: Global Trends,* (1st ed.). Routledge. https://doi.org/10.4324/9780203111628

Bruner, J.S. (1960). *The Process of Education*. Cambridge, M A: Harvard University Press. https://doi.org/10.4159/9780674028999

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: a review of literature. *European Journal of Engineering Education, 46*(1), 90-115. https://doi.org/10.1080/03043797.2020.1718615

Christie, M., & De Graaff, E. (2017). The philosophical and pedagogical underpinnings of Active Learning in Engineering Education. *European Journal of Engineering Education, 42*(1), 5-16. https://doi.org/10.1080/03043797.2016.1254160

Coyle, E., Allebach, J., & Krueger, J. (2006). The vertically integrated projects (VIP) program in ECE at Purdue: fully integrating undergraduate education and graduate research. In 2006 Annual Conference & Exposition (pp. 11-1336).

Crawley, E. F., & Hosoi, A. E. (2019). Moving Forward with the New Engineering Education Transformation (NEET) program at MIT - Building community, developing projects, and connecting with industry. ASEE Annual Conference and Exposition, Conference Proceedings. https://doi.org/10.18260/1-2--33124

Davis, M. (1998). Making a case for design-based learning. *Arts Education Policy Review, 100*(2), 7-15. https://doi.org/10.1080/10632919809599450

Dole, S., Bloom, L., & Doss, K. K. (2017). Engaged learning: Impact of PBL and PjBL with elementary and middle grade students. *Interdisciplinary Journal of Problem-Based Learning, 11*(2), 9. https://doi.org/10.7771/1541-5015.1685

Engineering Council. (2020). The Accreditation of Higher Education Programmes (AHEP) Fourth Edition. Engineering Council.

Fung, D. (2017). *Connected Curriculum for Higher Education*. UCL Press. https://doi.org/10.2307/j.ctt1qnw8nf

Gallagher, S.E. & Savage, T. (2023). 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

GMC. (2018). Outcomes for Graduates. General Medical Council, UK.

Goldberg, D.E., & Somerville, M. (2014). *A Whole New Engineer: The Coming Revolution in Engineering Education*. Douglas, MI: Threejoy Associates, Incorporated.

Goldberg, D.E., & Somerville, M., (2023). *A Field Manual for a Whole New Education: Rebooting Higher Education for Human Connection and Insight in a Digital World*. Douglas, MI: Threejoy Associates, Incorporated.

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

Habbal, F., Kolmos, A., Hadgraft, R.G., Egelund Holgaard J., & Reda, K. (2024). *Reshaping Engineering Education: Addressing Complex Human Challenges*. Springer. https://doi.org/10.1007/978-981-99-5873-3

Harden, R. M., & Stamper, N. (1999). What is a spiral curriculum? *Medical Teacher, 21*(2), 141-143. https://doi.org/10.1080/01421599979752

Hrynchak, P., & Batty, H. (2012). The educational theory basis of team-based learning. *Medical Teacher, 34*(10), 796-801. https://doi.org/10.3109/0142159X.2012.687120

Kolmos, A., De Graaff, E., & Du, X. (2009). Diversity of PBL – PBL Learning Principles and Models. In *Research on PBL practice in engineering education* (pp. 9-21). Brill. https://doi.org/10.1163/9789087909321_003

Kolmos, A. (2017). PBL Curriculum Strategies. In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), *PBL in Engineering Education – International Perspectives on*

Curriculum Change (pp 1–12). Rotterdam: Sense Publishers. https://doi.org/10.1007/978-94-6300-905-8_1

Lahiff, A., Tilley, E., Broad, J., Roach, K., & Detmer, A. (2019). Disciplinary learning in project-based undergraduate engineering education: The case for new knowledge. In: Kloot, B., (Ed.), *Proceedings of the 2019 Research in Engineering Education Symposium (REES 2019)* (pp. 578-587). REEN (Research in Engineering Education Network): Cape Town, South Africa.

Marginson, S. (2016). *Higher Education and the Common Good*. (1st ed.). Melbourne University Publishing: Melbourne, Australia.

Mitchell, J. E., Nyamapfene, A., Roach, K., & Tilley, E. (2021). Faculty wide curriculum reform: the integrated engineering programme. *European Journal of Engineering Education, 46*(1), 48-66. https://doi.org/10.1080/03043797.2019.1593324

Newman, J. H. (1996). *The idea of a university*. M. M. Garland, S. Castro-Klaren, G. P. Landow, G. M. Marsden, & F. Turner (Eds.). Yale University Press.

Premalatha, K. (2019). Course and Program Outcomes Assessment Methods in Outcome-Based Education: A Review. *Journal of Education, 199*(3), 111-127. https://doi.org/10.1177/0022057419854351

Roach, K., Tilley, E., & Mitchell, J. (2018). How authentic does authentic learning have to be? *Higher Education Pedagogies, 3*(1), 495-509. https://doi.org/10.1080/23752696.2018.1462099

Savery, J. R., & Duffy, T. M. (1995). Problem Based Learning: An Instructional Model and Its Constructivist Framework. *Educational Technology, 35*(5), 31-38.

Savery, J. R. (2015). Overview of Problem-Based Learning: Definitions and Distinctions. In Walker, A., Leary, H., Hmelo-Silver, C. E., & Ertmer, P. A. (Eds.), *Essential Readings in Problem-Based Learning: Exploring and Extending the Legacy of Howard S. Barrows* (pp. 5-16). Purdue University Press. https://doi.org/10.2307/j.ctt6wq6fh.6

Savin-Baden, M. (2000). *Problem-Based Learning in Higher Education: Untold Stories.* SRHE and Open University Press, Buckingham.

Savin-Baden, M., & Major, C. H. (2004). Foundations of Problem-Based Learning (p. 198). New York: Society for Research into Higher Education & Open University Press.

Smith, K.L. (2012). Lessons learnt from literature on the diffusion of innovative learning and teaching practices in higher education.

Innovations in Education and Teaching International, 49(2), 173-182. https://doi.org/10.1080/14703297.2012.677599

Short, E.C. (2002). Knowledge and the Educative Functions of a University: Designing the Curriculum of Higher Education. *Journal of Curriculum Studies, 34*(2), 139-148. https://doi.org/10.1080/00220270110069181

Spady, W. G. (1994). Outcome-based education: Critical issues and answers. Arlington, VA: American Association of School Administrators.

SRA. (2014). Academic Stage Handbook, Solicitors Regulation Authority, UK.

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Problem-Based Learning and Engineering Education for Sustainability

Where we are and where could we go?

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Abstract

Education for sustainability demands transformative knowledge, which can be obtained through problem-based, project-organized learning (PBL). However, the integration of PBL and sustainability in higher education has not yet met the needs required due to the lack of application of a systemic perspective and strategy. In this literature review, we present an overview of research trends being developed with PBL in education for sustainability and how PBL is being used to educate students for sustainability. The scientific production of the last 22 years is analyzed, and we verify that the use of PBL as a methodology for education in sustainability is a rather recent innovation, with an emphasis on the environmental dimension. Learning assessment methodologies are based on summative approaches using traditional methods like scoring tests. There is an explicit preference to integrate PBL and sustainability in undergraduate and graduate courses, mainly in engineering. We observe that most of the time, the subject of interdisciplinarity is not discussed. We concluded that there are a few concerns with research on education for sustainability using PBL. Although PBL proposes an innovative form of education, its implementation in education for sustainability has not been fully explored to its full potential, especially con-

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cerning the development of sustainability skills, transformative and holistic education, but rather as a form of content-based assessment.

Keywords: PBL, education for sustainability, literature review, research trends

Introduction

The Sustainable Development Goals (SDG) of the United Nations (UN) provide a framework for action for countries to achieve certain sustainability targets by 2030. Education must prepare and educate its graduates accordingly, with knowledge and competences to act locally and have global positive impacts (Sterling, 1996). In recent years, the commitment of higher educational institutions to education for sustainable development and SDG has increased considerably, leading to strategies to integrate them into educational, research, and outreach activities (Gamage & Silva, 2022). From an educational perspective, two main strategies have been used: adding sustainability to a curriculum in a compartmentalized way (i.e., education about sustainability), and integrating sustainability in a transformative and contextual way (i.e., education for sustainability) (Leicht et al., 2018). Education for sustainability emphasizes more than content, as in add-on strategies. It advocates a holistic approach to education that involves the head, hands, heart, and spirit, with a particular focus on the learning process and the development of competences and values to act for sustainability (Sterling, 2004; Hermes & Rimanoczy, 2018). Working from different frameworks, Annelin and Boström (2023) provided an overview and defined eight key sustainability competences, namely, systems thinking, strategic thinking, future/anticipatory thinking, values/norms thinking, interpersonal thinking, intrapersonal thinking, implementational thinking, integrated problem-solving competencies for sustainability, which are also related to competencies for employability and social transformation toward a sustainable future (Annelin & Boström, 2023, p. 55). That said, educating for sustainability calls for transformative, problem-oriented, contextual, collaborative, and inter- and transdisciplinary knowledge, with participatory and empowering learning environments, such as in problem-based, project-organized learning (PBL) (Guerra, 2017; Gutierrez-Bucheli et al., 2022; Rodríguez Aboytes & Barth, 2020).

PBL emerged from practice in the 1970s that intended to equip students with ready-to-use professional skills, such as problem-solving, teamwork, communication, critical thinking, and lifelong learning (Guerra & Kolmos, 2011). In a PBL environment, a group of students learns by formulating and solving real, authentic problems. The learning process begins with a problem

that can be presented to students in the format of cases or solved through projects. For example, project-organized, problem-based learning is the most common PBL curricular model used in engineering education, whilst medicine organize its PBL curriculum around cases. The role of the teacher shifts from that of a transmitter of knowledge to a facilitator of and for learning. PBL is grounded in principles such as contextual, experiential, and exemplary learning, as well as in democratic, emancipatory, and ownership values (Kolmos et al., 2009).

Although much has been achieved in recent years concerning educating for sustainability, we are still behind in what is necessary to equip future professionals with the qualification profile required to address present challenges and wicked sustainability problems (Annelin & Boström, 2023). The literature shows that most PBL integration is found in higher education and is at the course and program level, lacking a systemic perspective and strategy (Chen et al., 2020), where the main drivers for curriculum change are seldom related to the integration of sustainability but are rather used to equip students with professional skills on demand, lacking the integration of knowledge and competences required for action and contribution to sustainability (see, for example, Guerra et al., 2017). In addition, students in the exact sciences and engineering seem to be least active in participating in activities organized by higher education institutions toward environmental protection, the least aware of the UN's SDGs, and the least inclined to accept a lower salary to work in a job that promotes social and environmental change (Aleixo et al., 2021).

Recent literature reviews have reported on different aspects of education for sustainable development in higher education, namely the conceptualization of transformative learning and operationalization (Rodríguez Aboytes & Barth, 2020), experiences in higher education regarding the UN's SDGs in different activities areas (e.g., research, education, outreach, and management) (Serafini et al., 2022), the relationship between pedagogies, content, and development of specific "sustainability outcomes" (Probst, 2022), key sustainability competences and survey assessment tools (Annelin & Boström, 2023), pre-service teaching education for sustainability (Lorente-Echeverría et al., 2022), and professional development of teachers to foster the integration of sustainability in university curricula (Fischer et al., 2022).

The studies refer, explicitly or implicitly, to the need for problem-oriented pedagogies, such as PBL, to educate for sustainability. However, they seldom refer to the links between PBL, specific education contexts, and sustainability, as well in which this pedagogy has contributed to its development.

The research questions (RQs) that will guide this work are the following:

1. What are the research trends in PBL and sustainability in education?
2. How is PBL being used to educate students for sustainability?

We intend to answer both questions with a literature review.

Methodology

To begin with, we focus on sustainability, and from that, we seek to explore the ways that PBL and the integration of sustainability have been studied over the last 22 years. The search covers all levels of education, without distinction of disciplines, was made to verify insights and practices in general. This study is a literature review, with a systematic approach that was inspired by the Prisma 2020 model (Page et al., 2021). This methodology is a guideline for the preparation of systematic reviews and meta-analyses, through 27 checklist items, seeking standardization with the purpose of, among other things, facilitating the replication and updating of reviews.

For this study, as it is a review and not a meta-analysis, we did not use the full rigor of the methodology as we understood that certain items were unnecessary or not applicable to answer our research questions without, however, compromising the quality of the review. In this way, we fail to address items such as assessment of risk of bias, effect measures, or statistical treatments. We also did not perform sensitivity analyses to assess the robustness of the results found or confidence in the body of evidence. The studies analyzed were, in general, not discussed individually, unless they presented particular characteristics relating to our research question. In this research, we briefly present a flow diagram describing the results of the search and selection process. The approach is described below.

In response to the research questions, which focus on sustainability and PBL, we propose two search blocks, as shown in Table 1. Search block 1 includes keywords synonymous with PBL, while search block 2 includes keywords synonymous to sustainability.

Database	Search	Retrieved records
SCOPUS	BLOCK 1: PBL OR Problem-oriented OR Project-oriented OR Problem-based learning OR Project-based learning ***AND*** BLOCK 2: Sustainability OR Sustainable development OR Sustainable development goals OR SDG.	97
Web of Science	BLOCK 1: PBL OR Problem-oriented OR Project-oriented OR Problem-based learning OR Project-based learning ***AND*** BLOCK 2: Sustainability OR Sustainable development OR Sustainable development goals OR SDG.	711

Table 1. Strings used to search for each database and the number of records retrieved.

The SCOPUS database was searched on July 2, 2022, and the Web of Science database was searched on July 15, 2022. The search strings used for each database can be found in Table 2 and were used in the fields "article title," "abstract," and "keyword."

We used SCOPUS and the Web of Science as search databases. These databases are multidisciplinary, and article indexing goes through an evaluation process to ensure that minimum quality standards are met, including peer-review procedures and the provision of ethical and malpractice statements (Borrego, Foster, & Froyd, 2014).

The search included the inclusion and exclusion criteria shown in Table 2.

Criterion	Inclusion	Exclusion
Type of documents	Peer-reviewed articles, reviews, and conference papers	Books and book chapters
Years	2000 to the present	Under the year 2000
Databases	Scopus and the Web of Science	Other databases
Subject area	All	No restriction
Languages	English	Other languages
Fields	article title, abstract, and keywords	Other fields
The focus of the analysis	PBL was used to educate about Sustainability	Other methodologies than PBL, other themes than sustainability
Meaning of sustainability	Meet the needs of the present without compromising the ability of future generations to meet their own needs	Other meanings

Table 2. Criteria for the selection of articles.

The search result, using the inclusion and exclusion criteria and screening by abstracts, provided a total of 129 articles, as shown in Figure 1. The number of exclusions is high because, in our database search, there were no limitations regarding the subject area. In addition, because the search term PBL is an acronym, articles in other subjects that also use PBL but with a different meaning were also identified by the search.

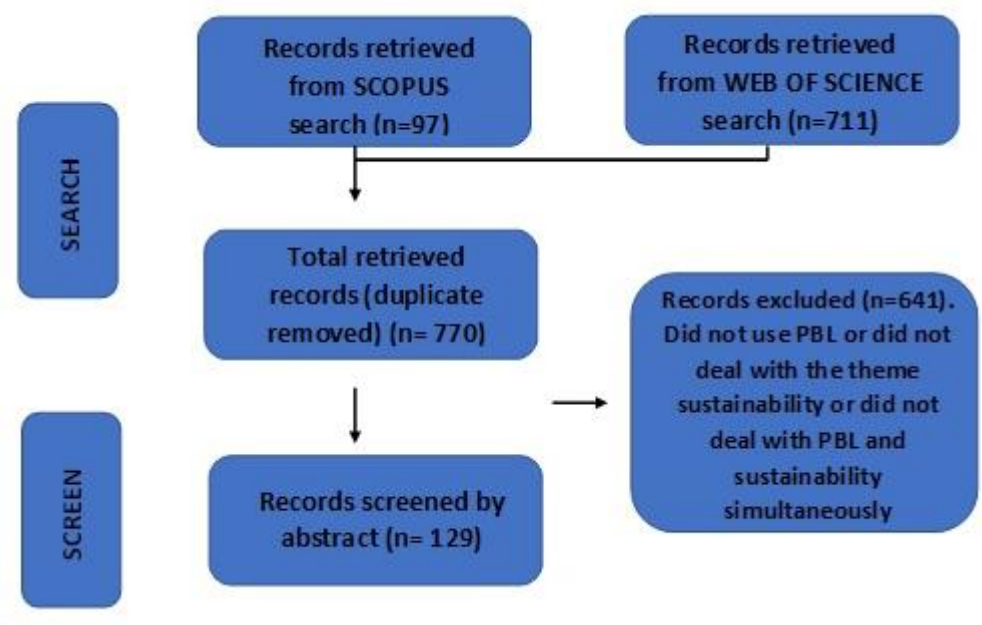

Figure 1. The flow chart for the searching and filtering process (N=129).

Before analysis, information from each of the 129 articles was extracted and documented. These articles served as the basis for the discussion of the metadata.

Database searches, filtering, and extraction of information from articles were carried out by only one of the authors. However, the other authors participated collaboratively in the discussion, validating the requirements established for inclusion and exclusion.

Among the 129 articles that met the inclusion/exclusion criteria, several were related to the description of activities where sustainability was just a subject for the development of the PBL methodology, without delving into the issue of sustainability. Others focused only on one topic, leaving the other in the background. However, for us to answer the questions in this paper, our focus needs to be on articles that integrate PBL with sustainability in a deeper way.

A table was created using Microsoft Excel, and, taking the guiding questions into account, the below analytical criteria were established, and developed for each article that integrates PBL with sustainability:

1. The type of research design
2. Type of RQs
3. PBL model and level of implementation
4. Level/type of sustainability learning

To construct the co-authorship network, the NodeXL program was used, which functions as a complement to Excel. This program creates a structural image of networks, to verify the existence of connected components, which are either related or not, making it possible to visually determine central components.

Results

This section presents the analysis for each of the questions and other relevant findings.

Research integrating PBL and sustainability (RQ1): Who and when has been researching? (N=129)

From 770 articles, 129 articles were selected using filtering, equivalent to 16.6% of the total group of articles that have PBL and sustainability as main themes.

Although our search was carried out from 2000 onwards, we identified the emergence of production from 2007 onwards (Figure 2), when articles began to appear in which PBL and sustainability are the themes or PBL is used as a main approach to integrating sustainability in the curriculum. An increase was also found in the concern to include the theme of sustainability in the curricula. We also observed a constant increase from 2014 onwards in the number of publications related to the theme (2022 shows an expected decrease because the search was carried out in the middle of the year). We also verified that more than twice as many articles as conference papers (89 articles/40 conference papers).

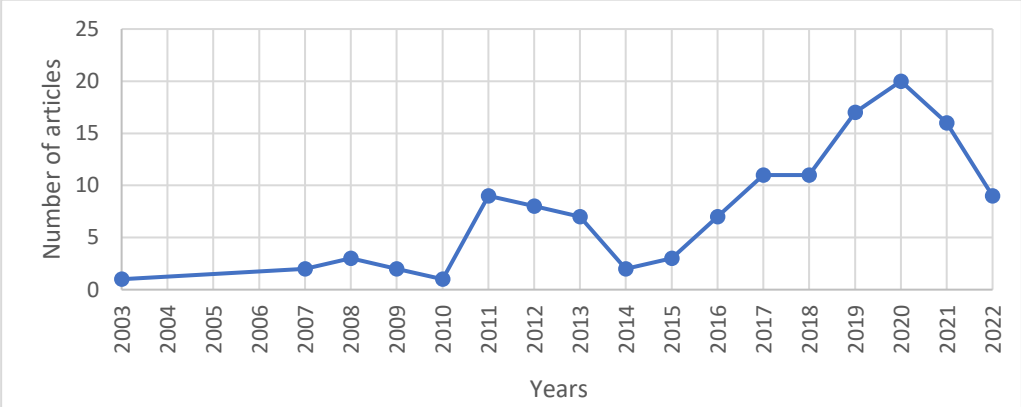

Figure 2. The distribution of articles per year (N=129).

We found that 54 authors were published more than once, out of a total universe of 384 authors. Even so, of these 54 authors, 15 have more than two publications in the set (Aida Guerra, n=4; Esther García-González, n=4; Bartlomiej Gladysz, n=3; Elisabete Alberdi, n=3; Elzbieta Jarzebowska, n=3; Heriberto Pérez-Acebo, n=3; Irantzu Álvarez, n=3; Isabel Eguia, n=3; Jens Myrup Pedersen, n=3; María José García Gonzalez, n=3; Mohamed Elzomor, n=3; Mónica Fernández-Morilla, n=3; Paulo Etxeberria, n=3; Sílvia Albareda-Tiana, n=3; and Stephanie Luster-Teasley, n=3). Of these, only Aida Guerra (2012, 2016, 2018, and 2021) and Mohamed Elzomor (2016, 2017, and 2021) show a regular history of publications on the subject. The others' publications were restricted to a few years, and some have not been published on the subject since 2011 or 2020. This may be an indication that this subject does not characterize a line of research but only produces results derived from isolated research projects that are abandoned. Furthermore, in general, the authors of the publications identified belong to segregated groups that do not collaborate among themselves. A group representing Spanish universities has emerged recently, showing publications after 2021, such as Esther García-Gonzáles, Sílvia Albareda-Tiana, Paulo Etxeberria, and María José García, who were co-authors of two papers developed at two Spanish universities.

It is commonly understood that the number of citations of an author reveals his or her importance as a researcher in the given field. Therefore, among the authors with more than 10 citations, we found that the two most cited references are not articles but official publications by UNESCO and the UN. This can be explained by the fact that they are a mandatory reference for the SDGs and sustainability-oriented education. Arnin Wiek has 40 citations, followed by Katja Brundiers with 33 citations, and Anette Kolmos, with 24. The complete list is presented in Figure 3. This clarifies the relationship between the cited publications and the articles' themes. These authors have many publications on PBL, sustainability, and both together.

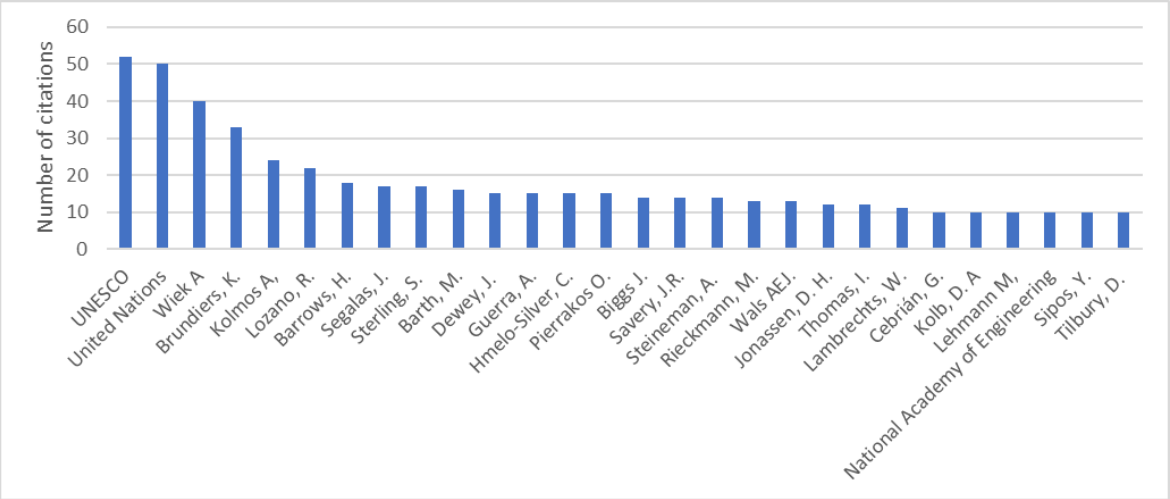

Figure 3. The number of citations per author with more than 10 citations.

Figure 4 shows the three universities that emerge as the largest producers of knowledge in PBL and/or sustainability since they are the affiliations of researchers who were cited more than 10 times.

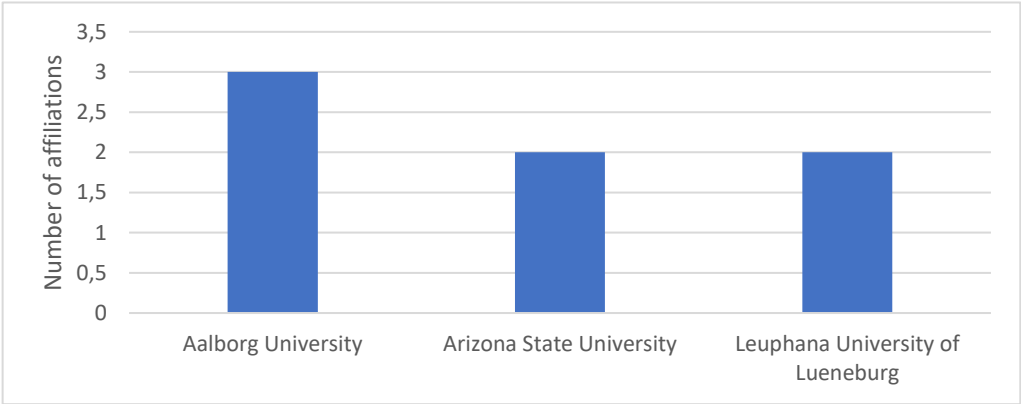

Figure 4. Universities with the highest number of researchers were cited more than 10 times.

On the other hand, we observed that Aalborg University and Arizona State University are significant knowledge producers since they are affiliations of authors cited more than 10 times, but Leuphana University did not produce any article that had both PBL and sustainability as themes. Comparing the number of affiliations with the number of articles, we note the normalization that best represents the importance of the university. As shown in Figure 5, some universities have many affiliations but a low number of articles, meaning that many authors from the same university were co-authors of the same work. In this context, Aalborg University established itself as the university with the largest number of researchers working on the subject of PBL and/or sustainability, and with the largest number of articles.

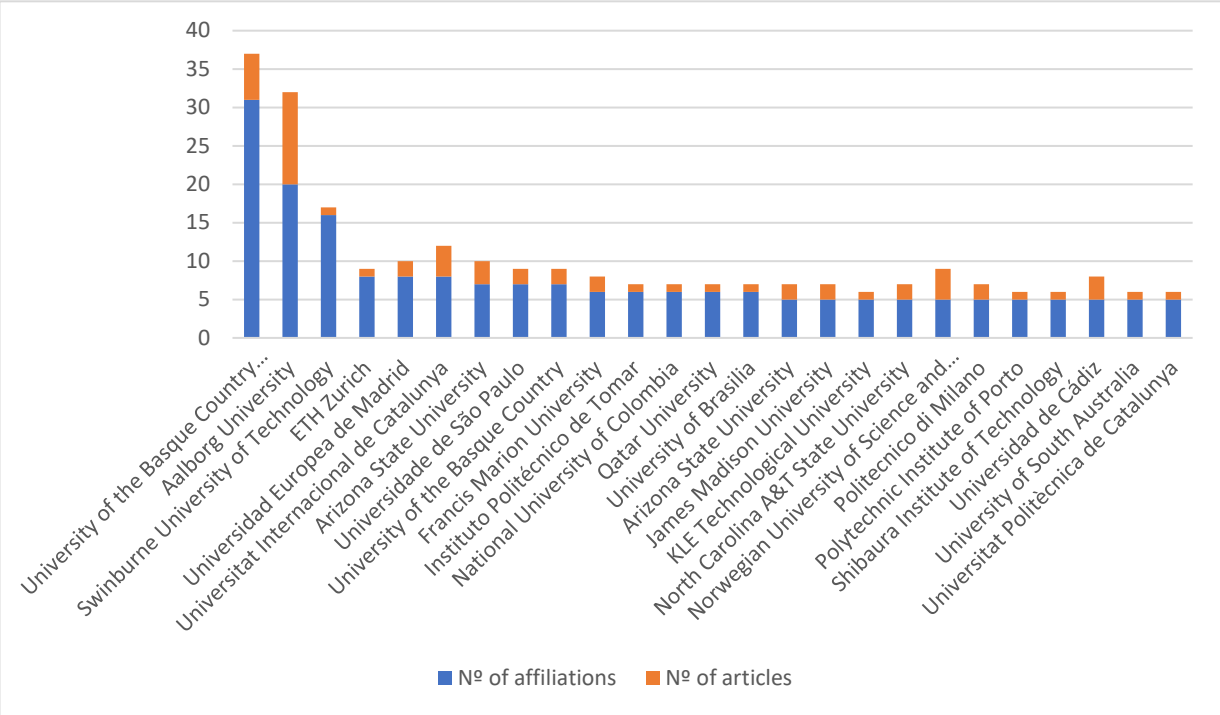

Figure 5. The number of affiliations per institution x number of articles per institution.

The co-authorship network shows how the authors interact with each other. In this work, we carry out a network analysis by institution (Figure 6), due to the low number of publications by authors. Of the 144 universities to which the authors were affiliated at the time of publication, 36 had no relationship with any other university, and 13 were related to more than 3 other institutions. These data show that institutions interact very little with each other, working, in an isolated and segregated way, for the most part. This tendency may perhaps explain the small number of publications on the subject, suggesting that these are not lines of research as such, but rather sporadic works carried out for a particular purpose.

As shown in Figure 6, a network analysis of the institutions shows a tendency away from collaborating with other institutions. However, in opposition to this tendency, the Norwegian University of Science and Technology and Aalborg University are collaborators with institutions from different parts of the world. When we analyze the graph of relationships, we see two connected components that are not related. One relates to relationships between universities in Spain, and the other is composed of two groups of universities, with the Norwegian University of Science and Technology as the central institution that connects the two groups.

Norwegian University of Science and Technology emerges as the central university linking two related components and works based there have the

highest number of collaborations. However, these are largely European institutions, in general with Nordic and Eastern European countries. This difference refers to the existence of different schools of thought. However, concerning the publications, we noticed that the Norwegian University has only three publications, two of which are related to the European Engineering Team project, which proposes a transnational teaching structure using PBL, with engineering students from four countries (Gladysz et al, 2018; Gladysz et al. 2020). Another work was related to the construction of a summer school, bringing together students from three Scandinavian countries (Buser et al., 2017). Therefore, the network within the Nordic countries can be explained not as the result of a line of thought, but as the result of a regional nature.

On the other hand, as we analyze the two interconnected networks, we see a tendency for the Norwegian University of Science and Technology group to focus more on the development of the PBL methodology, while the Aalborg University group is concerned with both methodology and sustainability-oriented education. The University of Aalborg also appears as a collaborator with researchers from Asian, European, North American, and South American institutions, with a more robust global collaboration network.

The production of interconnected groups rooted in Spanish universities has been recent, beginning in 2018, with no production in 2022. This year coincides with the creation of the EDINSOST project by the Spanish government, whose objective is to innovate in universities so that future graduates acquire the skills necessary for a sustainable society; nine Spanish universities are participating in this project. All of these groups' work is related to the EDINSOST project, which uses a rubric for assessing skills in sustainability, justifying the establishment of this disconnected network (Albared-Tiana et al., 2018; Tejedor et al., 2019; Albareda-Tiana et al., 2019).

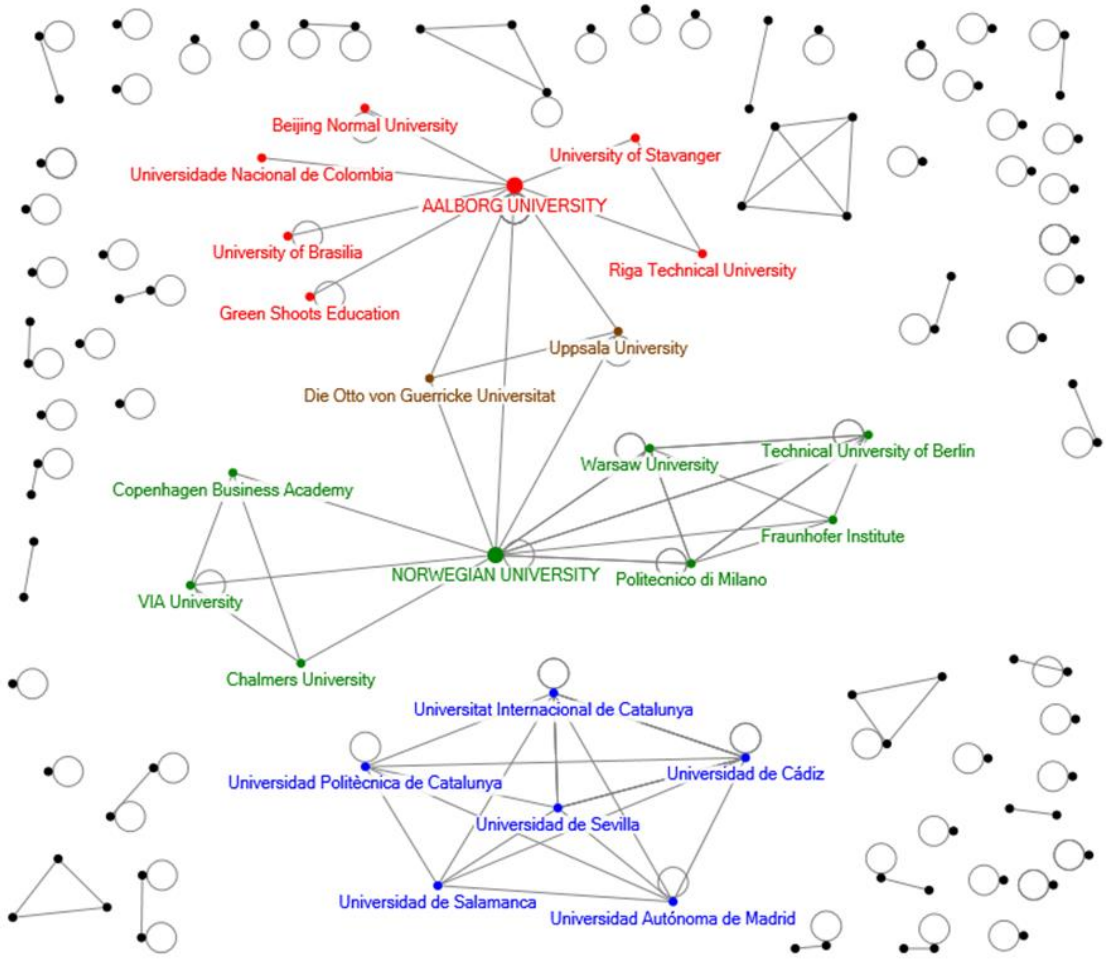

Figure 6. Co-authoring networks between institutions. Dots represent institutions, and lines are the connections between them. Circles represent co-authorships from the same institution.

When analyzing the countries where the articles were produced about the authors' affiliations at the time of publication, we identified a worldwide agreement of PBL suitability to educate for sustainability, with all continents represented (Figure 7). Although no African sources are shown in the figure (only countries with five or more affiliations were tabulated), there are four authors affiliated with universities in South Africa and one in Tanzania. We observe a predominance of the richest countries in the production of works.

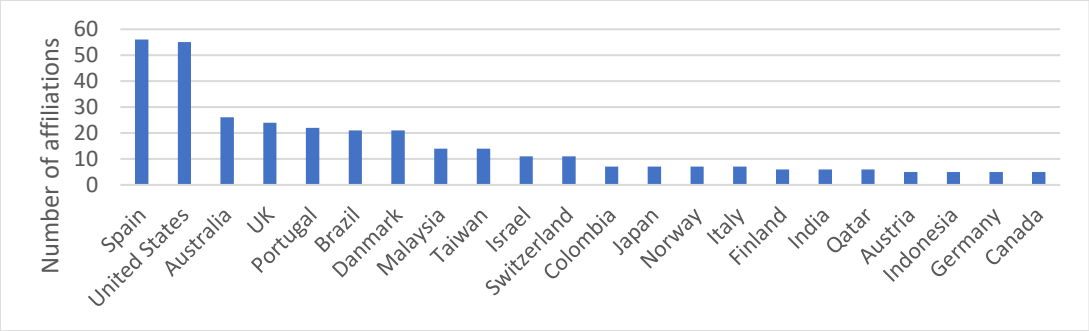

Figure 7. Number of times a country appears in article affiliations. Only countries with five or more affiliations are represented here.

We partially concluded that there was an increase in interest in the proposed themes from 2014 onwards. On the other hand, the subject does not present itself as an established line of research. We found that authors usually work in fixed groups, even if from different institutions, but do not collaborate with researchers outside these groups. One exception is the University of Aalborg. Furthermore, this university, together with Arizona State University, is the largest producer of knowledge on the subject. We also verified that the topic is of global interest.

Research integrating PBL and sustainability (RQ1): What type of research has been reported? (N=129)

The vast majority of these articles take a scholarly approach to teaching (n=65) and studying reports (n=64), as shown in Figure 8. These works deal with the application of PBL in practical terms, characterized by a scholarly approach to teaching and learning PBL implementation at the course level, followed by the evaluation of course changes and their impact on student learning. This application is mostly carried out through small proposals that involve the elaboration of research on a certain topic that is related to sustainability. For example, Xi and Wang (2022) use PBL in a landscape architecture course for a project aimed at pro-environmental awareness, and, through questionnaires, the results indicated that the PBL approach had a positive influence on values, knowledge, and pro-environmental attitudes in students. Likewise, Teff-Seker, Portman, and Kaplan-Mintz (2019) carried out research where students had to identify problems in their city and offer an EP solution. Using pre- and post-questionnaires, students reported a positive change in environmental behavior.

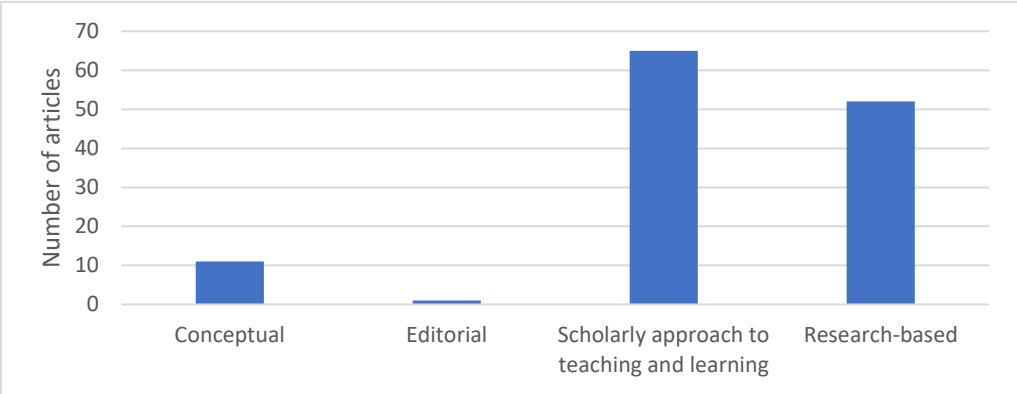

Figure 8. Types of research designs presented in articles (N=129).

Pre- and post-questionnaires are the most commonly used methodology for evaluating students' learning. Interviews, technical reports, self-assessments, product reviews, final exams, peer reviews, etc. are also mentioned as forms of evaluation (Figure 9). Of the total number of papers, 46 used two or more assessment methodologies.

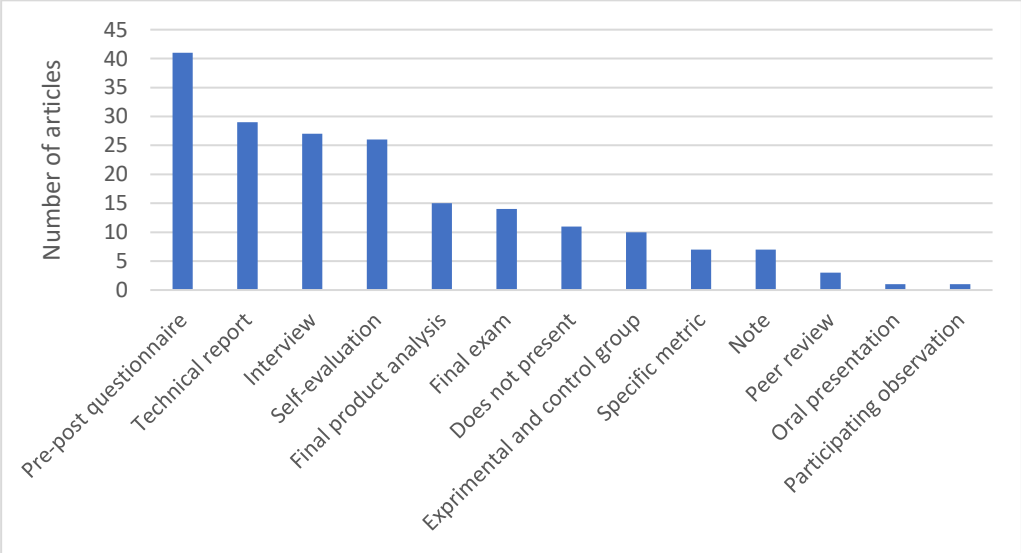

Figure 9. Methodologies were used to assess students at the end of the PBL experience (N=129).

Focusing on research-based studies (n=52), we perceive a significant concern for researchers in developing skills related to sustainability (Figure 10) (Wiltshier & Edwards, 2014; Yusof et al., 2016; Cabedo et al.; 2018; Albareda-Tiana et al., 2019; Martin-Garin et al., 2021). PBL marks the theme of the studies after the implementation processes, its successes, and its failures are analyzed. However, as previously noted, these data do not mean that the studies are focused on the

integration between PBL and sustainability. In general, the discussion revolves around PBL as pedagogy, using the theme of sustainability, but any other theme could be used.

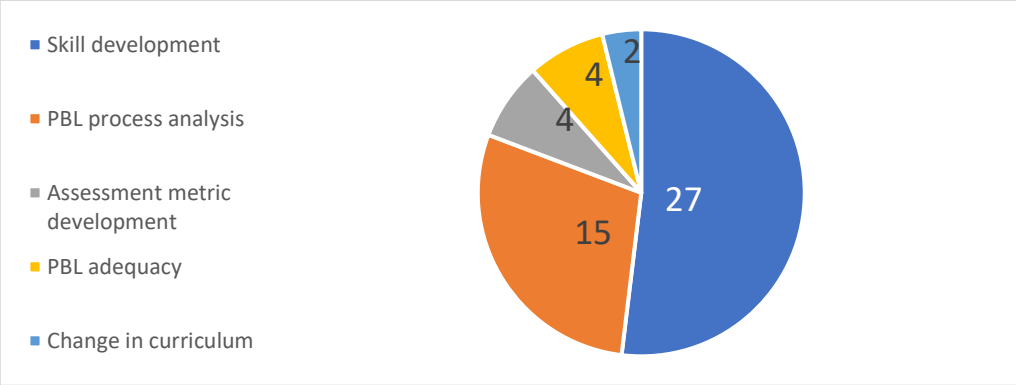

Figure 10. Topics developed in research-based articles (n=52). The values marked on the chart indicate the number of articles for a given approach. Some papers demonstrate more than one approach.

PBL was implemented to study sustainability in most cases of undergraduate university instruction, as shown in Figure 11, with most applications being in engineering-related courses, with 68 papers. Engineering plays an important role in the achievement of such goals through the development of innovative, sustainable solutions (ICEE, 2021), and the results show that to some extent.

This does not necessarily mean that PBL is not implemented at other levels, but rather that there is greater interest in research on the practice of PBL in universities (Chen, Kolmos & Du, 2021), where researchers are concentrated.

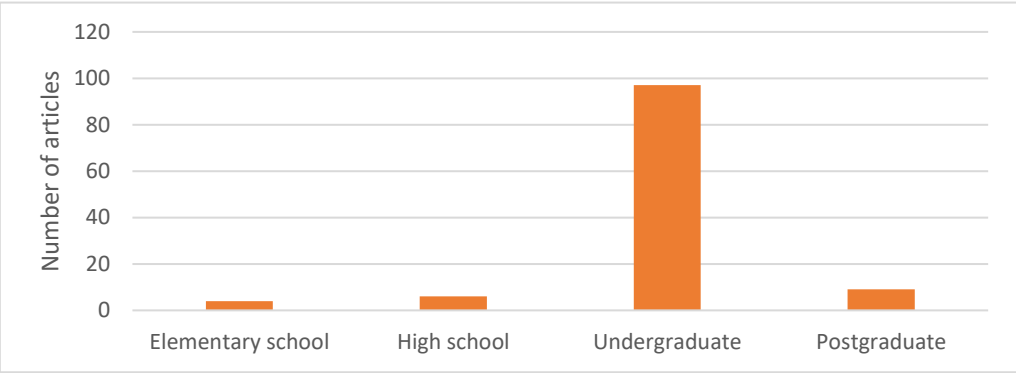

Figure 11. Level of implementation (n=116).

Regarding research trends on the topic, we concluded that most of the research design is a scholarly approach to teaching and learning. On the other hand, when we analyze research-based studies we notice that they do not discuss the integration of PBL with sustainability. We also observed that most of the studies are carried out in the undergraduate engineering course.

Engineering education for sustainability in a PBL environment (RQ2): What and how has been researched so far? (n=12)

The main concern of the works observed here is based on the ecological dimension. Among the ecological problems addressed here, we note green chemistry, lighting, bee extinction, reuse of effluents, and solid waste, organic gardening, composting, climate change, and recycling. The remainder are environmental conservation and sustainability projects, and no approaches refer to the social or economic dimensions that, together with the environment, make up the tripod on which sustainability is based (Elkington, 1994).

Of the articles classified as studying reports (n=64), 48 are case studies, conceptual or editorial. Only 16 discuss PBL and sustainability in depth, integrating the two themes (Appendix 1), and of these, 12 were taken in engineering courses, demonstrating that research on sustainability education using PBL emerges more prominently and deeply in engineering courses.

Although the first article derived from our selection using the filters (N=129) was in 2003 (Figure 1), with regularity from 2007 onwards, the articles that make an in-depth discussion on the topics, integrating PBL and sustainability (n= 16) have become more common since 2011 (Appendix 1). Until then, articles were limited to reporting experiences without focusing on scientific research. This demonstrates a maturity in the topic, although small, as reflected by the scarce number of articles.

This demonstrates that the authors' focus has been on the product and not on the process. This appears to be counterintuitive, as product-oriented education emphasizes content, and progress is measured concerning the number of correct results, as in traditional disciplines. PBL, on the other hand, is based on pedagogy that emphasizes the use of procedures to enable students to achieve results on their own, transcending content knowledge (De Graaf & Kolmos, 2003). PBL has been applied, at least concerning education for sustainability, as a methodology that promises to depart from traditional approaches but in practice does not differ from them and is not as a pedagogy that seeks protagonism for the students.

The apparent increase in publications in 2021 is not relevant, first, due to the small sample size, which prevents a reliable analysis, and second, because not many publications of the type appeared until the middle of 2022, indicating that this year could also have low representativeness of the publications.

These evaluations are usually subjective or fail to represent the reality of the evaluation, based on summative assessments, adopting traditional methods, such as tests, questionnaires, and product reviews. In addition, these assessments do not serve to identify learning needs and adjust teaching

accordingly. The evaluation by rubrics, that is, evaluation related to the quality of the project, does not exist in quantity (six articles) being largely proposed by the group working on the EDINSOST project in the Spanish government (Albareda-Tiana et al., 2018; Baligar et al., 2018; Tejedor et al. 2019; Albareda-Tiana et al., 2019; Martin-Garin et al., 2021; Hsiao et al., 2022). This may be in line with the perception that most of the time, PBL and sustainability are not discussed, only suggested, disregarding theory on the subject, predominating, just the application of a methodology in practical terms. For this line of thought, the evaluation of results becomes something secondary.

We also observed that most of the time, the theme of interdisciplinarity is not discussed but only suggested, disregarding theory on the subject and thus leading to a dominance of articles that deal solely with the application of interdisciplinarity in practical terms. As PBL promotes interdisciplinary learning in which students identify and delimit problems, interdisciplinarity is a key area that deserves a deeper discussion (Jensen, Ravn, & Stentoft, 2019), especially regarding the topic of sustainability.

In this subsection we concluded that only 16 studies bring a discussion that integrates PBL with sustainability, this being a recent and intermittent approach, demonstrating that the theme is maturing. However, most of this work was carried out in engineering courses, demonstrating a greater concern in this area of concentration. Assessment is based on pre-post questionnaires, analyzed subjectively, without specific metrics. We also observed that the ecological dimension of sustainability is the most addressed and interdisciplinarity is not discussed clearly.

Discussion, conclusion and recommendations

Higher education plays an important role in this context, as it prepares future professionals for sustainable competence and action. PBL methodology has been in use for over half a century in several universities around the world to develop specific skills in students (Kolmos & Fink, 2004). For this reason, it is not difficult to imagine PBL as a strategy for the development of sustainability-oriented skills.

Because PBL is a dynamic methodology, with a wide range of implementations (Chen, Kolmos & Du, 2020), in this systematic review, we seek to present an overview of the research trends that have been developed with PBL within sustainability education in the last 22 years.

PBL as a methodology for sustainability education is recent—the first article is dated 2003, but productivity has become constant since 2014. On the other hand, the subject does not present itself as an established line of research, as suggested by the low regularity of publications by the authors and the small rate of collaboration between them. This may be due to the 2005 beginning of the United Decade for Education for Sustainable Development, which sought to integrate sustainability concepts in all areas of education. However, half of the production is related to a scholarly approach to teaching and learning reports, as well as a few conceptual approaches. On the other hand, when we analyze research-based studies we notice that they do not discuss the integration of PBL with sustainability. This reflects the immaturity of the research area, which can be expected given the small time devoted to this line of study. Although PBL has acquired increasing numbers of adherents, there is still no consensus on its use.

To answer how PBL is being used to educate engineering students for sustainability, it was necessary to delve deeper into the articles that integrate PBL with the development of skills for sustainability. Of the 128 articles that dealt with the topic of sustainability and PBL together, only 16 brought a discussion that integrated PBL with sustainability (Appendix 1). This small number concerning a much larger universe of articles demonstrates that there has been little scientific research on the topic, so much so that articles are limited to reporting experiments. This corroborates our previous hypothesis that the use of PBL in education for sustainability is still in a maturation process.

Based on this data, we conclude that there are few concerns with research on education for sustainability using PBL. Possibly due to the need to achieve the goals of the 2030 Agenda, through the implementation of education for sustainability, teachers are developing PBL-type activities and choosing any SDG as a project/problem theme. Although the PBL methodology proposes an innovative form of education, its implementation has been carried out in traditional forms. No extensive concern is seen with the development of skills, or a form of assessment based on content. In short, our data indicate that the full potential of using the PBL environment is not being explored, and there is no trend toward PBL research in sustainability education, but rather a central concern with the classroom experience.

Our recommendations for future experiences are based on explicitly integrating sustainability competencies into PBL design, as well as considering assessment methods that capture the development of practical skills, sustainable attitudes, and the application of knowledge to solve real-world sustainability-related problems. This could involve creating training programs for teachers that address effective methods of implementing PBL for sustainability education, such as workshops, professional development courses, and resources to

support the integration of innovative practices. About research, we recommend that researchers seek to follow the experiments in more depth, taking the discussion to the level of integration of PBL with sustainability. This may involve greater collaboration between groups and research institutions or creating platforms for educators to share their experiences, best practices, and resources related to using PBL for sustainability.

We are aware of certain limitations of this work, such as the fact that several other indexing banks were not researched. On the other hand, we believe that this work can serve as a reference for expanding discussions on the use of PBL for education in sustainability by presenting the strengths and weaknesses of the use of the methodology.

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References

Albareda-Tiana, S., Vidal-Raméntol, S., Pujol-Valls, M., & Fernandez-Morilla, M. (2018). Holistic approaches to develop sustainability and research competences in pre-service teacher training, *Sustainability*, 10(10), 3698. https://doi.org/10.3390/su10103698

Albareda-Tiana, S., Garcia-Gonzáles, E., Jiménez-Fontana, R., & Solis-Espallargas, C. (2019). Implementing pedagogical approaches for ESD in initial teacher training at Spanish universities. *Sustainability*, 11(18), 4927. https://doi.org/10.3390/su11184927

Aleixo, A. M., Leal, S., & Azeiteiro, U. M. (2021). Higher education students' perceptions of sustainable development in Portugal. *Journal of Cleaner Production*, *327*, 129429. https://doi.org/10.1016/J.JCLEPRO.2021.129429

Annelin, A., & Boström, G.O. (2023). An assessment of key sustainability competencies: a review of scales and propositions for validation. *International Journal of Sustainability in Higher Education*, *24*(9), 53–69. https://doi.org/10.1108/IJSHE-05-2022-0166

Baligar, P., Kavale, S., Kaushik, M., Josh, G., & Shettar, A. (2018). Engineering exploration: a collaborative experience of designing and evolving a freshman course, *Proc., 2018 World Engineering Education Forum - Global Engineering Deans Council (WEEF-GEDC)*, Albuquerque, NM, USA, 1-5. https://doi.org/10.1109/WEEF-GEDC.2018.8629768

Borrego, M., Foster, M.J., & Froyd, J.E. (2014). Systematic literature reviews in engineering education and other developing interdisciplinary fields,

Journal of Engineering Education, 103(1), 46-76. https://doi.org/10.1002/jee.20038

Buser, M., Store-Valen, M., Olsen, E.B., Lauridsen, K.A., & Straub, M. (2017). Defining education to support sustainable operation of buildings in the Nordic countries, *Proceeding of the 9th Nordic Conference on Construction Economics and Organization*, Goteborg, Sweden, 69 – 78.

Cabedo, L., Royo, M., Moliner, L., & Guraya, T. (2018). University social responsibility towards engineering undergraduates: the effect of methodology on a service-learning experience. *Sustainability*, 10(6), 1823. https://doi.org/10.3390/su10061823

Chan, M., & Nagatomo, D. (2021). Study of STEM for Sustainability in Design Education: Framework for Student Learning and Outcomes with Design for a Disaster Project, *Sustainability*, 14(1), 312. https://doi.org/10.3390/su14010312

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: a review of literature. *European Journal of Engineering Education*, 46(1), 90-115. https://doi.org/10.1080/03043797.2020.1718615

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheik, A. (2011). The case study approach. *BMC Medical Research Methodology*, 11 (100), 1-9. https://doi.org/10.1186/1471-2288-11-100

De Graaf, E., & Kolmos, A. (2003). Characteristics of Problem-based learning. *International Journal of Engineering Education*, 19(5), 657-662.

Dobson, H.E., & Tomkinson, C.B. (2012). Creating sustainable development change agents through problem-based learning, *International Journal of Sustainability in Higher Education*, 13(3), 263 – 278. https://doi.org/10.1108/14676371211242571

Doukarani, E., Ktoridou, D., Efthymiou, L., & Epaminonda, E. (2021). The Quest for Sustainable Teaching Praxis: Opportunities and Challenges of Multidisciplinary and Multicultural Teamwork, *Sustainability*, 13(13), 7210. https://doi.org/10.3390/su13137210

Du, X., Su, L., & Liu, J. (2013). Developing sustainability curricula using the PBL method in a Chinese context, *Journal of Cleaner Production*, 61, 80-88. https://doi.org/10.1016/j.jclepro.2013.01.012

Edström, K., & Kolmos, A. (2014). PBL and CDIO: Complementary Models for Engineering Education Development. *European Journal of Engineering Education*, 39(5), 539–555. https://doi.org/10.1080/03043797.2014.895703

Elkington, J. (1994). Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development. *California Management Review*, 36, 90-100. http://dx.doi.org/10.2307/41165746

EU Science Hub. (2022). *GreenComp: the European sustainability competence framework*. European Commission. https://joint-research-

centre.ec.europa.eu/greencomp-european-sustainability-competence-framework_en

Fisher, D., King, J., Rieckmann, M., Barth, M., Büssing, 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

Gamage, K. A. A., & Silva, E. K. de. (2022). Barriers, New Developments, and Emerging Trends in Sustainability in HE. *The Wiley Handbook of Sustainability in Higher Education Learning and Teaching*, 453–459. https://doi.org/10.1002/9781119852858.CH22

Gladysz, B., Urgo, M., Gapari, L., Pozzan, G., Stock, T., Haskins, C., Jarzebowska, E., & Kohl, H. (2018). Sustainable innovation in a multi-university master course, *Procedia Manufacturing*, 21, 18-25. https://doi.org/10.1016/j.promfg.2018.02.090

Gladsz, B., Urgo, M., Stock, T., Haskins, C., Sieckmann, F., Jarzebowska E., Kohl, H., Strandhagen, J.O., & Tollio, T. (2020). Sustainable engineering master module – insights from three cohorts of European engineering team. *International Journal of Sustainable Manufacturing*, 4 (2/3/4), 413-432. https://doi.org/10.1504/IJSM.2020.107130

Guerra, A. (2012) Problem-based learning and education for sustainable development: an overview in engineering education, *Proc. International Conference on Education and New Learning Technologies* - Barcelona, Spain, 557-565.

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

Guerra, A., & Kolmos, A. (2011). Comparing problem-based learning models: suggestions for their implementation. In J. Davies, E. De Graaff, & A. Kolmos (Eds.), *PBL across the disciplines: Research into best practice*, Aalborg: Aalborg Universitetsforlag, 3-17.

Guerra, A., & Rodriguez, F. (2021). Educating engineers 2030 – PBL, social progress and sustainability, *European Journal of Engineering Education*, 46(1), 1-3. https://doi.org/10.1080/03043797.2020.1828678

Guerra, A., Ulseth, R., & Kolmos, A. (2017). PBL in engineering education: International perspectives on curriculum change. In *PBL in Engineering Education: International Perspectives on Curriculum Change*. https://doi.org/10.1007/978-94-6300-905-8

Gutierrez-Bucheli, L., Kidman, G., & Reid, A. (2022). Sustainability in engineering education: A review of learning outcomes. *Journal of Cleaner Production*, *330*, 129734. https://doi.org/10.1016/J.JCLEPRO.2021.129734

ICEE (2021). Engineering for sustainable development: delivering on the Sustainable Development Goals. In *Engineering Innovations and the*

Sustainable Development Goals - ICCE UNESCO, 2021. https://unesdoc.unesco.org/ark:/48223/pf0000375644.locale=en

Herath, H.M.T.R.; Rathnayake, P.S. (2019). A critical approach towards sustainable development models – a review. *International Journal of Agriculture Innovations and Research*, 7(4), 446-454, ISSN 2319-1473.

Hermes, J., & Rimanoczy, I. (2018). Deep learning for a sustainability mindset. The International Journal of Management Education, 16, 460-467. https://doi.org/10.1016/j.ijme.2018.08.001

Hibbert, R. (2016). What is an immature science? *International Studies in the Philosophy of Science*, 30(1), 1–17. https://doi.org/10.1080/02698595.2016.1240433

Hsiao, H., Chen, J., Chen, J., Zeng, Y., & Chung, G. (2022). An assessment of junior high school students' knowledge, creativity, and hands-on performance using PBL via cognitive-affective interaction model to achieve STEAM, *Sustainability*, 14(9), 5582. https://doi.org/10.3390/su14095582

Jensen, A.A., Ravn, O., & Stentoft, D. (2019). Problem-Based Projects, Learning and Interdisciplinarity in Higher Education. In Jensen, A. A., Stentoft, D., & Ravn, O. (Eds.), *Interdisciplinarity and Problem-Based Learning in Higher Education. Innovation and Change in Professional Education.* https://doi.org/10.1007/978-3-030-18842-9_2

Kagawa, F. (2007). Dissonance in students' perceptions of sustainable development and sustainability: Implications for curriculum change, *International Journal of Sustainability in Higher Education*, 8(3), 317-338. https://doi.org/10.1108/14676370710817174

Kuhn, T. S. (1970). *The Structure of Scientific Revolutions*. 2nd ed. Chicago, IL: University of Chicago Press.

Kolmos, A., & Fink, F. K. (2004). *The Aalborg PBL Model: Progress, Diversity and Challenges*. Edited by L. Krogh. Aalborg: Aalborg University Press.

Kolmos, A., Graff, E., & Du, X. (2009). Diversity of PBL - PBL Learning Principles and Models. In X. Du, E. Graaff, & A. Kolmos (Eds.), *Research on PBL practice in Engineering Education*, 9–21. https://doi.org/10.1163/9789087909321_003

Leicht, A., Heiss, J., & Byun, W. J. (2018). *Issues and trends in Education for Sustainable Development*, 2018. http://www.unesco.org/open-access/terms-use-ccbysa-en

Lorente-Echeverría, S., Murillo-Pardo, B., & Canales-Lacruz, I. (2022). A Systematic Review of Curriculum Sustainability at University: A Key Challenge for Improving the Professional Development of Teachers of the Future. *Education Sciences*, 12(11), 753. https://doi.org/10.3390/EDUCSCI12110753

Martín-Garin, A., Millán-Garcia, J.A., Leon, I., Oregi, X., Estevez, J., & Marieta, C. (2021). Pedagogical Approaches for Sustainable Development in

Building in Higher Education, *Sustainability*, 13(18), 10203. https://doi.org/10.3390/su131810203

Orozco-Messana, J., & De la Poza, E. (2018). The ISA Lab workshop: a Project based learning initiative, *Proc. 4th International Conference on Higher Education Advances (HEAd'18)*, Valencia, Spain, 1593 – 1600. https://doi.org/10.4995/HEAD18.2018.8395

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuiness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welsch, V.A., Whiting, P., & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ, 372(71). https://doi.org/10.1136/bmj.n71

Pariatamby, A., & Hansen, J.A. (2007). Universities in Capacity Building in Sustainable Development: Focus on Solid Waste Management and Technology, *Waste Manage Research,* 25(3), 241–246. https://doi.org/10.1177/0734242X07079155

Podogórska, M., & Zdonek, I. (2022). Sustainable Technologies Supported by Project-Based Learning in the Education of Engineers: A Case Study from Poland, *Energies*, 15(1), 278. https://doi.org/10.3390/en15010278

Poursharif, G., Doss, T.P., Broadbent, R., & Knight, G. (2021). Developing Global Engineers Through Interdisciplinary PBL and Design Thinking, *Proc. 2021 IEEE Global Engineering Education Conference (EDUCON)*, Vienna, Austria, 194-198. https://doi.org/10.1109/EDUCON46332.2021.9453869

Probst, L. (2022). Higher Education for Sustainability: A Critical Review of the Empirical Evidence 2013-2020. *Sustainability (Switzerland)*, 14(6), 3402. https://doi.org/10.3390/SU14063402

Rodríguez Aboytes, J. G., & Barth, M. (2020). Transformative learning in the field of sustainability: a systematic literature review (1999-2019). *International Journal of Sustainability in Higher Education*, 21(5), 993–1013. https://doi.org/10.1108/IJSHE-05-2019-0168

Scerri, A., & James, P. (2010). Communities of citizens and "indicators" of sustainability. *Community Development Journal,* 45(2), 219–236. https://doi.org/10.1093/cdj/bsp013

Serafini, P. G., Moura, J. M. de, Almeida, M. R. de, & Rezende, J. F. D. (2022). Sustainable Development Goals in Higher Education Institutions: A systematic literature review. *Journal of Cleaner Production*, 370, 133473. https://doi.org/10.1016/J.JCLEPRO.2022.133473

Stake, R.E. (1995). *The art of case study research* London: Sage Publications Ltd.

Sterling, S. (1996). Education in Change. In John Huckle & Stephen Sterling (Eds.), *Education for Sustainability*, Earthscan, 18-39.

Sterling, S. (2004). Higher Education, Sustainability, and the Role of Systemic Learning. *Higher Education and the Challenge of Sustainability*, 49–70. https://doi.org/10.1007/0-306-48515-X_5

Tasdemir, C., & Gazo, R. (2020). Integrating sustainability into higher education curriculum through a transdisciplinary perspective, *Journal of Cleaner Production*, 265, 1-14. https://doi.org/10.1016/j.jclepro.2020.121759

Teff-Seker, Y., Portman, M.E., & Kaplan-Mintz, K. (2019). Project-based Learning in education for sustainable development: a case study of graduate planning students, *Case Studies in the Environment*, 3(1), 1-16. https://doi.org/10.1525/cse.2018.001537

Tejedor, G., Segalàs, J., Barrón, A., Fernández-Morilla, M., Fuertes, M.T., Ruiz-Morales, J., Gutiérrez, I., García-González, P.A., & Hernàndez, A. (2019). Didactic strategies to promote competencies in sustainability. *Sustainability*, 11(7), 2086. https://doi.org/10.3390/su11072086

Terrón-López, M.J., Velasco-Quintana, P.J., Lavado-Anguera, S., & Espinosa-Elvira, M.C. (2020). Preparing Sustainable Engineers: A Project-Based Learning Experience in Logistics with Refugee Camps, *Sustainability*, 12(12), 4817. https://doi.org/10.3390/su12124817

Thürer, M., Tomasevic, I., Stevenson, M., Qu, T., & Huisingh, D. (2018). A systematic review of the literature on sustainability into engineering curricula, *Journal of Cleaner Production*, 181, 608-617. https://doi.org/10.1016/j.jclepro.2017.12.130

UN (2015). *Transforming our world: The 2030 agenda for sustainable development*, A/RES/70/1.

UNESCO (2004). *United Nations Decade of Education for Sustainable Development 2004-2005* – Draft International Implementation Scheme, New York.

United Nations Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022: Summary of Results. UN DESA/POP/2022/TR/NO. 3.

Wiltshier, P., & Edwards, M. (2014) Managing knowledge transfer partnership for a rural community, *Kybernetes*, 43(3/4), 629-651. https://doi.org/10.1108/K-07-2013-0128

WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT (WCED). (1987). *Our Common Future*; Oxford University Press: New York, NY, USA.

Wu, Y.J., & Shen, J. (2016). Higher education for sustainable development: a systematic review. *International Journal of Sustainability in High Education*, 17(5), 633-651. https://doi.org/10.1108/IJSHE-01-2015-0004

Xi, J., & Wang, X. (2022). Development of Landscape architecture design students' pro-environmental awareness by Project-Based Learning, *Sustainability*, 14(4), 2164. https://doi.org/10.3390/su14042164

Yasin, R.M., & Rahman, S. (2011). Problem-Oriented Project Based Learning (POPBL) in Promoting, *Procedia Social and Behavioral Sciences*, 15, 289-293. https://doi.org/10.1016/j.sbspro.2011.03.088

Yousof, K.M., Sadikin, A.N., Phang, F.A., & Aziz, A.A. (2016). Instilling Professional Skills, and Sustainable Development through Problem-Based Learning (PBL) among First Year Engineering Students, *International Journal of Engineering Education,* 32(1B), 333–347.

Appendix 1

Table 3. Articles that use PBL to educate for sustainability.

Year	Article	Authors	Type of research design	Approach	Type of research questions	PBL model and level of implementation	Level/type of sustainability learning
2007	Universities in Capacity Building in Sustainable Development: Focus on Solid Waste Management and Technology	Pariatamby, A., Hansen, J.A.	Research-based	Qualitative	Discussion on PBL methodology for education for sustainability	Interdisciplinarity Postgraduate students	Environmental
2011	Problem-Oriented Project Based Learning (POPBL) in Promoting	Yasin, R.M., Rahman, S.	Conceptual	Qualitative	Discussion on PBL methodology for education for sustainability	Problem-Oriented Project Based Learning; interdisciplinarity Undergraduate course	General
2012	Creating sustainable development change agents through problem-based learning	Dobson, H.E., Tomkinson, C.B.	Conceptual	Qualitative	Discussion on PBL methodology for education for sustainability	interdisciplinarity	Environmental
2012	Problem-based learning and education for sustainable development: an overview in engineering education	Guerra, A.	Research-based	Qualitative	Curriculum development for sustainability using PBL	undergraduate engineering course	General
2013	Developing sustainability curricula using the PBL method in a Chinese context	Du, X., Su, L., Liu, J.	Research-based	Qualitative	Curriculum development for sustainability using PBL, considering cultural aspects	cross-courses model undergraduate engineering course	Environmental

2016	Instilling Professional Skills and Sustainable Development through Problem-Based Learning (PBL) among First Year Engineering Students	Yousof, K.M., Sadikin, A.N., Phang, F.A., Aziz, A.A.	Research-based	1st qualitative 2nd quantitative	Discussion on PBL methodology for education for sustainability	Cooperative Problem-based learning undergraduate engineering course	Environmental
2016	Integration of sustainability in engineering education Why is PBL an answer?	Guerra, A.	Conceptual/ Research-based	Qualitative	Curriculum development for sustainability using PBL	undergraduate engineering course	General
2018	The ISA Lab workshop: a Project based learning initiative	Orozco-Messana, J., De la Poza, E.	Research-based	Qualitative	Discussion on PBL methodology for education for sustainability, considering cultural aspects	Interdisciplinarity Master and undergraduate course Engineering, law, and architecture	Environmental
2020	Integrating sustainability into higher education curriculum through a transdisciplinary perspective	Tasdemir, C., Gazo, R.	Research-based	Quantitative	Curriculum development for sustainability using PBL	Transdisciplinarity Undergraduate course	Environmental
2020	Preparing Sustainable Engineers: A Project-Based Learning Experience in Logistics with Refugee Camps	Terrón-López, M.J., Velasco-Quintana, P.J., Lavado-Anguera, S., Espinosa-Elvira, M.C.	Research-based	Qualitative	Discussion on PBL methodology for education for sustainability	Interdisciplinarity undergraduate engineering course	Social
2021	Developing Global Engineers Through Interdisciplinary PBL and Design Thinking	Poursharif, G., Doss, T.P., Broadbent, R., Knight, G.	Research-based	Qualitative/ quantitative	Discussion on PBL methodology for education for sustainability	Interdisciplinarity and design thinking undergraduate engineering course	Environmental

2021	Educating engineers 2030 – PBL, social progress and sustainability	Guerra, A., Rodriguez, F.	Editorial	Qualitative	Discussion on PBL for education for sustainability	undergraduate engineering course	not applicable
2021	Pedagogical Approaches for Sustainable Development in Building in Higher Education	Martín-Garin, A., Millán-García, J.A., Leon, I., Oregi, X., Estevez, J., Marieta, C.	Research-based	Qualitative	Discussion on PBL methodology for education for sustainability	Multidisciplinary Problem-based learning, research-based learning, computational thinking undergraduate engineering and architecture course	Environmental
2021	Study of STEM for Sustainability in Design Education: Framework for Student Learning and Outcomes with Design for a Disaster Project	Chan, M., Nagatomo, D.	Research-based	1st qualitative 2nd quantitative	Discussion on PBL methodology for education for sustainability	Multidisciplinarity Innovation design undergraduate course	Social
2021	The Quest for Sustainable Teaching Praxis: Opportunities and Challenges of Multidisciplinary and Multicultural Teamwork	Doukanari, E., Ktoridou, D., Efthymiou, L., Epaminonda, E.	Research-based	1st Quantitative 2nd qualitative	Discussion on PBL methodology for education for sustainability, considering cultural aspects	Case-based learning and PBL Undergraduate Business School and Computer Science course	Social
2022	Sustainable Technologies Supported by Project-Based Learning in the Education of Engineers: A Case Study from Poland	Podgórska, M., Zdonek, I.	Research-based	Qualitative/ quantitative	Discussion on the use of SDGs in the PBL (which ones and who is interested in which)	Multidisciplinarity undergraduate engineering course	General

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Examining the Application of a Similar Problem-Based Learning Procedure in Teacher Education and Engineering Education Programs

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Abstract

This multiple case study aims to describe how Turkish students in English Language Teaching (ELT) and Electrical-Electronics Engineering Program (EEP) conceive of Problem-based Learning (PBL), and how they experience their studies within a PBL-oriented curriculum. With the inclusion of these two cases into the study, the rationale is to represent two different educational perspectives and to obtain in-depth, extensive, and comparable data. The participants from the ELT and EEP were first-year students who pursued courses in English, which is taught as a foreign language in Turkiye. During one semester, the data were collected through open-ended questionnaires and reflection reports, both of which were analyzed qualitatively with an interpretative phenomenological approach. The results revealed commonalities as well as differences in how students in these two comparable programs perceived and experienced PBL. Commonalities were many in number and involved positive perceptions along with beneficial experiences of PBL. Yet, differences only stemmed from the number of frequencies of some similar issues raised by both groups of students. The most eye-catching difference was that the EEP students emphasized the anticipated benefits of PBL less frequently than the ELT students did. However, at the end of the process, the EEP students proposed benefits gained from PBL more frequently.

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Introduction

Complexity of problems faced and the authenticity of settings where practices are made in various disciplines is a vital issue that needs to be addressed by educators. Within the contexts of education and engineering, sustainability and social benefit are the primary concerns for growing professional individuals. In education, with the perpetual influences of globalization in information societies, the role of teachers in moderating society necessitates reforms in teacher education (Tarman, 2010). To provide sustainability in educational development, teacher education programs are of noteworthy significance (Katitia, 2015). In the field of education, students need to be trained in a way that they become autonomous, active, cooperative, and skillful problem-solvers (Budaghyan, 2015). Identically, engineering requires one to empower his/her agency through individual development in a community. This empowerment entails the talents of mentoring, networking, and shared reflections. Accordingly, the changing roles of teachers and engineers now lead educators to design and implement student-oriented learning, especially at the undergraduate level. To meet such a need, Scott (2015) suggests that PBL is one of the most ideal models which can be compatible with twenty-first-century pedagogy since, as Hatisaru (2015) proposed, it is effective in promoting such skills as questioning, access to information, critical thinking, learning to learn and self-efficacy.

Aligning with the theories of socio-constructivism (Anderson, 2005), PBL is a well-known alternative approach to traditional disciplinary based educational programs in higher education (Dahlgren & Dahlgren, 2002). It was first implemented in medical education at McMaster University in Canada about forty years ago. At that time, PBL was recognized as an educational method designed to facilitate student motivation and interest in clinically based situations (Happell, 1991). It is regarded as representing a shift from the traditional perspective of higher education where much attention has been paid to teachers and teaching methods to a perspective that gives priority to student learning. Regarding learning/teaching style, it is a learning method based on the principle of using problems as a starting point for the acquisition and integration of new knowledge (Barrows, 1980). Among the diverse key pedagogical principles of PBL, Kolmos and DeGraaff (2014) categorize PBL approaches into three dimensions: the learning approach (Problems identified at the beginning shape the purpose of the whole learning; and it contains

identification, analysis, and solution phases), the social approach (Dialogic interaction takes place between team members while solving problems), and the content approach (Various theories specific to multiple disciplines are applied for problem-solving). Apart from these, Kolmos and DeGraaff (2014) claim that PBL is one of the most successful approaches that could yield positive outcomes in preparing engineers for their careers. Similarly, via PBL, teacher knowledge and skills can be fostered through authentic scenarios, group collaborations and self-directed learning (Borhan, 2014).

PBL is a more useful instructional method compared to lecture-based instruction regarding the development of skills and long-term retention (Strobel & van Barneveld, 2009). Particularly in teacher education, as a way to close the gap between theory and practice, PBL is an important tool to make student teachers use theoretical and practical resources in generating appropriate solutions (Kırkgöz, 2015; Pourshafie & Murray-Harvey, 2013). Kırkgöz (2017, 2018) also acknowledged that PBL is an effective instructional method endowing student teachers with diverse perspectives. Through solving real-life problems, student teachers become capable of transferring teaching skills to professional life (Borhan, 2014). In parallel with this, Kırkgöz and Turhan (2021) claimed that student teachers who are involved in PBL could gain more than theoretical knowledge. Moreover, PBL enables student teachers to think critically while solving problems. Namely, PBL is important for teacher education because it makes it possible for students to improve their analysis and evaluation skills, but still, there are some blank spaces in the realization of PBL in teacher education (Major & Mulvihill, 2018). To exemplify, one of the prerequisites of PBL is students' ability to be self-directed in learning; and instructors' first duty should be ensuring that students have this ability at the beginning of the PBL process (Kırkgöz & Turhan, 2021). This is because instructors should implement alternative learning strategies for students (English & Kitsantas, 2013). To this end, teacher education courses could be designed with the inclusion of technology-enhanced PBL practices (So & Kim, 2009) to make PBL more appealing to twenty-first-century students.

In engineering, there exists a need to move away from traditional learning methods toward PBL methods, especially the need to equip students with teamwork skills. This is because PBL necessitates students to participate in group work where their motivation and performance are expected to boost; however, either students do not have positive feelings toward their prior teamwork experiences or they have not had any experiences with teamwork and PBL (Chen et al., 2021). If the ones who have no previous experiences in PBL do not receive PBL skills training, they face various challenges in coping with conflicts in groups (McQuade et al., 2018). Another vital requirement of PBL might be self-learning skills, and some scholars assume that it is hard for

students to solve real-life problems in a self-learning process (e.g. Bledsoe & Flick, 2012; Hu et al., 2014; Lutsenko, 2018). More importantly, students need to reflect on their own progress and achievements to obtain efficacious learning gains from PBL (Gratchev & Jeng, 2018). In order to meet such requirements, students should receive continuous guidance on group work, self-learning and reflection. To accomplish these, specific lectures, workshops, or seminars could be added to the PBL-oriented curriculum through introducing theories of communication and problem-solving as a part of the professional community. Otherwise, PBL does not yield fruitful consequences in the long run, and obstacles may arise.

In the implementation of PBL in engineering, one of the main obstacles is the lack of community and industry involvement, which results in only a few opportunities for engineer candidates to put their factual knowledge into practice (Roach et al., 2018; Ruhizan et al., 2009) although they should be trained through PBL so that they can successfully fulfill the requirements of their profession. During and after such training, formative assessment practices are crucial in well-designed PBL systems (Thomas, 1997). Besides, such control tools as self-assessment, peer assessment, and meeting records should be utilized to gain a deeper understanding of student learning in PBL (Palmer & Hall, 2011; Qattawi et al., 2014). Along with such assessment tools, developing critical thinking skills through PBL is vital for an engineer's whole career (Said et al., 2005; Yadav et al., 2011). As for previous PBL studies in EEP, Bijzak (2008) highlighted students' higher test results and positive attitudes of both students and faculty members toward PBL. Likewise, de Camargo Ribiero (2008) postulated that students find PBL more engaging thanks to the construction of their own knowledge instead of only absorbing the teacher's words, as well as the improvements in research and communication skills. Moreover, Canavan (2008) concluded that PBL is an effective pedagogical tool enabling students to think deeply, feel more responsible toward their work and become effective communicators. In spite of these beneficial aspects of PBL, students' reports revealed that they learned more in traditional lectures because PBL did not help them become familiar with basic concepts (Yadav et al., 2011). This could be because of the non-existence of proper scaffolding, which is central to preventing students from feeling frustration in PBL (Yadav, 2006).

In light of this review, the present study aims at understanding how PBL is realized in two different academic contexts. The rationale of involving education and engineering in the study is that they are similar because both prioritize the practical side of the profession rather than equipping students only with theoretical knowledge. Conversely, they are different because education is more directly related to human beings and social aspects of learning; yet, engineering requires one to work with both humans and non-

living things. Moreover, the philosophy dominant in education is largely constructivist with multiple realities, though it is more individualistic with more unaltered realities in engineering. The study can also be regarded as valuable since it investigates the outcomes of PBL in courses taught in a foreign language at tertiary level. The purposes of this study are to evaluate the possible shifts in students' perspectives before and after an experience with PBL and to compare the commonalities and differences between the perceptions and experiences of the ELT and EEP students in relation to PBL. Depending on these purposes, the following research question was formulated:

- What are the commonalities and differences in the ELT and EEP students' perceptions and experiences in relation to PBL?

Method

Research design

The present study was designed as a multiple case study in order to have an in-depth investigation into perceptions and experiences of ELT and EEP students in a PBL environment. Multiple case studies explore differences within and between cases with the intent of replicating results across cases in a certain period of time (Yin, 2003). In this direction, we aimed to ascertain whether similar PBL implementations in different undergraduate programs result in any similarities and differences. Beyond that, we aimed to either accept or refuse the propositions concerning the success or failure of the implementations. The implementations of the curriculum in both programs took place in consecutive semesters; one (EEP) in the fall term and the other (ELT) in the spring semester. This was to prevent the time lag between the implementations. In fact, a PBL implementation that is compatible with the twenty-first-century pedagogy (Scott, 2015) seems to be reasonable for teacher and engineer education at tertiary level, each of which adapts differing views toward learning but attaches great importance to making real-life like practices. Beyond that, examining the implementation of a similar PBL procedure in a specific context would be a wise act to equip teacher and engineer candidates with the practice-oriented qualifications necessary for surviving in their future community of practice. Overall, the ultimate aim of this multiple case study is to determine whether we need to tailor one of the PBL-oriented curricula based on the predictions of similar and contrasting results across cases.

Participants

Participants were all freshmen from the ELT and EEP departments at a state university in Turkiye. 58 students from the ELT department and 68 students from the EEP were included in the study; in total, 126 volunteer students, whose average age was 21.5, took part in the study. We did not find it necessary to equalize the number of students in the groups so as not to intervene with the integrity of the study in its natural context. Both groups of students followed their courses through English. The majority of the participants had experiences in some kind of project; however, none of them experienced a PBL project. Due to their unfamiliarity with PBL, we assumed that the initial stages of the projects would be an adaptation period when such qualifications as self-directed decisions, higher-order thinking, and cooperation were dominant.

Procedures

In the scope of this study, PBL was incorporated into both a Reading-Writing course for ELT students and the Technical English course for EEP students. These courses were delivered by the first author of this study through the medium of English language. The ultimate objective of the steps taken during the study was to compare students' initial and final perceptions and experiences in a fourteen-week course. The weekly schedule of both courses consisted of three-hour PBL sessions and one-hour lectures. The PBL sessions focus on certain key features of PBL as listed below:

- Working in groups to find solutions to complex problems (Ferreira & Trudel, 2012)
- Giving value to learning (Tan, Van der Molen & Schmidt, 2016)
- Coping with learning challenges (Tan, Van der Molen & Schmidt, 2016)
- Resorting to higher-order thinking skills (Jerzembek & Murphy, 2013)
- Self-directed learning (English & Kitsantas, 2013)

The first step was to orient the students toward the logic of PBL in both theory and practice. The students were instructed about the educational principles and implementation steps of PBL. This orientation gave the students an understanding of educational methods and theory at the pre-exposure phase. Afterwards, throughout 14 weeks, the students were involved in the PBL sessions that were accompanied by the application of pre- and post-course questionnaires and weekly reflection reports. Four classes (Two ELT classes and two EEP classes), in the form of 45-minute sessions, were conducted three times a week. Students worked in groups most of the class time and their project topics concentrated on authentic problems related to their disciplines. Each group received the tutorials from the first of the study. The tutor was an indirect facilitator, rather than being directive, who developed the students' conceptual

schemata through discussions. During the PBL sessions, the first author, who is an experienced academician and has a number of studies on PBL, was not only a model of an effective problem-solver but also a model of a critical thinker and professional communicator. Most importantly, the first author guided the problem-solving procedures of the ELT and EEP students in different manners due to the complexity of the problems and the availability of diverse solutions. Roughly, we realized that the EEP students tended to raise more specific problems accompanied by few alternative solutions. However, the ELT students were more inclined to select well-rounded problems that might be dealt with many possible solutions. Therefore, it was more demanding for the first author to facilitate the ELT students' PBL experiences. Besides, the second author made herself familiar with the main tenets of the PBL implementations thanks to the regular meetings with the first author; and collaborated with the first author for the analyses and reporting of the findings.

Data collection tools

Designed by the authors, pre- and post-course questionnaires and reflection reports were the primary data sources of the study. The pre-course questionnaire was administered during the initial stage of the implementation to reveal what students understood from the concept of PBL as a new learning method and what they felt about being involved in a PBL project. In order to examine how PBL influenced students' perceptions and experiences, the post-course questionnaire was administered at the end of the course. To this end, students shared their opinions on the advantages and disadvantages of being a part of PBL projects. Additionally, they reflected on their experiences with this novel learning method in their weekly reflection reports examining what students carried away with them after the sessions. In formulating questions included in each data collection tool, expert opinions were obtained. Figure 1 illustrates the content and implementation sequence of the data collection tools:

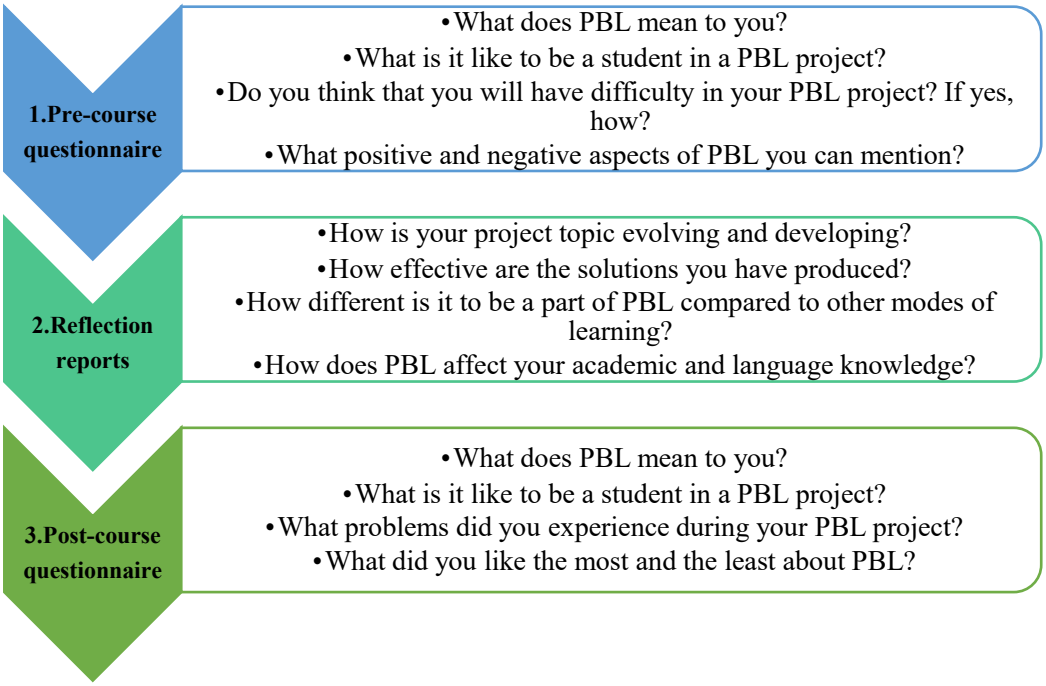

Figure 1. The content and implementation sequence of data collection tools.

Data analysis technique

The process of analysis was an iterative and cyclical movement between the individual data elicited from the questionnaires and reflections. The construction of an interpretative narrative which portrays the characteristic similarities and differences of the answers within each group (Dahlgren & Dahlgren, 2002) was the aim of all the analyses. Student responses in the open-ended questionnaires and reflection reports were analyzed qualitatively with an interpretative phenomenological approach focusing on the individual students' comments on his/her experiences. Each data source was thoroughly read, coded and subjected to content analysis to identify the most significant statements and meaningful units. A cross-case, interpretative and preliminary narrative was constructed, based on the merged series of selected statements for each group, respectively. The preliminary narratives were then condensed for expressing the typical and common traits of each group. Common themes in the two groups were used as a structure for comparison and determining the differences. To ensure trustworthiness, two independent coders analyzed the data. One coder, the first author of this study coded the entire data set; and the second author coded 80% of the whole data. Overall, there was 87% inter-coder agreement, which shows that the data analysis resulted in a trustworthy data interpretation process. The disagreements about the codes were only a few and were resolved through joint discussion. As for reporting of the results, the frequencies and percentages were shared to present the main themes; however,

sub-themes were not quantified. Instead, we reported the most prominent sub-themes in tandem with convenient excerpts.

Findings

In this section, first, findings related to pre- and post-course questionnaires are reported. Second, analyses of reflection reports are presented. All the themes emerged in accordance with the research scope with a specific focus upon perceptions and experiences. Overall, the elicited themes revolved around positive, negative or typical aspects of PBL, feelings and collaboration during the PBL project. Table 1 shows the themes constructed from the evaluation of both pre- and post-course questionnaires for the ELT and EEP students.

The results of the pre-course questionnaire	
ELT	EEP
Anticipated benefits (f:62, 28%)	Features of PBL (f:48, 28%)
Features of PBL (f:47, 21%)	Group work (f:40, 23%)
Feelings toward PBL (f:44, 20%)	Feelings toward PBL (f:38, 22%)
Group work (f:43, 20%)	Anticipated benefits (f:35, 20%)
Initial difficulties experienced (f:23, 11%)	Initial difficulties experienced (f:12, 7%)
The results of the post-course questionnaire	
ELT	EEP
Benefits gained (f:51, 28%)	Benefits gained (f:84, 36%)
Feelings toward PBL (f:48, 26%)	Feelings toward PBL (f:56, 24%)
Features of PBL (f:26, 14%)	Features of PBL (f:38, 16%)
Favorable and unfavorable aspects of PBL (f:26, 14%)/(f:3, 2%)	Favorable and unfavorable aspects of PBL (f:23, 10%)/(f:8, 3%)
Group work (f:25, 13%)	Group work (f:18, 8%)
Difficulties experienced (f:6, 3%)	Difficulties experienced (f:6, 3%)

Table 1. The results of the pre- and post-course questionnaires

As is evident in Table 1, five themes from the pre-course questionnaire results and six themes from the post-course questionnaire results emerged. The theme "anticipated benefits" in the results of the pre-course questionnaire is categorized under the theme "benefits gained" in the post-course questionnaire. Besides, we have one new theme at the end of the study, which is "favorable and unfavorable aspects of PBL". Table 1 demonstrates that in the initial stages, the ELT students mentioned anticipated benefits of PBL more frequently, yet the EEP students paid more attention to the features of PBL. This

may arise from the ELT students' possible tendency to think about the usefulness of certain teaching strategies, as they are more interested in the educational profits of learning procedures. On the other hand, the EEP students might care more about the characteristics of a new learning experience in which they are involved. Even so, both groups expressed opinions on feelings toward PBL, group work and difficulties as well as benefits and features of PBL in the pre-course questionnaires. The initial difficulties experienced were fewer for the EEP students. At the end of the process, the ELT and EEP students took into consideration the same issues with the issues they expressed in the initial stages of the study. Additionally, both groups raised a new issue regarding favorable and unfavorable aspects of PBL. It is observed that the EEP students focused on benefits gained more frequently than the ELT students did although it was the EEP students who made fewer references to the benefits in the initial stages. The frequencies of the other themes for both groups were similar. As for comparing the total results of the pre- and post-course questionnaire, it can be claimed that the initial difficulties experienced were more numerous compared to the difficulties experienced toward the end of the process. This is promising since both groups of students appear to gain a noteworthy familiarity with PBL and accumulate professional knowledge through PBL.

Theme 1: Features of PBL

For both groups of students, the theme of "features of PBL" was developed around the concepts of authenticity, relevance, constructing links with the real world, and awareness of the PBL philosophy before and after the PBL projects. In addition to these, in the post-course questionnaires, students expressed that PBL made them more independent in taking on a personal responsibility for the development of their projects; and they believed that PBL was applicable to the other courses as shown below.

> "The process of defining a problem that you showed us, to me, was very valuable, in that I started thinking about this not only in this course but in every assignment for other subjects." (ELT-Student19/post-course)

The EEP students' initial perceptions of PBL are primarily characterized by the authenticity of the studies. The authenticity mainly functions as a tool for the students in choosing a topic of current relevance to offer solutions to daily problems encountered. Namely, the aspects of relevance and authenticity go hand-in-hand because PBL engages students in learning information in ways that are similar to the ways in which it will be recalled and employed in future real-life situations and assesses learning in ways, which demonstrate understanding and not mere acquisition. The following excerpt illustrates these.

> "After some research, we all agreed on 'anti-waves'. This was necessary because when we concentrate on our lesson, someone's mobile phone rings off and our attention gets distracted. Therefore, we are trying to solve this problem by inventing a machine. This device will help us concentrate on the lesson and we won't have to deal with such distractions anymore." (EEP-Student21/pre-course)

Authenticity is also expressed in the sense that the EEP students get a feeling of coping with the kind of problems they will encounter later as professionals, in other words, as a link to their professional lives. Likewise, the ELT students believe that gaining some skills towards solving a real-life problem would have a great relevance to their future professional life as the skills and information they acquired would help them while teaching. The following excerpt gives a representative image of this.

> "We are working on a real-life problem, which is the insufficiency of classroom equipment. Knowing what kind of problems our education system has will help me now and, in the future, when I become a teacher." (ELT-Student13/pre-course)

It has also been noted that, even during the first month of the PBL project and at the end of it, both ELT and EEP students mentioned an awareness of PBL philosophy. A relevant excerpt is as follows:

> "This project is quite different from the other projects I have done so far, as it's based on daily facts, not imaginary situations…" (EEP-Student22/post-course)

Theme 2: Group work

This theme clearly demonstrates that students recognized how PBL involves teamwork, cooperation and responsibility toward others for both groups of students. Students generally found it important to learn from group members, learn how to effectively work in a group, how to deal with conflict management, to gain a sense of responsibility and to promote friendship. The first part of the following excerpt emphasizes the benefits of working together whereas the latter part explains the frustration involved.

> "Preparing this project as a group is useful in many ways. It develops our thoughts and personality. We learn how to help each other. I feel more creative. In the group, we learn new ideas from each other. We feel proud of what we do, but sometimes there are some disagreements that discourage us from progressing ahead." (EEP-Student12/pre-course)

Specifically, for the EEP students, PBL demanded a transition from the habit of working on their own to working in groups; and they accepted the tutorials as a significant learning environment because during tutorials, fellowship was fostered. They regarded the tutorial as an instrument for tuning their understanding of concepts and strategies for problem-solving and appreciating different points of view. Thus, tutorials fulfill several functions by giving opportunities for comparing one's own understanding with that of others. The following excerpt is a concise summary of all these.

> "However, we get rid of our concerns and confusion about the conflicts in the tutorials where we have the chance to give constructive feedback and reach a common understanding. It was a unique experience, indeed." (EEP-Student51/post-course)

On the other hand, especially in the beginning stages of PBL; the shift from individual work to group work made things harder for both groups of students who had been accustomed to working on their own. Though it was the students' first experience with working in groups, initial outcomes demonstrate that many students recognized and valued cooperation and teamwork. Some students, though, felt uneasy about adapting to working as a group.

> "At first, it was hard to adapt with my group friends as everybody had different ideas about the project. But later on, it became more and more enjoyable to take part in such a group activity." (ELT-Student4/pre-course)

Different from all these, an ELT student reported that group work is one of the best ways to teach a subject. Most ELT students stated that PBL provided peer and group interactions useful to them in completing the assignment; and similarly, for the EEP students, working in a group did not cause obstacles that might reduce the quality of their work. The below excerpt presents evidence for those findings.

> "Our topic was problematic student-teacher relationships. I learned interesting ideas from my friends, and they broadened my perspective. I now find myself better at taking responsibilities in a group. At first, I thought it would be hard to work in groups, and I thought I would be unsuccessful. My friends gave me a lot of courage and I was sure I would succeed. I decided to use PBL as my favorite teaching method in future." (ELT-Student14/post-course)

Theme 3: Feelings towards PBL

This theme demonstrated how students felt about taking part in the PBL project. The EEP students mostly felt challenge accompanied by determination,

satisfaction of having chosen a topic, self-confidence, excitement, pride, anxiety, or nervousness. Identical feelings were also detected for the ELT students such as confidence, challenge accompanied by determination, enjoyment, satisfaction, pride, worry, or anxiety. Generally, positive ones toward the end of the projects replaced negative feelings. Most importantly, both ELT and EEP students declared that they acquired a new identity, as they would serve for the benefit of the society. The related excerpts are presented below.

> "The topic of our project is "the education of disabled children". It is a crucial problem for Turkiye. To solve the related problems, we have interviewed some people. Besides, we have taken some photos and talked to the disabled people in schools. I hope, at the end of this study, we will make great contributions to the problems of disabled children." (ELT-Student23/post-course)

> "While working on our PBL project, I had the spirit of a researcher. Now, I am looking at problems from an entirely different perspective. Even sometimes, I am not angry about problems because I know how to solve them..." (EEP-Student30/post-course)

Another challenge for both groups of students was the confusion experienced because of the initial worries about the PBL process followed by the feeling of determination and satisfaction as is clear below.

> "At first, I thought it would be a difficult job, so I worried a lot… but as we moved further, I saw that we could do it, and I started to relax. Despite all the difficulties, I think our project will teach us about real life. Therefore, we are all determined to move on by doing extensive research..." (ELT-Student46/pre-course)

Theme 4: Anticipated benefits/Benefits gained

Anticipated benefits/benefits gained include the contributions of PBL to research and language skills. For the EEP students, the potential research skills ranged from organizing information, accessing information, effective use of the Internet, and use of journals as information sources. As for the contribution to language skills, they emphasized that their vocabulary knowledge was well developed; they improved their writing skills (especially in terms of sentence construction), and their presentation skills were fostered. The following excerpts summarize the benefits expressed by the EEP students.

> "This project is useful in many ways: it will help us improve our English. The most important part of this project is to develop our research and information organization skills using various sources." (EEP-Student19/pre-course)

> "I believe that PBL will help us in many ways in future because as engineer candidates, we need to do a lot of research. With the help of this specific method, we learned innovative techniques to conduct quality research." (EEP-Student7/post-course)

Besides, the ELT students' anticipation of the benefits did not greatly differ from those of the EEP students. Many ELT students were also aware of the benefits of PBL regarding subject-specific knowledge development as clearly shown below.

> "For me, we are involved in such a project that will make us aware of how certain things (creating an electronic dictionary) will make language learners' lives easier, and this project will help us be equipped with information about our profession." (EEP-Student35/pre-course)

Different from the previous statements, in the case of the ELT students, research skills gained priority over language skills, particularly in terms of developing a deeper understanding of how to carry out research as evidently expressed in the following excerpt.

> "In PBL, you have to explore yourself... in the lectures, we just take information and write it down, but PBL makes us go into more details with the help of hands-on experiences." (ELT-Student51/post-course)

Theme 5: Initial difficulties experienced/Difficulties experienced

Difficulties can be grouped as topic selection, finding sources, being incompetent in language skills, time constraints, dealing with the feeling of uncertainty, and achieving consensus on the divergent ideas. The difficulty in choosing authentic topics was also associated with reaching appropriate sources as highlighted in the excerpts below.

> "The most difficult part of it was to choose the problem. As a result of an agreement with my group friends, we decided to work on the harmful software on the web, which could be accepted as an up-to-date topic." (ELT-Student29/post-course)

> "Having decided on our topic, the next difficulty was where and how to find suitable documents for this topic. We soon found out that the answer to this question was hidden in our research topic "Internet". We found the rest of the documents from journals and the library, and we had to do some translation as well...." (EEP-Student17/post-course)

Maybe, a more frustrating experience for the EEP students was that they felt incompetent in English language skills as clarified below.

> "Initially, preparing a PBL project seemed frightening to me. Despite completing a one-year English language program, I have not been able to improve my reading, writing, and listening skills. Despite language-related difficulties, I believe that we will be able to complete this project successfully. It will be useful for improving my English since the project is totally run in English." (EEP-Student6/pre-course)

A few students from both groups drew attention to the allocated time for the project, and one of the ELT students in the following excerpt explained the reason behind the time constraint.

> "Our topic requires us to spend much time at school. The only solution is working in a group. If I were working alone, I would not have enough time to study." (ELT-Student54/pre-course)

Moreover, students had to cope with the feeling of uncertainty at the beginning. Welcoming divergent ideas caused uneasiness for a few although differences were appreciated for the majority. These two initial difficulties were noted in the following excerpt.

> "…we're having difficulty coming to an agreement on certain issues in our group. For example, we are still not sure about the title of our project. I am not sure whether we will complete the project or not." (EEP-Student10/pre-course)

Theme 6: Favorable and unfavorable aspects of PBL

The most positive aspect was that both groups of students had the opportunity to acquire knowledge about the subject investigated; in other words, the majority sincerely liked expanding their knowledge as is obvious in the following excerpt.

> "The thing I liked the most about this project is that I learned about what knowledge an engineer should have." (EEP-Student64/post-course)

Another common favorable aspect of PBL was the improvement in time management skills. Students attributed this improvement to the use of planning sheets, diaries and working in groups. One student stated that one of the best aspects of the course was being able to plan and reflect on his work and achievements on a regular basis. More specifically, the majority of the ELT students seemed to like working in groups, taking responsibility, conducting research, presenting the projects in front of their peers and witnessing the realities of their country. One ELT student as seen in the following excerpt expressed this.

> "What I liked the most was to gain awareness of the realities of my country. While doing this research, I saw that there were children, young people whose parents were divorced and had financial problems..." (ELT-Student1/post-course)

As for what they liked the least, a few difficulties related to group work and some minor research-related issues were addressed. The prominent unfavorable aspect for the EEP students was that they did not like being obliged to cope with the disagreements in the group. In sum, it is clear that the favorable aspects outnumbered the unfavorable aspects.

Apart from open-ended questionnaire results, the examination of reflection reports also provided valuable data. The reflections revealed two main themes as "ingredients of PBL and PBL as a learning journey". The figure below picturizes the four ingredients of PBL, which are authentic work, work relevant to the real world, tutorials and divergent ideas:

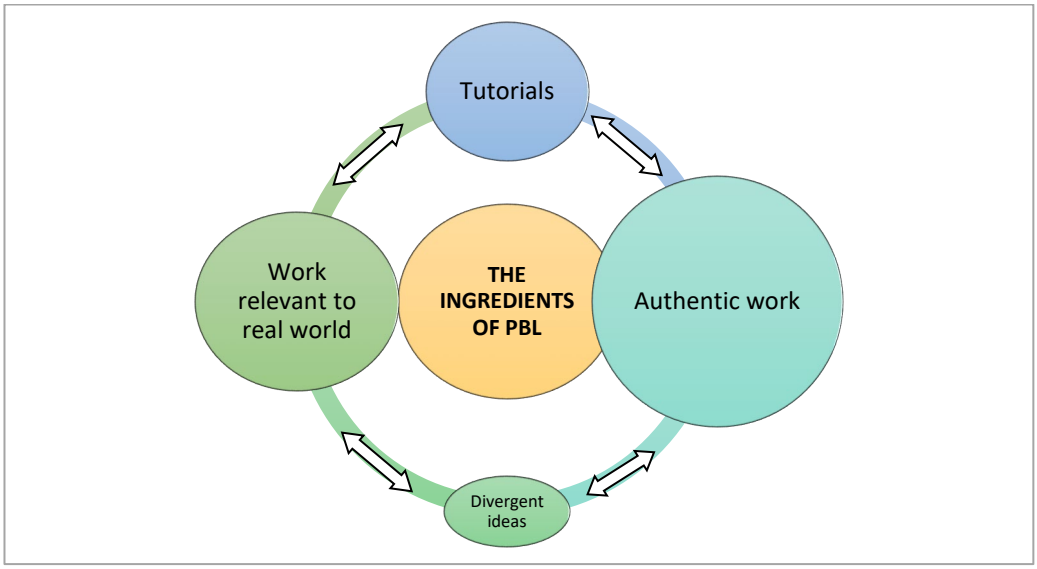

Figure 2. Conceptualizations regarding the ingredients of PBL.

In Figure 2, the size of the circles indicates the level of importance attributed to each sub-theme. Besides, each sub-theme is intertwined with each other from the students' point of view. To clarify, students from both groups believed that their PBL projects were considerably authentic and relevant to the work that they would be involved in during their daily lives. The excerpt below is evidence for this.

> "Cooling systems are produced to make these electronic goods work better. Because of that reason, all electronic machines that we use at home should have an effective cooling system to work perfectly well. We have decided to search on this important topic." (EEP-Student59)

ELT students also felt the necessity to solve a real-life problem. This is because it would help them use this PBL skill in their future teachings as indicated in the excerpt below.

> "I think it is also a part of our routine life. We always face problems, and we get over them by choosing the best solution… Therefore, doing a PBL project is the same as real life itself. To be successful, we need to do nothing but take it seriously." (ELT-Student37)

The remaining ingredients are the ones which were less frequently emphasized by the two groups of students. The first one is the emergence of divergent ideas during group work and the second one is the effectiveness of the tutorials as a learning platform. Many students appreciated the existence of divergent ideas although some others did not welcome it. The following excerpts exemplify these different opinions.

> "Before starting the project, we reviewed some articles, and everybody found different solutions. While doing so, our friendship has become stronger. I feel better as a person who is contributing to the problem-solving process." (ELT-Student22)

> "In the group, we learn new ideas from each other. But sometimes there are some disagreements which may have some bad effects on our motivation." (EEP-Student33)

In relation to tutorials, especially the EEP students indicated that they had efficient learning experiences thanks to the tutorials. Both groups of students regarded the tutorials as a significant learning environment for the reason that they considered fellowship in the groups to be of great value to themselves. They also used the group as an instrument for tuning their own understanding of concepts and strategies for problem-solving. A student expressed this as follows.

> "Tutorials are quite new to me. It is enjoyable but sometimes ideas clash and it becomes difficult to reach consensus. Secondly, it is a big pressure since you are responsible not only to yourself but also to your friends. However, those difficulties and pressures made us feel stronger as long as we produced more fruitful ideas." (EEP-Student7)

The second main theme, which is "PBL as a learning journey", is illustrated in Figure 3:

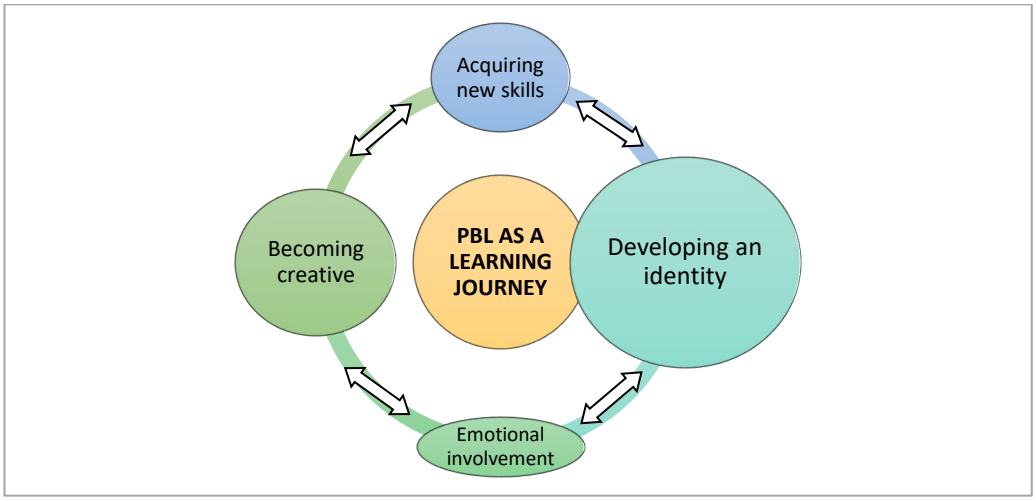

Figure 3. The PBL journey.

Figure 3 clearly shows that, just as in Figure 2, the sub-themes in the bigger circles represent the ideas, which were more frequently mentioned by the two groups of students. The focal point of Figure 3 is that each sub-theme is a part of the PBL journey and interrelated. That is, PBL is considered a journey in which students develop a new identity, become more creative, acquire new skills and are emotionally involved in rich learning experiences. The realization of PBL as a journey is obvious in the following excerpt.

> "This project will consolidate my English. I know that I am at the beginning of this road and if I could get a good start, I think that the rest will follow perfectly." (ELT-Student49)

As for crucial parts of this PBL journey, students reported that they gained a new identity not only as being university students but also as prospective professionals. They developed self-confidence and more positive feelings toward their profession and their peers. Moreover, students discovered their creativity and potential. The relevant excerpts about identity development and creativity are presented below.

> "This project made me feel important in the sense that I and my friends could be a real hero and heroine who were equipped with unique skills and original ideas." (ELT-Student2)

> "This is an opportunity for us to reveal our thoughts and use our creativity. However, in some other projects, information is only based on what we read in the texts or what we get from the Internet. This one is different because it forces us to think over problems with the aim of finding original and creative solutions." (EEP-Student13)

The last two sub-themes, which are acquiring new skills and emotional involvement, pinpoint that the students from both groups acquired new skills through trial and error. In addition, different from other courses they took, they were not only involved in projects with their academic knowledge but also with their personality, feelings, attitudes, or visions. All these are evident in the following excerpt.

> "I like doing these kinds of projects... In my opinion, bringing your potential into life, learning new things, and developing your skills with your whole body and soul are only possible if you participate in such projects." (EEP-Student60)

Discussion, conclusions and suggestions

Findings indicate that PBL is an approach that might better prepare students for the world of teaching and engineering by aligning curriculum delivery with existing undergraduate programs. This trial has been an encouraging first attempt in an ELT context and a novel method for the instruction in a Technical English course designed for EEP students. Though it was the first time for the participants of the current study to be engaged in a PBL project, they easily became familiar with the primary tenets of PBL, and they were good at differentiating between the implications of PBL curricula and other courses taught in traditional methods, which only or dominantly supported the transfer of theoretical knowledge. Among the tenets identified by the ELT and EEP students, the most prominent ones are authenticity, independence, responsibility, conflict management, teamwork and research skills. Depending on these, such PBL applications provide academically, personally and emotionally richer learning experiences because they enhance the skills of questioning, obtaining information, thinking critically, learning to learn and self-efficacy (Hatısaru, 2018). This finding is also evident in the students' utterances indicating that PBL is considerably different and beneficial to a degree that its philosophy should be applied in other courses offered in their departments. Another important reason for the inclusion of PBL tenets into the field of education and engineering might be the need, as Budaghyan (2015) proposes, for well-designed training where students become autonomous, cooperative, active participants of the learning process, and talented problem-solvers.

It is clear that both ELT and EEP students had similar perceptions and experiences throughout the projects. This is evident in the identical conclusions drawn from the comparisons of the initial and final perceptions and experiences and from the commonalities between the findings of the questionnaires and

reflection reports. Those similarities were mainly linked to the benefits, characteristic features, and favorable aspects of PBL along with positive feelings toward PBL. Herein, the most prominent finding is that the EEP students anticipated fewer benefits in relation to PBL; yet, at the end of the process, they proposed benefits that are more varied. This may indicate that the EEP students' perceptions in the initial and final stages of PBL differ more widely. Compared to all these positive perceptions and experiences, negative aspects or feelings as well as difficulties in relation to PBL were fewer in number. These positive attitudes toward PBL signify that teacher knowledge and skills can be developed through authentic scenarios, group collaborations and self-directed learning (Borhan, 2014); and engineer candidates could be suitably prepared for their careers (Kolmos & DeGraaff, 2014) thanks to a PBL-oriented curriculum. Bijzak (2008) also argued similar positive attitudes of EEP students as well as the faculty members toward PBL.

Specifically, for how our PBL implementation in the ELT and EEP differ from each other, it should be noted that the slight differences might be derived from the educational contexts of the two cases. That is, both the content and the medium of instruction is English for the ELT case whereas the EEP case struggles to learn a technical content in a foreign language. This disparity is reflected in a number of findings. For instance, the ELT students reported more benefits in relation to the improvement of their research skills during the PBL project. Yet, the EEP students paid much of their attention to the improvement of foreign language skills through PBL. In a similar vein, the EEP students faced language-related troubles, unlike the ELT students. As a solution, the EEP students might be encouraged or taught to reflect on their progress and learning outcomes (Gratchev & Jeng, 2018), particularly for language-related challenges before or during the PBL procedure. The common troubles, which resulted in unfavorable PBL experiences, were mainly disagreements in the group, divergent ideas in the tutorials and conducting quality research. In spite of these negative perceptions and experiences, the participants regarded some of those as crucial parts of their PBL experience (see Figure 2). Moreover, the PBL journey of the participants (see Figure 3) led to an identity change, which was accompanied by emotional involvement, creativity and acquiring new skills. Although these are considered as separate concepts, it may be argued that these three concepts constitute the identity changes. Namely, it would be better to acknowledge the concept of identity change as an umbrella term explaining the whole PBL journey. It was not highlighted by the participants, but the ability to self-direct is essential for the quality of learning through PBL (Kırkgöz & Turhan, 2021), and may be an important factor for a smooth identity development process. There are still some blank spaces in the implementation of PBL (Major & Mulvihill, 2018), and being self-directed is a blank space in this study. Finally, yet importantly for the differences, the ELT students provide

hints about their broader perspective toward the educational realities of Turkiye (see Theme 6) as a result of engaging in the PBL project. Similarly, some previous studies propose that PBL has the potential to illuminate the student teachers' diverse perspectives (e.g. Kırkgöz, 2017; 2018). Evidently, some significantly different perceptions and experiences in relation to PBL were explored despite the fact that the participants' similar perceptions and experiences dominated the entire set of findings. Thus, we can support the argument that our PBL procedures have comparable characteristics. We should honestly admit that we might reach identical results if we scrutinized only one of the cases. Nevertheless, examining the two cases provided an inspiration about how we could tailor a PBL-oriented curriculum in light of the predictions of similar and contrasting results across the cases.

The study offers implications for those who are experiencing difficulties with implementing problem-based curricula, and those who are designing problem-based models. Especially for teachers and engineering education, the findings of this study could be inspiring. It is the student-oriented activities based on the PBL philosophy (Anderson, 2005), which provide inspiration for educators to design and apply a PBL-oriented curriculum. The participants of this study noted that their previous education had not prepared them for interactive, student-oriented practices and PBL. Thus, guidance and support provided by the educators might be more essential so that students could experience a smoother transition in their first problem-based learning experience. This is also vital to deal with and minimize the inefficacious aspects of traditional learning approaches in which theoretical knowledge was dominant. If there is no guidance or support in the format of scaffolding during PBL, then students may be confronted with frustration (Yadav, 2006), which most probably leads to a loss of motivation toward PBL. Such negative feelings (e.g. worry, anxiety, and nervousness) were also detected in our participants; however, certain positive feelings (e.g. satisfaction, pride, confidence) were evident and increased toward the end of the projects. Another implication is linked to the theory and practice dilemma. In teacher education contexts, teacher candidates face difficulties in putting their theoretical knowledge into practice (Kırkgöz, 2015; Pourshafie & Murray-Harvey, 2013; Kırkgöz & Turhan, 2021) because of traditional training methods (Özçınar & Deryakulu, 2011); and besides, Turkish teacher trainees could only apply theory in a limited teaching environment just like argued by Hennissen et al. (2017), who found out that theory is included in primary school teacher training but is not embedded in teaching practices. As for engineering, PBL has proven itself as a method, which creates strong educational results (Mann et al., 2021); nevertheless, its outcomes should be unpacked in engineering courses where the medium of instruction is not the native language of the students just as in this study. This is highly crucial since theoretical knowledge learnt through a foreign or second language has to be put into

practice in real engineering settings; yet, unfortunately, prospective engineers have solely a few chances to do so at undergraduate level (Roach et al., 2018; Ruhizan et al., 2009).

To increase the opportunities for practice, PBL applications should be substantially incorporated into undergraduate courses. Even technology-supported teacher training courses taught through PBL, also mentioned by So and Kim (2019), may be offered so that student participation, equality and individual needs could be prioritized (Scott, 2015). Online courses are also fundamental for engineering education and have become more of an issue in the time of pandemic since 2020. The integration of online tools in PBL was found to be useful to improve critical thinking skills, as well (Hussin et al., 2019). For this reason, a further study could focus on how online or digital tools can enhance PBL experiences of students at tertiary level. We also believe that the combination of PBL and technology-supported tasks provides agency to be maximized in a specific way so that students become socially and environmentally responsible professionals who are more responsive and sensitive to future professional challenges. Depending on the positive outcomes of a PBL-oriented curriculum in two different contexts within this study, comprehensive longitudinal studies on PBL need to be conducted across disciplines. Particularly disciplines in which the medium of instruction is a foreign language should be within the scope of further PBL studies.

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References

Anderson, J. R. (2005). *Cognitive Psychology and Its Implications*. New York: Worth.

Barrows, H. S. (1980). *Problem-based learning: An approach to medical education*. Springer series on Medical Education, New York.

Bizjak, G. (2008). Load flow network analysis with problem-based learning approach. *International Journal of Electrical Engineering Education, 45*(2), 144–151. https://doi.org/10.7227/IJEEE.45.2.6

Bledsoe, K. E., & L. Flick. (2012). Concept development and meaningful problem-based laboratory experience. *Journal of Science Education and Technology, 21*(2), 226–245. https://doi.org/10.1007/s10956-011-9303-6

Borhan, M. T. (2014). Problem based learning (PBL) in teacher education: A review of the effect of PBL on pre-service teachers' knowledge and skills. *European Journal of Educational Sciences, 1*(1), 76–87. https://doi.org/10.19044/ejes.v1no1a9

Budaghyan, S. (2015). Technology teacher training in a remote region of Armenia. *Procedia -Social and Behavioral Sciences, 197*, 197–200. https://doi.org/10.1016/j.sbspro.2015.07.123

Canavan, B. (2008). A summary of the findings from an evaluation of problem-based learning carried out at three UK universities. *International Journal of Electrical Engineering Education, 45*(2), 175–180. https://doi.org/10.7227/IJEEE.45.2.9

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: A review of literature. *European Journal of Engineering Education, 46*(1), 90-115. https/10.1080/03043797.2020.1718615. https://doi.org/10.1080/03043797.2020.1718615

Dahlgren, M. A., & Dahlgren, L. O. (2002). Portraits of PBL: Students' experiences of the characteristics of problem-based learning in physiotherapy, computer engineering and psychology. *Instructional Science, 30*, 111-127. https://doi.org/10.1023/A:1014819418051

de Camargo Ribeiro, L. R. (2008). Electrical engineering students evaluate problem-based learning (PBL). *International Journal of Electrical Engineering Education, 45*(2), 152–161. https://doi.org/10.7227/IJEEE.45.2.7

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem- and project based learning. *Interdisciplinary Journal of Problem-Based Learning, 7*(2), 128-150. https://doi.org/10.7771/1541-5015.1339

Ferreira, M. M., & Trudel, A. R. (2012). The impact of problem-based learning (PBL) on student attitudes toward science, problem-solving skills, and sense of community in the classroom. *Journal of Classroom Interaction, 47*(1), 23-30.

Gratchev, I., & Jeng, D. S. (2018). Introducing a project-based assignment in a traditionally taught engineering course. *European Journal of Engineering Education 43*(5), 788–799. https://doi.org/10.1080/03043797.2018.1441264

Happell, B. (1991). Problem-based learning: Providing hope for psychiatric nursing? *Medical Education, 25*(2) 140-3.

Hatisaru, V. (2015). Investigating student growth in problem based learning treatment mathematics classes. *Gaziantep University Journal of Social Sciences, 14*(2), 459–477. https://doi.org/10.21547/jss.256769

Hennissen, P., Beckers, H., & Moerkerke, G. (2017). Linking practice to theory in teacher education: A growth in cognitive structures. *Teaching and Teacher Education, 63*, 314–325. https://doi.org/10.1016/j.tate.2017.01.008

Hu, J., Martinez Ortiz, A., & Sriraman, V. (2014, June). *Implementing PBL in a Concrete Construction Course*. American Society for Engineering Education.

Hussin, W. N. T. W., Harun, J., & Shukor, N. A. (2019). Problem based learning to enhance students critical thinking skill via online tools. *Asian Social Science, 15*(1), 14–23. https://doi.org/10.5539/ass.v15n1p14

Jerzembek, G., & Murphy, S. (2013). A narrative review of problem-based learning with school-aged children: Implementation and outcomes. *Educational Review, 65*(2), 206-218. https://doi.org/10.1080/00131911.2012.659655

Katitia, D. M. O. (2015). Teacher education preparation program for the 21st century. Which way forward for Kenya? *Journal of Education and Practice, 6*(24), 57–64.

Kirkgöz, Y**.** (2015). Designing and implementing an innovative problem-based teacher education course. *American Journal of Educational Science, 1*(5), 229-239.

Kirkgöz, Y. (2017). Working the problem: Finding solutions to student dissatisfaction in EAP for engineering. In Stewart, T. (Ed.), *TESOL voices: Insider accounts of classroom life higher education* (pp.17-26). Alexandria, Va: TESOL Press.

Kirkgöz, Y. (2018). Problem-based learning in a teacher education program: A study of learning outcomes. In Genç, Z. S. (Ed.), *Updating perspectives on English language teaching and teacher education* (pp 79- 92). Peter Lang.

Kirkgöz, Y., & Turhan, B. (2021). Views of Turkish EFL teacher trainees toward technology-integrated PBL practices. *English Language Teaching Educational Journal*, *4*(1), 74-86. https://doi.org/10.12928/eltej.v4i1.3748

Kolmos, A., & DeGraaff, 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 (CHEER)* (pp. 141–160). New York: Cambridge University Press. https://doi.org/10.1017/CBO9781139013451.012

Lutsenko, G. (2018). Case study of a problem-based learning course of project management for senior engineering students. *European Journal of Engineering Education, 43*(6), 895–910. https://doi.org/10.1080/03043797.2018.1454892

Major, T., & Mulvihill, T. M. (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

Mann, L., Chang, R., Chandrasekaran, S., Coddington, A., Daniel, S., Cook, E., & Smith, T. D. (2021). From problem-based learning to practice-based

education: A framework for shaping future engineers. *European Journal of Engineering Education*, *46*(1), 27-47. https://doi.org/10.1080/03043797.2019.1708867

McQuade, R., Wiggins, S., Ventura-Medina, E., & Anderson, T. (2018). Knowledge disagreement formulations in problem-based learning tutorials: Balancing pedagogical demands with saving face. *Classroom Discourse, 9*(3), 227–243. https://doi.org/10.1080/19463014.2018.1495089

Özçınar, H., & Deryakulu, D. (2011). The effects of reflection points in video-cases and teacher participation in online discussion groups on reflective thinking. *Hacettepe University Journal of Education, 40*, 321–331.

Palmer, S., & Hall, W. (2011). An evaluation of a project-based learning initiative in engineering education. *European Journal of Engineering Education, 36*(4), 357–365. https://doi.org/10.1080/03043797.2011.593095

Pourshafie, T., & Murray-Harvey, R. (2013). Facilitating problem-based learning in teacher education: Getting the challenge right. *Journal of Education for Teaching*, *39*(2), 169-180. https://doi.org/10.1080/02607476.2013.765190

Qattawi, A., Venhovens, P., & Brooks, J. (2014). Rethinking automotive engineering education: Deep orange as a collaborative innovation framework for project-based learning incorporating real-world case studies. In Proceeding of *121st ASEE Annual Conference & Exposition* (pp. 1–28). Indiana: ASEE Prism.

Roach, K., Tilley, E., & Mitchell, J. (2018). How authentic does authentic learning have to be? *Higher Education Pedagogies, 3*(1), 495–509. https://doi.org/10.1080/23752696.2018.1462099

Ruhizan, M. Y., Ramlee, M. & Azami, Z. (2009). Promoting creativity through problem-oriented project-based learning in engineering education at Malaysian Polytechnics. In Proceedings of *the 8th WSEAS International Conference*. https://www.semanticscholar.org/paper/Promoting-creativity-through-problem-oriented-based-Yasin-Mustapha/ff0c46b67809111cc7dd26b52170141bb3576417

Said, S. M., Adikan, F. M., Mekhilef, S., & Rahim, N. A. (2005). Implementation of the problem-based learning approach in the department of electrical engineering, University of Malaya. *European Journal of Engineering Education, 30*(1), 129-136. https://doi.org/10.1080/03043790512331313895

Scott, C. L. (2015). The futures of learning 3: What kind of pedagogies for the 21st century? UNESCO Education Research and Foresight, Paris. ERF working papers series, no. 15.

So, H. J., & Kim, B. (2009). Learning about problem based learning: Student teachers integrating technology, pedagogy and content knowledge. *Australasian Journal of Educational Technology, 25*(1), 101-116. https://doi.org/10.14742/ajet.1183

Strobel, J., & van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-Based Learning, 3*(1), 44-58. https://doi.org/10.7771/1541-5015.1046

Tan, C. P., Van der Molen, H. T., & Schmidt, H. G. (2016). To what extent does problem-based learning contribute to students' professional identity development? *Teaching and Teacher Education, 54*, 54-64. https://doi.org/10.1016/j.tate.2015.11.009

Tarman, B. (2010). Global perspectives and challenges on teacher education in Turkey. *International Journal of Arts and Sciences, 3*(17), 78–96.

Thomas, R. E. (1997). Problem-Based Learning: Measurable Outcomes. *Medical Education, 31*(5), 320–329. https://doi.org/10.1046/j.1365-2923.1997.00671.x

Yadav, A. (2006). *Video cases in teacher education: What role does task play in learning from video cases in two elementary education literacy methods courses?* (Doctoral dissertation, Michigan State University). East Lansing, MI.

Yadav, A., Subedi, D., Lundeberg, M. A., & Bunting, C. F. (2011). Problem-based learning: Influence on students' learning in an electrical engineering course. *Journal of Engineering Education*, *100*(2), 253-280. https://doi.org/10.1002/j.2168-9830.2011.tb00013.x

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage.

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General Problem-solving Skills Can be Enhanced by Short-time Use of Problem-Based Learning (PBL)

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Abstract

Future students are confronted with a complex world that demands the ability to solve problems in unstructured, undefined, and unfamiliar situations. The aim of the present study was to investigate the development of problem-solving skills through the implementation of Problem-Based Learning (PBL). While previous research has primarily focused on content-related and long-term measurements when examining the effects of PBL, this study took a different approach by exploring the general increase in problem-solving skills resulting from PBL. The sample consisted of 90 second-semester students who were assessed at three different time points using three subscales of the Wilde-Intelligenz-Test I & II: *analogies (AL), letter series (BR) and numerical series (ZN)*. The findings revealed a significant improvement in general problem-solving abilities within the PBL group. These results provide valuable insights into the impact of PBL on the development of general problem-solving skills, even within a domain-independent and short-term context. Lecturers are encouraged to consider implementing PBL in their study programs, as it equips graduates with the necessary skills to tackle the challenges of today's dynamic and constantly changing world.

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Keywords: Problem-solving, measuring learning development, intelligence test, Problem-Based Learning (PBL), cognitive psychology, analogies, future skills, contextual learning.

Introduction

Problem-solving has emerged as a crucial competency necessary to tackle today's challenges and prepare individuals for future employment opportunities. Higher Education recognizes problem-solving as an essential skill for graduates to succeed in their professional lives (Funke et al., 2018). Problem-solving can be defined as "an individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations to achieve one's potential as a constructive and reflective citizen" (OECD, 2014, p. 30).

Torp and Sage (1998, 2002) emphasize the significant role of problem-solving in a rapidly changing world. In their opinion, this doesn't necessarily yield a one-size-fits-all solution for addressing every challenge. However, research underscores the significance and impact of this specific competence. As a generic skill, problem-solving has the potential to be trained on current problems and be transferred to future societal and occupational challenges. Lezak et al. (2012) describe this process of problem-solving as the ability to abstract a problem, think of alternatives and develop a concept of decision-making. For the development of this skill, past research identified PBL as an effective learning method (Strobel & van Barneveld, 2009). Graaf and Kolmos (2003) outlined the process of learning through PBL by highlighting four key aspects. According to this perspective, learning is stimulated by *problems* and developed by working on a *project* with a certain amount of *experience* in a specific *context.* PBL aligns with constructivist thinking, which places the responsibility on learners to identify and construct potential solutions to problems. As a student-centered method, PBL actively engages learners, fosters collaboration, and cultivates the ability to transfer knowledge to various situations. The primary cognitive processes involved in problem-solving, namely representing, planning, executing, and monitoring (Mayer, 2013) closely align with the aspects emphasized in PBL. This can be recognized by having a deeper look at the structure of the 7-step framework and its application in the PBL tutorials. The framework starts with a clarification of the PBL case. First, the students identify unknown content. This is followed by a collection of possible challenges or issues represented by the case. After this, the brainstorming section starts to discuss and collect any thoughts about relevant

content of the case which focusses on the solution. The next step is to cluster the collected aspects, rate them in their relevance and impact on the problem-solving and finally the group decides how the problem is formulated with which the students are going to start their research. Afterwards, the phases of planning the solution, researching for relevant information and clustering the collected information with a close monitoring of the progress begins. This finally ends with a reiterating group discussion in the tutorials until the group agrees on having solved the case and formulated a good solution. This process – of course on a more detailed level – seems to be quite similar to the process of problem-solving. The original PBL method follows a 7-step framework (Konermann, 2016) that guides learners through the resolution of presented cases. As this study wants to present a way to measure the impact of PBL in an early period of learning, we decided to take the 7-step framework as it tightly guides learners through the process of case-based reasoning while practicing the PBL tutorials. Additionally, the 7-step method is supported by PBL tutors to assure a learning process without the need of huge prior knowledge which is widely not existing in this period of first-year bachelor students. It begins by clarifying unfamiliar content or terminologies, identifying relevant information including useful criteria compared to prior knowledge and initiating a brainstorming process. Learners engage in discussions to prioritize the resolution of the case and define a problem that must be solved to address the overarching issue. They then embark on the problem-solving process by conducting research, gathering information, comparing it to the given problem, and continuously monitoring their progress with a focus on potential solutions.

It is reasonable to assume that problem-solving abilities can be effectively trained through PBL due to its inherent characteristics and methodology. Through repeated exposure to different problems, learners become adept at employing various problem-solving techniques such as brainstorming, hypothesis testing, and logical reasoning. They learn to think creatively, generating innovative solutions and considering multiple perspectives. One key advantage of PBL is its emphasis on analytical skills. By presenting learners with authentic problems, PBL stimulates their ability to analyze situations, identify relevant information, and break down complex problems into manageable components. This process enhances their capacity to think critically, evaluate evidence, and make informed decisions—a crucial skill set applicable across a wide range of domains. By this, this pedagogical method is supposed to offer numerous benefits in addressing general problem-solving abilities and equipping individuals with the skills needed to navigate complex challenges effectively. By engaging in PBL, individuals acquire a repertoire of problem-solving strategies that can be transferred and applied to diverse situations, presumably contributing to their overall problem-solving capabilities. Finally, PBL provides learners with a realistic and contextualized

learning experience. By immersing themselves in authentic problems, learners gain a deeper understanding of how concepts and theories are applied in practice. This contextualized learning enhances their ability to transfer knowledge from one domain to another, enabling them to tackle unfamiliar problems with confidence and adaptability.

So far, the evaluation of PBL has predominantly relied on assessing its impact using practical problems that closely resemble previously encountered issues (Albanese & Mitchell, 1993; Almulla, 2020; Berkson, 1993; Castillo-Megchun et al., 2021; Dochy et al., 2003; Kasim, 1999; Newman, 2003; Reznich & Werner, 2001; Sharma, 2015; Vernon & Blake, 1993). Where Albanese & Mitchell, Berkson, Castillo-Magchun et al., Kasim, Newman, Reznich & Werner and Vernon & Black mostly focus on healthcare related programs, Almulla, Dochy and Sharma focus more on the seniority of the learner and its period of study. Consequently, the effects have primarily been measured within the content and context that aligns with the original PBL environment or the learners progress in study. This approach presents challenges in determining whether the benefits extend to different problem types and contexts or if it enhances general problem-solving skills. Given that problem-solving can be considered a skill that transcends specific contexts, it is crucial to explore its transferability to various scenarios. In terms of assessment, the more abstract and dissimilar the context of measurement the more applicable the results should be to any other fields of application. Barnett & Stephen (2002) discussed the concept of learning from the perspective of the proximity or distance of a topic to its corresponding domain. This leads to different ways of understanding and transferring skills which are needed to develop and strengthen competencies in the specific domain. Further learning research divides by the transfer of skills which is the training of content across various fields (Barnett & Ceci, 2002) and relates to a central topic in cognitive psychology. Emphasizing learning that is closely aligned with the domain is crucial for ensuring a profound understanding. Additionally, decontextualizing the learning content is vital to maximize the effectiveness of competence transfer. One of the primary objectives of PBL is to cultivate domain-independent skills rather than skills that are limited to specific contexts. Therefore, relying solely on practical problems as assessment measures may not provide a comprehensive understanding of the impact of PBL. Additionally, most of PBL research is conducted during advanced study periods, typically occurring in higher semesters after the fourth or fifth semester. (Almulla, 2020; Barrows, 1980, 1996; Barrows & Tamblyn, 1980; Caplow et al., 1997; Castillo-Megchun et al., 2021; Davis & Harden, 1999). To ensure a broader assessment of PBL's impact it would be beneficial to also investigate PBL learning scenarios in earlier study periods, such as the first or second semester, to minimize reliance on prior knowledge.

While PBL is often utilized in later stages of the curriculum, its impact should be examined from a learner's perspective in various courses, not exclusively advanced ones. By adopting a more independent assessment method the impact and effectiveness of PBL on learning can be evaluated and provide individual feedback at any stage of the course, rather than solely in advanced courses. Additionally, some studies have employed measures such as scores from regular Secondary Education certificates (Thomas, 2000) as dependent variables to demonstrate the effectiveness of PBL. However, using average grades at the end of the school year as measures of PBL's impact does not adequately support individual facilitation within the specific course where PBL is implemented. The measurements are usually long ago and susceptible to confounding influences. Furthermore, the effects of PBL are often investigated from a long-term perspective (Yew & Goh, 2016), overlooking potential short-term interventions or adaptations that learners can utilize for their individual development and adjustments - an essential aspect of successful student-centered facilitation (Kolmos et al., 2008). Therefore, the present study adopted a different approach by examining the short-term impact of PBL on general thinking and problem-solving abilities. We employed various cognitive instruments within a domain-independent context and an early stage of the study to address the limitations of previous research and shed light on the missing short-term and transfer-related effects of PBL independent of prior knowledge in the respective field of study.

To summarize our argumentation which leads to our research design as well as our main research hypothesis, there are mainly three different aspects we want to address by our study design:

1. Field of study or subject which leads to a dependence on content
2. Method of measurement which leads to a dependence on context
3. Progress of learners in its study period which leads to a dependence on the prior knowledge or experience of the learners

In a crossover research-design we treated the learning methodology as the independent variable and the development of problem-solving abilities as the dependent variable. This leads to the main research hypothesis: The two different learning methodologies, a traditional course group (CG) and a Problem-Based Learning group (PBL) show a statistically significant difference in their development of problem-solving across the measured timepoints. This main hypothesis includes three inevitable premises and a fourth additional to be tested before determining the main hypothesis:

(1) No difference in the baseline measurement at timepoint t_0

(2) Significant difference between the two measurements of CG and PBL from timepoint t_0 to timepoint t_2 after the PBL intervention
(3) Pairwise comparison of the development of each group
(4) Interaction effect for timepoint and group

Method

Research design

A total of 168 first-year psychology students were randomly assigned to two groups. with the first group participating in a traditional tutorial led by a tutor, referred to as the "course group". The second group engaged in a PBL tutorial, led by the students themselves and structured according to the 7-Step-Method of PBL (Konermann, 2016; Maurer & Neuhold, 2012), and will be referred to as the "PBL group". To ensure both groups covered the same foundational content in Differential and Personality Psychology, PBL-oriented cases were developed for the PBL group while the course group received regular presentations with equivalent content for. In contrast to the PBL group, where students had to formulate the problem statement and utilize the traditional 7 Step Method of PBL, the course group was instructed by a tutor who presented and discussed the content from slides. To assess general problem-solving abilities, subscales of the Wilde-Intelligenz-Test (Version 1 and 2) were applied (Althoff & Jäger, 1994; Kersting et al., 2008). The research background of both the Wilde-Intelligenz-Test I (WIT1) and the Wilde-Intelligenz-Test II (WIT2) are based on Thurstone's (1938) model of Primary Mental Ability (PMA). The PMA model comprises seven primary factors: (1) Reasoning, (2) Space, (3) Number, (4) Verbal, (5) Memory, (6) Word Fluency and (7) Perceptual Speed (Kersting et al., 2008). The factor relevant for the current study is (1) Reasoning, which includes three subtests (1.1.) Analogy, (1.2) Processing, and (1.3) Numeral Series. Over time, Thurstone's model has been developed, modified and validated by various researchers. Jäger (1982), for example, focused on reasoning and introduced the *Modified Model of Mental Abilities (MMPMA)*. Jäger identified common factors in numeral and verbal series as explanatory factors of problem-solving. The reasoning factor, encompassing these different aspects, can be measured using their sum score to validly represent *Reasoning* (Jäger, 1982). As demonstrated earlier, problem-solving, as assessed by the WIT instrument, serves as a common criterion to measure problem-solving abilities. Initially, Jäger (1968) started to deal with common factors to represent the dimension of *reasoning*. This facet is usable to measure the cognitive performance in a way of deductive reasoning which is also described as complex problem-solving. As this is used for personnel selection processes (Kersting et al., 2008; Schmidt & Hunter, 2004) it is a robust and representative criterion (Wilhelm, 2004) for the

present study and its purpose of measuring the problem-solving ability on an abstract, content independent level. The WIT provides two versions of tasks (Version A and B) to measure the groups at three different timepoints. This ensures that tasks are not repeated and minimizes learning effects. By employing a crossover design, we administered the subscales of *numerical*, *verbal* and *letter series* at three timepoints. The first assessment took place one week before the intervention, the second assessment occurred after two weeks, and the third assessment occurred after the final course but before the exam. At the second timepoint, the groups switched their learning methods. Each week consisted of three mandatory course sessions.

Participants and exclusions

The participants of this study were in their first-year psychology bachelor students enrolled at the Faculty of Applied Psychology of the SRH University of Applied Sciences in Heidelberg. Out of a potential sample size of N=168, a total of N=136 students participated at the first timepoint. For the second timepoint, the number of participants decreased to N=121 and at the third timepoint, there were N=111 students who took part in the study. The age range of the participants was between 18 to 25 with a mean age (M) of 20.85 and a standard deviation (SD) of 1.978. The gender distribution of the sample leaned towards females, with n = 81 (73 %) female participants and n = 30 (27 %) male participants.

Participation in the study was voluntary, and students received a total of seven test subject hours, which is a common requirement for psychology students during their study program, for their involvement in all three timepoints. The box plot method as a common method in social sciences was employed to identify outliers (Bortz & Schuster, 2016; Döring, 2022; Döring & Bortz, 2016), resulting in the exclusion of n=31 students from further analysis.

The following table gives an insight on our participant's characteristics.

Participants		Age		
		Mean (SD)	Min	Max
Gender	N (%)	20.85 (1.987)	18	27
Female	81 (73%)	20.62 (1.921)	18	27
Male	30 (27%)	21.47 (2.030)	18	27

Table 1. Overview of participants characteristics.

Materials

The participants were provided with all study materials in printed format. The testing instruments included information regarding data privacy and an informed consent form. The study received approval from the ethics committee of the SRH University Heidelberg and the Heidelberg University of Education. It was assured that neither of the groups experienced any systematic disadvantages during the study.

Variables

Three scales from the WIT1 and WIT2 were utilized to assess the construct of *formal logical thinking* also known as *reasonable thinking.* The WIT1 scales included *analogies (AL)*, *letter series (BR)* and *numerical series (ZN).* The WIT2 scales comprised *analogies (AL)*, *numerical series (ZN)* and *transaction (AW), which* were representative of the problem-solving skill (Kersting et al., 2008). Both testing instruments involved completing various series within a given time frame and marking the correct answer from multiple choice options provided on the answer sheet.

In the *Analogies* subtest participants were presented with an equation that consisted of two given words on the left side (e.g. *Sheep* and *Wool*) and one word on the right side (e.g. *Bird*) with the second word missing. Below the equation, participants were provided with five answer options (a-e) and had to select the correct one. In this case, the correct answer would be *d) Feathers.*

The *Numerical Series* subtest involved a given series of six numbers (e.g. *2, 5, 8, 11, 14, 17, ?*). Participants had to identify the rule by which the numbers were generated and write down the correct upcoming number. In this case, as the rule means *add 3 to each number*, the correct answer would be *20.*

The Letter Series subtest presented participants with 10 randomly combined letters (e.g. *a h b h c h d h e h ? ?*) from which they had to deduce the underlying pattern. On the answer sheet, five options (1-5) were provided, and participants had to select the correct one. In this case, following the *correct sequence of the alphabet (a, b, c, …) with an h in between,* the correct answer would be *4) f h.*

The *Processing* subtest required participants to mentally visualize the folding of a figure. They were presented with 20 unfolded figures displaying different patterns such as black boxes, stripes, dots, or notches on the outside. On the right side, participants saw five proposed folded figures, of which four were not derived from the unfolded figure on the left side. Participants had to imagine how to fold the initial figure and mark the correct answer.

Procedures

Each group, consisting of approximately 12-15 participants, was accompanied into the testing room by an instructor who had received prior training from the authors. All groups were simultaneously tested in 12 separate rooms. Each testing session lasted for approximately one hour. Prior to the start of the assessment, materials including introductions, information regarding data privacy, and informed consent were already arranged on the tables. The test scales of the WIT1 and WIT2 each had predefined time limits for participants to complete each section. The instructors commenced each phase by informing the participants about the allocated time for completing the tasks. After the three sections, with durations of 7 minutes, 11 minutes, and 8 minutes and 30 seconds the participants were instructed to stop writing.

Statistical Analyses

To address the main hypothesis, the following analyses were applied. First, an independent t-test was conducted to ensure there were no differences in problem-solving abilities between the CG and the PG at baseline (t_0). The score of the baseline measurement served as the dependent variable, while the group the students started with was the independent variable. To test the first premise of our main hypothesis, a general linear modeling approach was used. Additionally, we used a paired t-test to examine the development between the two groups from t_0 to t_1, after the PBL intervention of each group. To investigate potential interactional effects, we conducted a repeated measures ANOVA considering timepoints and groups, as well as analyzing each subdimension individually, to identify the origin of the differences in problem-solving.

This analysis allowed us to examine the development of the PG group between t_0 and t_1, as well as the CG between t_1 and t_2, compared to the CG's development from t_0 to t_1 where there was no PBL intervention. (see Figure 1 for further details)

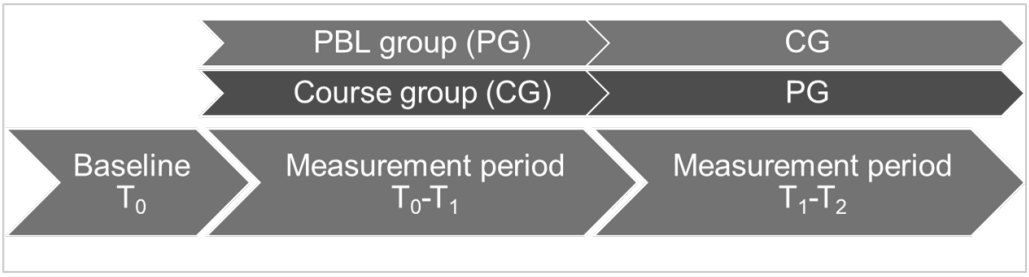

Figure 1. Cross-over design measurement periods.

Results

First, it was confirmed that both groups had a similar baseline performance (t_0) (CG: t(109) = 0.58, p = 0.567, M=325,17, SD=13.11 and PG: M=323,81, SD=11,67 (see also Figure 2)).

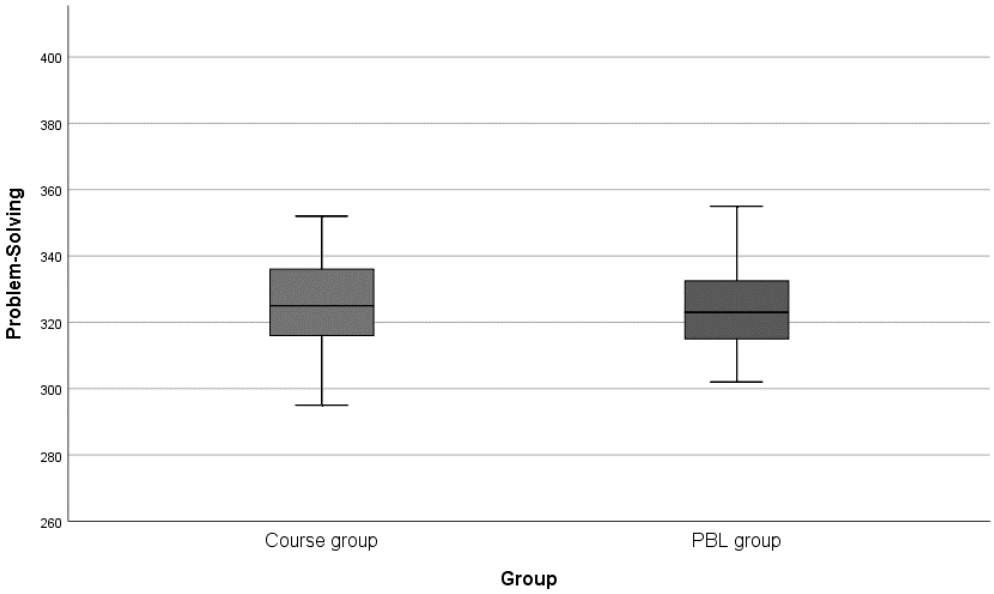

Figure 2. Baseline (t_0) measurement between CG and PG.

The second analysis aimed to compare the development of the intervention itself, measured at the selected timepoints, using the applied measurement instruments. The results revealed a significant difference in problem-solving skills. The sample consisted of N=80 students, and the findings indicated a statistically significant overall development between the different measurement timepoints with $F(1, 78) = 29{,}843$, $p < .001$. Based on these results, the second premise can be accepted. To test the third premise of the main hypothesis, a paired t-test was conducted for both groups and the two timepoints (see Figure 3 for details).

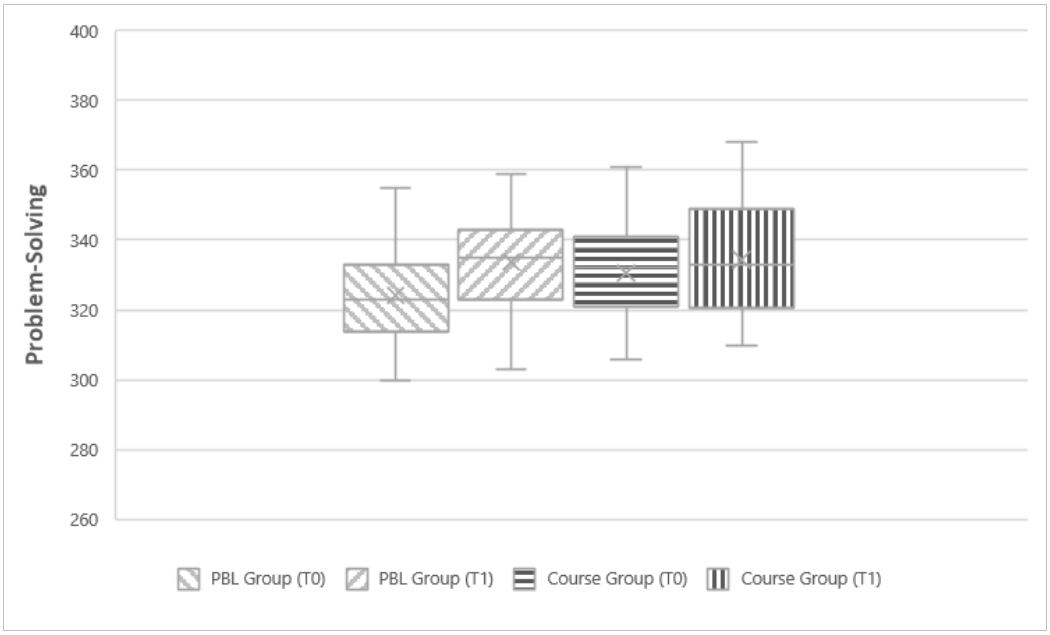

Figure 3. Comparing Deductive Reasoning between the two groups and timepoints.

The results demonstrate a significant development in the problem-solving skills of the PBL group, as observed from the scores before (M = 323.46, SD = 12.58) and after the intervention (M = 333.57, SD = 12.04). Specifically, a significant increase of 10.11 points (95%CI[-15.15, -5.08]) was observed when comparing the results between the first and the second timepoints. This difference was statistically significant, t(34) = -4,08, p < .001. In contrast to the course group before the treatment (M = 326.76, SD = 12.91) and after treatment (M = 327.24, SD = 20.90) there is a development of 0.49, 95%CI[-7.32, 6.34] which was not statistically significant, t(44) = -0.14, p > .05. With this result the third premise and therefor our inevitable premises for our main hypothesis can be accepted. Paired t-test for each subscale yielded more differentiated results. For *Analogies,* the course group (CG) did not show a significant difference between the timepoints with M = 106.43, SD = 8.14 before and M = 108.14, SD = 6.37 after the treatment with a development of 1.74, 95%CI[-4.60, 1.18] which was not statistically significant, t(34) = -1,21, p = .234. In opposite to this the PBL group (PG) showed a development of 5.25, 95%CI[-8.12, -2.38] 10.11, 95%CI[-15.15, -5.08] which was a statistically significant increase with t(34) = -4,08, p < .001.

In contrast to the control group, the PBL group (PG) demonstrated a statistically significant increase (t(34) = -4.08, p < .001) with a difference of 5.25 (95%CI [-8.12, -2.38]) compared to 10.11 (95%CI [-15.15, -5.08]) in the control group. None of the other scales showed statistically significant differences. The Letter Series CG exhibited a difference of 0.21 (95%CI [-4.64, 4.21]), t(34) = -0.10, p = .922 while the PG demonstrated a difference of 2.80 (95%CI [-7.47, 1.87]), t(34) = -1.25, p =

.225. Similarly, the Numerical Series CG displayed a change of 2.00 (95%CI [-7.00, 3.00]), t(34) = -0.82, p = .419, while the PG exhibited a change of 1.75 (95%CI [-8.46, 4.96]), t(34) = -0.55, p = .591. None of these differences were statistically significant.

Furthermore, the authors performed a repeated measures ANOVA as a fourth and mostly additional premise to compare the effect of the learning format on problem-solving.

The results show a significant difference between the two timepoints with Wilk's Lambda = 0.89 (F(1,73) = 9.45, p = .003 but no interaction between the timepoints and the groups with Wilk's Lambda = 1.00 (F(1,73) = 0.01, p = .943). Furthermore, the differences between the subscales were analyzed to identify if there are variations in the repeated measures concerning the subscales *Analogies*, *Letter Series* and *Numerical Series*. Also, for the subscales, no significant differences were found in relation to an interactional effect. This is supported by Wilk's Lambda values of 0.997 (F(1,72) = 0.18, p = .669) for Analogies, 1.00 (F(1,72) = 0.10, p = .759) for the subscale Letter Series, and 1.00 (F(1,72) = 0.02, p = .892) for Numerical Series.

Discussion

The present study and its results demonstrate that PBL can be effectively measured in short-term periods within a Higher Education learning environment. Additionally, we provide evidence that PBL leads to a general enhancement of problem-solving measurable via common standardized intelligence tests, more specifically the construct *reasoning* represented by one subdimension *Analogies* and irrespective of specific content. Another significant finding of the study is the ability to measure the impact of PBL using a domain-independent research design. The hypotheses were confirmed, revealing a new method of measuring effects by three aspects: (1) the short-term development of problem-solving skills, (2) the use of practical tasks as an independent variable to represent the impact of PBL, and (3) the applicability of this method in a context with fundamental learning content. Previous studies, such as Gallagher et al. (1992), Lohman & Finkelstein (2002), and Zumbach et al. (2004) have reported similar findings, demonstrating the effectiveness of PBL as a learning method. Although these studies were conducted in different contexts (primary/secondary education) or focused on longer timespans (more than one year), they also indicated improvements in problem-solving skills as observed in the present study. We conducted four premises to prove our hypothesis which were (1) to prove that there is no difference in the baseline measurement at timepoint t_0, to prove the (2) significant difference between the two

measurements of CG and PBL from timepoint t_0 to timepoint t_2 after the PBL treatment and (3) that there is significant difference in the pairwise t-test for the PBL group as well as (4) an interaction effect between timepoint and group. Various studies have shifted their focus towards practical or professional skills, which can be seen as essential competencies analogous to problem-solving itself (e.g. Albanese & Mitchell, 1993; Berkson, 1993; Dochy et al., 2003; Gijbels et al., 2005; Kasim, 1999; Newman, 2003; Smits et al., 2002; Vernon & Blake, 1993). These studies have highlighted a significant enhancement in professional competence through the implementation of PBL. In this study, a different measurement approach was employed, and it identified a similar increase in problem-solving skills within a shorter timeframe compared to recent studies. Notably, we found, that the effects of PBL could also be observed through standardized intelligence tests, further validating the positive outcomes. These findings provide valuable insights for educators to effectively support and facilitate the learning process of individual learners. Typically, the impact of interventions is assessed over long-term periods (Yew & Goh, 2016), posing challenges in intervening and providing timely support to the learners. This finding has already been emphasized by Kolmos et al. (2008) who conducted research demonstrating the importance of individual facilitation in enhancing the problem-solving skills of students. Additionally, Koh et al. (2008) confirmed the positive impact of PBL on the development of professional skills, specifically in the field of medicine, using practical testing scenario as a measure.

Another aspect that can be linked to the effects of PBL is the self-regulation in learning and the utilization of planning and thinking strategies. Several studies, such as those conducted by Weber; and Zumbach (2007; 2003), have described the students' abilities to effectively handle large amounts of information. PBL appears to support the cognitive processes involved in identifying, understanding, sorting, and determining the crucial aspects of this information. This cognitive process bears a striking resemblance to the cognitive ability of problem-solving. The present study's results also demonstrate the impact of PBL on this particular facet of cognitive ability, further supporting its practical implications. Notably, the most significant finding is the effectiveness of a learning method practised within the realm of – in this case – basic psychological theories, models, and perspectives, often encountered in the early stages of various study programs. This learning approach leads to a significant enhancement in problem-solving skills, thus exerting a profound influence on students' cognitive growth. Especially analogies play a crucial role in problem-based learning. The use of analogies allows individuals to bridge the gap between unfamiliar or abstract ideas and more familiar or concrete ones, enabling them to make connections and gain deeper insights into the problem at hand. Thus, analogies serve as a powerful problem-solving method by

harnessing the ability to recognize patterns, draw connections, and transfer knowledge from one domain to another When confronted with a complex problem, employing analogies allows individuals to approach the problem from a different perspective, tap into their existing knowledge, and unlock creative solutions (e.g. Gentner et al., 2003). The study also highlights this crucial role of analogies in the development of problem-solving skills as students engage in PBL practices.

Limitations

Following Berliner (2002) who described the challenges of educational research in a nutshell our design had similar restrictions we wanted to address. We combined a mostly laboratory study design with a real learning setting to prove the possibility of measuring its effectiveness and impact. This leads to a typical confrontation of internal and external validity. While we chose not to validate PBL with its usual assessments common in various fields of study, we instead opted to gauge its effectiveness through intelligence testing. Here, we focused on a short-term timeframe to exclude other external factors while allowing for the learners' experiences and development. However, it's a conventional yet acknowledged limitation inherent in educational research (Berliner, 2002). Another effect of our research design leads us to the impact of the carry-over effect in learners experience. Known from crossover designs (Piantadosi, 2013) as presented in our study, learners who are treated with PBL in the first section will not *forget* how the process of thinking works when they switch to the course group. This leads to the limitation with which we had to deal by accumulating the groups *before treatment* and *after treatment* of PBL to ensure its exclusiveness.

Through the implementation of the intelligence test, we opened a new field of measurement in the context of assessing the impact of PBL on problem-solving skills. This introduces an element of uncertainty regarding the availability of representative and comparable studies to validate the feasibility of these assessment tools. However, as one of the primary objectives of our study is to pioneer a novel approach to measuring the impact of PBL we acknowledge this limitation. To address this, we intensively supervised the research and testing procedure with more than 15 people such as scientific assistants, tutors and professors involved.

Furthermore, problem-solving is commonly conceptualized across three dimensions as described above. Our study, however, demonstrated its impact on only one of these three dimensions, thereby constraining our conclusion to the fully represented dimension of *reasoning* in our research design using the WIT 1 and WIT 2 intelligence tests. Importantly, we acknowledge that this is not a crucial limitation for us, given the strong correlation between the learning setting and the content presented to students during our experiment, which closely aligns with one of the subdimensions of *reasoning*. In our study, *Analogies* exhibited a significant impact of PBL, notably tied to the learning process within PBL tutorials. Here, students engage in case-based learning, wherein they identify analogies between the presented cases and literature, from which they may derive both problem formulations and solutions. By consistently employing this methodology, our suggestion is that learners predominantly refine the competence represented by *Reasoning, specifically* through the subdimension of *Analogies*. However, this learning process does not exert a comparable influence on the other subdimensions *Numerical Series* and *Verbal Series, resulting in a notable* difference within this single facet.

We were able to show a significant development by the utilization of paired t-tests. Further, we performed repeated measures ANOVA which is fairly discussed to be indispensable for interventional studies. In considering our sample size we want to admit that there is no numerical proof for the estimated interactional effect. We refer to the prior discussion where educational and mostly field studies have limitations with which we have to deal in practical settings, especially with research designs as we present in our study.

Conclusions

The present study contributes to a deeper understanding of how PBL can impact skills and knowledge in short-term periods. It introduces a method for assessing the individual's problem-solving skill level from a short-term perspective. In the realm of Higher Education, learning should focus on facilitating PBL as an impactful method for developing key skills in each individual student. While PBL has traditionally been associated with face-to-face-settings, recent developments in distance education and the aftermath of the Corona pandemic have highlighted the importance of integrating PBL into a wider range of educational contexts, such as blended learning, hybrid approaches, or fully online-scenarios. This expansion necessitates a focus on the social dimensions of PBL (Lozinski et al., 2017). Building upon the present research design, distance learning scenarios can be employed without compromising the valuable information concerning the individual learner's development in problem-solving skills. As emphasized by Torp and Sage; Torp

and Sage (1998, 2002) educators must cultivate these skills within their learners to prepare them for future challenges and problem-solving tasks. With the ongoing and accelerating digitalization, simple tasks are increasingly automated by technology, leaving complex problems enriched with emotional and sensitive aspects that require human intervention. Whereas Zhao et al. (2022) already tried to examine the possibility of computers to deal with emotions, it still remains a complex combination of speech, facial expressions and gestures. In this field, human beings are more suitable to integrate this parallel information in communication processes. Compared to the definition of deductive reasoning and problem-solving skills in the field of cognitive psychology (Lezak et al., 2012), this shows a higher importance of research on how to enable learners to gain and facilitate this skill. Irwin et al. (2003) discussed the relationship between problem-solving skills and methods that help individuals navigate an interconnected and information-rich world. In their work, they referenced the significance of these skills for prevention, drawing from the contributions of Beck and Greenberg (1984).

Subsequent research by Beck & Alford (2014) further emphasized the utilization of these skills as to promote overall well-being and support the recovery process of individuals with mental health conditions.

Considering these aspects, PBL emerges as an impactful method that has already found application in the field of higher education. Future research should utilize these findings to provide educators with a method for assessing the development of problem-solving skills in their learners. This approach aligns with the goal of achieving a better alignment between the learners' skill sets, their individual developmental levels and the learning methods employed. The ultimate objective is to equip future graduates with a healthier skill set that prepares them to tackle the increasingly complex interdisciplinary and intercultural challenges of our ambiguous future world. In summary, the central tenet is to prioritize the training of learners' ability to navigate difficult situations, identify or develop relevant structures, and leverage analogies to solve problems in our dynamic and intricate world.

References

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, *68*(1), 52–81. https://doi.org/10.1097/00001888-199301000-00012

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), 215824402093870. https://doi.org/10.1177/2158244020938702

Althoff, K., & Jäger, A. O. (1994). *Der WILDE-Intelligenz-Test (WIT) Ein Strukturdiagnostikum. Herausgegeben von der Deutschen Gesellschaft für Personalwesen e.V.* (2., revidierte Auflage). Hogrefe.

Ash, I. K., Jee, B. D., & Wiley, J. (2012). Investigating Insight as Sudden Learning. *The Journal of Problem Solving*, *4*(2). https://doi.org/10.7771/1932-6246.1123

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin*, *128*(4), 612–637. https://doi.org/10.1037/0033-2909.128.4.612

Barrows (1980). Problem-based Learning: An Approach to Medical Education.

Barrows (1996). Problem-based learning in medicine and beyond: a brief overview.

Barrows, H., & Tamblyn, R. (1980). Problem-based learning: an approach to medical education. *Undefined*.

Beck, A. T., & Alford, B. A. (2014). *Depression: Causes and Treatment* (Second edition). University of Pennsylvania Press; De Gruyter. https://doi.org/10.9783/9780812290882

Beck, A. T., & Greenberg, R. L. (1984). Cognitive Therapy in the Treatment of Depression. In N. Hoffman (Ed.), *Foundations of Cognitive Therapy* (pp. 155–178). Springer US. https://doi.org/10.1007/978-1-4613-2641-0_7

Berkson, L. (1993). Problem-based learning: Have the expectations been met? *Academic Medicine*, *68*(10 Suppl), p79-88. https://doi.org/10.1097/00001888-199310000-00053

Berliner, D. C. (2002). Comment: Educational Research: The Hardest Science of All. *Educational Researcher*, *31*(8), 18–20. https://doi.org/10.3102/0013189X031008018

Bortz, J., & Schuster, C. (2016). *Statistik für Human- und Sozialwissenschaftler: Extras online* (Limitierte Sonderausgabe, 7., vollständig überarbeitete und erweiterte Auflage). *Springer-Lehrbuch*. Springer.

Caplow, J. A., Donaldson, J. F., Kardash, C., & Hosokawa, M. (1997). Learning in a problem-based medical curriculum: Students' conceptions. *Medical Education*, *31*(6), 440–447. https://doi.org/10.1046/j.1365-2923.1997.00700.x

Castillo-Megchun, I. C., López-Rossell, C. G., Padilla-Rivera, M. A., Villalobos-Molina, R., & Tapia-Pancardo, D. C. (2021). Problems-Based Learning during COVID-19 Pandemic: Experiences by Nursing Students. *Open*

Journal of Nursing, *11*(11), 920–932. https://doi.org/10.4236/ojn.2021.1111075

Davis, M. H., & Harden, R. M. (1999). *Problem-based learning: A practical guide*. *AMEE medical education guide: no. 15*. AMEE.

Dochy, F., Segers, M., van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: a meta-analysis. *Learning and Instruction*, *13*(5), 533–568. https://doi.org/10.1016/S0959-4752(02)00025-7

Döring, N. (2022). *Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften* (2022). Springer Berlin Heidelberg.

Döring, N., & Bortz, J. (2016). *Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften* (5. vollst. überarb. Aufl.). *Springer-Lehrbuch*. Springer.

Funke, J. (2010). Complex problem solving: A case for complex cognition? *Cognitive Processing*, *11*(2), 133–142. https://doi.org/10.1007/s10339-009-0345-0

Funke, J., Fischer, A., & Holt, D. V. (2018). Competencies for Complexity: Problem Solving in the Twenty-First Century. In E. Care, P. Griffin, & M. Wilson (Eds.), *Educational Assessment in an Information Age. Assessment and Teaching of 21st Century Skills* (pp. 41–53). Springer International Publishing. https://doi.org/10.1007/978-3-319-65368-6_3

Gallagher, S. A., Stepien, W. J., & Rosenthal, H. (1992). The Effects of Problem-Based Learning On Problem Solving. *Gifted Child Quarterly*, *36*(4), 195–200. https://doi.org/10.1177/001698629203600405

Gentner, D., Loewenstein, J., & Thompson, L. (2003). Learning and transfer: A general role for analogical encoding. *Journal of educational psychology*, *95*(2), 393. https://doi.org/10.1037/0022-0663.95.2.393

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

Jäger, A. (1982). Multimodal classification of intelligence achievement: Experimentally controlled, further development of a descriptive intelligence structure model. *Diagnostica*, *1982*, 28(3), 195–225.

Kasim, R. M. (1999). What Can Studies of Problem-Based Learning Tell Us? Synthesizing and Modeling PBL Effects on National Board of Medical Examination Performance: Hierarchical Linear Modeling Meta-Analytic Approach. *Advances in Health Sciences Education*, *4*(3), 209–221. https://doi.org/10.1023/A:1009871001258

Kersting, M., Althoff, K., & Jäger, A. O. (2008). *Wilde-Intelligenz-Test 2: WIT-2; Manual* (2. vollständig überarb. Version). Hogrefe.

Koh, G. C.-H., Khoo, H. E., Wong, M. L., & Koh, D. (2008). The effects of problem-based learning during medical school on physician

competency: A systematic review. *Canadian Medical Association Journal*, *178*(1), 34–41. https://doi.org/10.1503/cmaj.070565

Kolmos, A., Du, X., Holgaard, J. E., & Jensen, L. P. (2008). *Facilitation in a PBL environment*.

Konermann, T. (2016). Die Methode „Siebensprung". In R. D. Brinkmann (Ed.), *Problembasiertes Lernen im Studienfach Psychologie: Konzepte, Methoden, Evaluation* (1st ed., pp. 51–66). Heidelberger Hochschulverlag.

Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (Fifth edition). Oxford University Press.

Lohman, M. C., & Finkelstein, M. (2002). Designing cases in problem-based learning to foster problem-solving skill. *European Journal of Dental Education: Official Journal of the Association for Dental Education in Europe*, *6*(3), 121–127. https://doi.org/10.1034/j.1600-0579.2002.00247.x

Maurer, H., & Neuhold, C. (2012). *Problems Everywhere? Strengths and Challenges of a Problem-Based Learning Approach in European Studies*. APSA 2012 Teaching & Learning Conference Paper.

Mayer, R. E. (2013). Problem solving. In Daniel Reisberg (Ed.), *Oxford library of psychology. The Oxford handbook of cognitive psychology.* Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195376746.013.0048

Newman, M. (2003). *A Pilot Systematic Review and Meta-Analysis on the Effectiveness of Problem-Based Learning*.

OECD. (2014). *Pisa 2012 Results: Creative Problem Solving: Students' Skills in Tackling Real-Life Problems (Volume V)*. PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264208070-en

Piantadosi, S. (2013). Crossover Designs. In S. Piantadosi (Ed.), *Wiley Series in Probability and Statistics. Clinical Trials: A Methodologic Perspective* (2. Aufl., pp. 515–527). Wiley-Interscience. https://doi.org/10.1002/0471740136.ch20

Reznich, C., & Werner, E. (2001). Integrating Technology into PBL Small Groups in a Medical Education Setting.

Schmidt, F. L., & Hunter, J. (2004). General mental ability in the world of work: Occupational attainment and job performance. *Journal of Personality and Social Psychology*, *86*(1), 162–173. https://doi.org/10.1037/0022-3514.86.1.162

Sharma, R. (2015). Effect of Problem Based Learning on Nursing Students' Clinical Decision Making and Learning Satisfaction. *International Journal of Science and Research (IJSR)* 4(7), 163–165.

Smits, P. B. A., Verbeek, J. H. A. M., & Buisonjé, C. D. de (2002). Problem based learning in continuing medical education: A review of controlled evaluation studies. *BMJ (Clinical Research Ed.)*, *324*(7330), 153–156. https://doi.org/10.1136/bmj.324.7330.153

Thurstone, L. L. (1938). The perceptual factor. *Psychometrika*, *3*(1), 1–17. https://doi.org/10.1007/BF02287914

Torp, L., & Sage, S. (1998). *Problems as possibilities: Problem-based learning for K-12 education*. Association for Supervision and Curriculum Development.

Torp, L., & Sage, S. (2002). *Problems as possibilities: Problem-based learning for K-16 education* (2. ed.). Association for Supervision and Curriculum Development.

Vernon, D. T., & Blake, R. L. (1993). Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine*, *68*(7), 550–563. https://doi.org/10.1097/00001888-199307000-00015

Weber, A. (2007). Problem-Based Learning – Eine Lehr- und Lernform gehirngerechter und problemorientierter Didaktik. In J. Zumbach, A. Weber, & G. Olsowski (Eds.), *Problembasiertes Lernen: Konzepte, Werkzeuge und Fallbeispiele aus dem deutschsprachigen Raum* (1st ed., Vol. 1, pp. 15–32). hep-Verl.

Wilhelm, O. (2004). Measuring Reasoning Ability. In O. Wilhelm (Ed.), *Handbook of understanding and measuring intelligence* (pp. 373–392). SAGE. https://doi.org/10.4135/9781452233529.n21

Yew, E. H., & Goh, K. (2016). Problem-Based Learning: An Overview of its Process and Impact on Learning. *Health Professions Education*, *2*(2), 75–79. https://doi.org/10.1016/j.hpe.2016.01.004

Zumbach, J., Kumpf, D., & Koch, S. (2004). Using Multimedia to Enhance Problem-Based Learning in Elementary School. *Information Technology in Childhood Education Annual*, *2004*(1), 25–37.

Zumbach, J. (2003). *Problembasiertes Lernen: [PBL]*. Zugl.: Hamburg, Univ., Diss, 2003. *Internationale Hochschulschriften: Vol. 424*. Waxmann.

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Negotiating Epistemic Experience vs. Epistemic Expertise in PBL Supervision

Exploring confrontations between students and their supervisor in PBL

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Abstract

Supervision in higher education (HE) often balances the tension between fostering student autonomy and providing sufficient guidance, especially within undergraduate programs. This paper explores an under-researched area: the dynamics of group supervision in undergraduate education, specifically how students challenge their supervisor's expertise. Using video recordings of a group of engineering students at Aalborg University working within a Problem-Based Learning (PBL) framework, the study investigates moments of disagreement between students and their supervisor during project supervision. Employing conversation analysis (CA), the study examines the negotiation of epistemic claims—where students draw on their experience to challenge the supervisor's expertise—and the subsequent impact on the learning trajectories. The findings highlight that students use their epistemic authority from experience to challenge their supervisor's proposed academic direction, while the supervisor defends their stance based on disciplinary knowledge. The study emphasizes the importance of aligning cognitive congruence and situated learning to facilitate productive supervision interactions. Ultimately, the paper sheds light on the critical yet often overlooked role of student agency in supervision and offers insights into improving the supervisory process in HE, particularly in group settings.

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Keywords: Supervision; Higher Education; Epistemics; Resistance; Conflict; Undergraduate; CA; Conversation Analysis

Introduction

Supervision in higher education (HE) presents a complex and sometimes conflicting relationship between autonomy and support (Del Río et al., 2018). In one aspect, the focus is to assess the skills acquired by students to determine whether they have gained relevant competencies and knowledge. In another aspect, the challenge is to provide sufficient support to students through supervision to make them capable of writing at the required level (Todd et al., 2004). According to West (2020): "supervision remains a largely hidden encounter" (p.2) thus, it is rare to see empirical interactional investigations of supervision. Furthermore, most research on supervision is focused on the dissertation process, and there is a lack of international literature on the supervision of undergraduates (from 1st to 6th semester). The difference in this regard seems to be the level of autonomy to expect from undergraduates compared to graduate students. Thus, the goal for undergraduate students becomes supported autonomy and not competent autonomy (Gurr, 2001). Here, a supervisor guides the students to improve their academic and scientific level. What happens, then, when students disagree or challenge the supervision given to them? West (2023) points towards a gap in the literature in: "the exploration of the tension between the supervisor's expertise and the student's competence and experience" (p.591) thus these challenges and direct disagreements from undergraduate students towards the supervisor are, to these authors' knowledge, an overlooked aspect of supervision research—and will be the main scope of this paper.

To analyse what happens when undergraduate students challenge their supervisor, we looked at video data of one supervision meeting in which a group of engineering students challenged their supervisor's approach. In interaction research the focus is typically on micro instances of the interaction, thus it is quite normal for this type of research that the data only entails one case (Antaki et al., 2008; Bridges & Imafuku, 2020; Goodwin, 2018; Hendry et al., 2016; McQuade et al., 2019; Sacks & Jefferson, 1995; Velmurugan et al., 2021) Furthermore, we want to highlight, that according to our knowledge international research about supervision in higher education tends to be focused on a single supervisor and a single student. Thus, to these authors' knowledge, there is a lack of international research on the supervision practices entailing one supervisor and a group of (undergraduate) students.

The video data is from Aalborg University (AAU), where problem- and project-based learning (PBL) is a university-wide pedagogical approach (Askehave et al., 2015; Kolmos et al., 2004)[1]. In this model, the students must work in groups each semester to write up a project with a point of departure in a problem, which counts up to 50 percent of their ECTS. Thus, we want to emphasise our data consists of engineering students working together in a group, who are provided with one supervisor to guide them. This differs from the normal situation in HE, where a single student is often provided with a supervisor at the end of their degree. The students are provided with a supervisor who is a researcher and will provide guidance and feedback on the students' work, ensuring the academic quality of their project. Throughout the project writing phase, the supervisor's task is to guide the students in addressing the problem academically with the use of specific theory and methodology (Kolmos et al., 2004; Moallem et al., 2019; Servant, 2016). During the project, the supervisor might suggest a course of action that the group of students disagrees with. Thus, the question becomes how the group manages this disagreement. From the opposite perspective, how do supervisors handle this dilemma and approach the group's wishes to do something that may not align with that specific discipline's practice while respecting their autonomy? Thus, to improve supervision in the future, we need to understand how students challenge their supervisor and how the supervisor and students handle these challenges to improve supervision practice, in relation not just to PBL but to all cases of supervision in HE. Thus, our research question becomes:

How do students challenge their supervisor, and how do students and supervisor interactively handle these disagreements?

Theoretical framework

Cognitive Congruence

When looking at the PBL literature about supervision, the term 'cognitive congruence' is often mentioned (Hmelo-Silver et al., 2019; Hmelo-Silver & Barrows, 2006; Schmidt & Moust, 2000; Yew & Yong, 2014). Cognitive congruence can be defined as a supervisor's ability to understand and express themselves at the student's level of knowledge (Schmidt and Moust 2000; Yew and Yong 2014). Furthermore, it requires a supervisor's sensitivity towards the students who are encountering a problem in their work. A requirement for cognitive congruence is that the supervisor has relevant subject knowledge, as this is required to identify knowledge gaps in students and thus actively pose questions to get them to reflect and identify relevant learning issues. Other tools

the facilitator can use in this regard are asking open-ended questions; asking students to argue for their thinking processes; pushing for an explanation; using what, why, and how questions; revoicing or rephrasing what the students just said; summarizing; and asking a student to summarise the discussion (Hmelo-Silver et al., 2019; Hmelo-Silver & Barrows, 2006). The concept of questions as effective tools in a supervision context has previously been documented in papers examining supervision in HE (Donaghue, 2020; Engin, 2015). Thus, as existing studies point out, the role of the supervisor is complex and requires variation in interactions with students (Savin-Baden & Wilkie, 2004). The concept of cognitive congruence describes the 'textbook way' of handling an interaction during supervision; it will be interesting to see if this happens in actual practice. Although empirical literature exists about supervision in higher education (Leyland, 2018; West, 2020, 2023), to these authors' knowledge, there have not been any video observational studies looking at supervision at the undergraduate level towards a group of students. By examining the social practices with video data, focused on microanalysis, we get an insight into how supervision unfolds and how this relates to the literature on supervision that often lacks this interactional empirical perspective. Furthermore, the video provides insight into the nonverbal ways of conducting supervision and how this affects supervision.

Situated learning trajectories

In this paper we are inspired by Lave and Wenger's (1991) situated view of learning; a further development of this theory's perspective is the notion of situated trajectories of learning (de Saint-Georges & Filliettaz, 2008). De Saint-Georges and Filliettaz (2008) elaborate that: "The notion of trajectory aims to capture that (a) learning occurs through situated and highly contextualized micro activities and (b) that these activities occur within historical sequences of events, which come to form over time dynamic trajectories" (p.213). This concept embraces two propositions: first, a situated perspective that focuses on actions in real-time through the accomplishment of the interlocutors, and, second, the idea of a learning trajectory that goes beyond the immediate horizon of situated action to account for longer time frames (de Saint-Georges & Filliettaz, 2008). The term should be understood as a heuristic notion, consisting of linked portions of empiric events that the researcher deems relevant in an exploration of the concrete learning activity. They argue learning should be conceptualised from three perspectives, firstly: "As situated, that is as phenomena to be approached in the real-time conditions of their accomplishment" (de Saint-Georges & Filliettaz, 2008, p. 214). Thus, if you adhere to this perspective, learning is best explored by analysing these situated social situations where they occur. Secondly as: "collective processes, that is

processes involving the participation of various "others" in their accomplishment" (de Saint-Georges & Filliettaz, 2008, p. 214) testifying to the social nature of learning, thirdly they highlight how learning is also a multimodal activity involving the use of material objects, visual props and the performance of various kinds of actions to make meanings. These processes of learning are often examined using a conversation analysis (CA) approach to produce microanalyses to show diverse learning trajectories created in different instances of interaction. The learning trajectories are dynamic and can change at any time in the ongoing interaction. They are marked by a co-configuration, in which we in the present constitute the future of the trajectory and the place where the past of the trajectory is mutually reinterpreted (R. Scollon & Scollon, 2004; S. W. Scollon & de Saint-Georges, 2012). In a concrete learning situation, a trajectory manager (often the teacher) projects a specific course of learning (several things needed to be done to state that the learner has learned the content or practice aimed for) that the learner engages with and helps shape by appropriating or reconfiguring it to make sense of it (Kress et al., 2014). Thus, the trajectory is always open for a reinterpretation or renegotiation. We look at these trajectories because we assume that when students and their supervisor interactively disagree about something, they are negotiating which trajectory to follow; to see how these trajectories are negotiated and produced, we use a CA approach. To analytically find these trajectories, we orient towards how the interlocutors orient toward past interactions to explain or in our example question a future action.

In our microanalysis, we will use a CA approach. CA aims to identify structures that underlie social interaction (Stivers & Sidnell, 2013). This is done by producing detailed transcriptions of the interaction taking place through a reliance on a case-by-case analysis that leads to generalisations across cases without allowing them to set into an aggregate (Stivers & Sidnell, 2013). CA examines what an utterance does to the preceding one(s), and what implications an utterance poses for the next one(s) (Arminen, 2005). Specific CA tools we will use are Turn Construction Units (TCU) which marks a speaking turn and the concepts of turn initiation and transition relevant place (TRP), which mark the transfer of speakership that normally happens at certain specifiable junctures (Clayman, 2013). In our extracts, this will be especially relevant in the pauses and gaps shown in the transcripts. A pause happens within a TCU and a gap between two different TCUs (Hepburn & Bolden, 2013). Thus, as turn-taking often happens fluently in conversations, gaps and pauses of more than 0.5 seconds will be marked as trouble in the conversation (Clayman, 2013). The last term we wish to introduce is 'repair', which is defined as practices to interrupt the ongoing course of action to attend to possible trouble in speaking, hearing, or understanding the talk (Kitzinger, 2013). This can be an other-initiated repair by a coparticipant or the speaker's self-initiated repair. These specific concepts

within CA will help us determine whether the interaction happens 'fluently' or is marked by dispreferred answers and long gaps and pauses indicating the participants are experiencing trouble within their interaction. Although focusing on the interlocutors' utterances is important, it is equally important to have an embodied view of the interaction (Goodwin, 2018; Heath & Luff, 2013). The term 'embodied' should be understood as:

> the ways in which the production and intelligibility of action is accomplished in and through bodied action, the spoken and the visible, and where appropriate, the use of various objects and artifacts, tools and technologies. (Heath and Luff 2013, 295)

Correspondingly, an additional focus will be on the embodied nature of the interaction with the use of various artefacts and technologies. This will be shown in the analysis with direct screenshots of the video recordings embedded in the transcriptions. As our focus is on how students and supervisor interactively negotiate the direction of the project when encountering disagreements, we argue the first place to start the analysis is by focusing on the students' challenge of epistemic claims from the supervisor. Thus, we will shortly account for the literature on challenging epistemic claims in a CA context.

CA research in epistemics focuses on the knowledge claims that interactants assert, contest, and defend in their turn-taking (Heritage, 2013). Within social psychology and sociology, it has been recognised that mutual action and interaction rest on parties' abilities to recognise what each knows about the world and to adjust actions and understandings with that recognition (Garfinkel, 1967; Heritage, 2012; Mead, 1934). The social significance of epistemics became clear with the recognition that knowledge is socially distributed (Knorr-Cetina, 1999), which can form the basis for specific epistemic communities. Furthermore, epistemic claims that are enacted in turns-at-talk are central to the management and maintenance of identity (Heritage & Raymond, 2005). The way we produce our utterances orients towards specific recipients, often entailing a categorisation of the recipients. Thus, it might be considered quite normal and within the script when a supervisor challenges students' epistemic claims, as this is often the supervisor's role; however, the opposite is rarely expected. When these epistemic claims produced by the supervisor are challenged by students, one could argue the students are challenging the learning trajectory the supervisor has set out for them. The difference is that the epistemic claim is focused on the present interaction, where a reconfiguration of previously stated learning trajectories takes place and new trajectories might be produced. Thus, the learning trajectory is oriented towards a past and future trajectory for the group to follow; the

challenge of epistemic claims becomes a present challenge of a proposed trajectory for the group.

Materials and Methods

The setting for data collection

The research data for this study comprises video recordings of one group of engineering students' PBL work. The group was provided with their room, where they could work on their project during the semester. In this room, a 360-degree camera was placed as part of a data collection for a Ph.D. study looking into students' group work. A total of 225 hours of video was recorded, and so far, only 80 hours have been looked through by the first author of this paper. This section was chosen because it showed something that we don't see that often in the literature: a confrontation between students and supervisor. Furthermore, it also shows how the nonverbal signals influence the atmosphere in the room. All participants signed an agreement providing us with written consent from both students and supervisor to record and present the data in journals, teaching activities, and workshops without any kind of anonymisation. They were all provided with the opportunity to withdraw this consent if they came to regret their decision. As we had permission to show the data without anonymisation in journals, we have chosen to do this because we believe this provides a more authentic view of the interaction. We further highlight the purpose of this research is to show how supervision takes place and how students and supervisors might handle disagreements. By choosing this approach it is within our interests to show body language as truthfully as possible because research on interaction has shown the importance of body language to create and foster meaning in interaction (Derry et al., 2010; Goodwin, 1994, 2004, 2013; Heath et al., 2010) This does not mean we do not consider the ethical consequences of the clips we choose to publish, and there are clips in our material that we will not publish (even though we as of now have the legal right to do so) because we think it is not ethically justifiable to show to a wider audience. This has not been the case for the clips chosen for this analysis, although they foster quite different reactions. The clips have been shown at different research seminars and conferences, the reactions we got there will be described further at the end of this paper.

The recordings took place in 2018, before the COVID-19 pandemic. To answer our research question about how students challenge their supervisor, we have chosen a clip where the supervisor is present, and the students directly challenge the supervisor's epistemic claims.

360-degree video recordings

A chart of the students' group room is shown below.

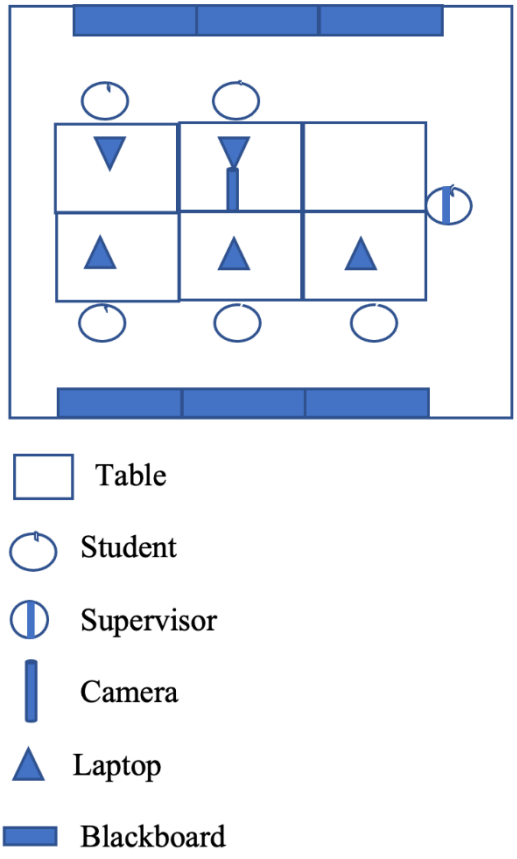
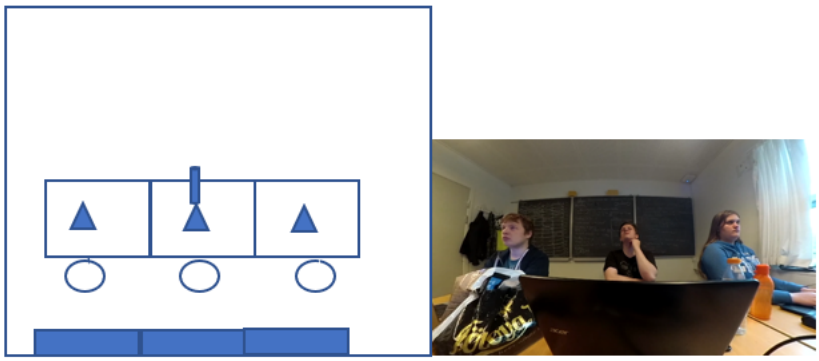


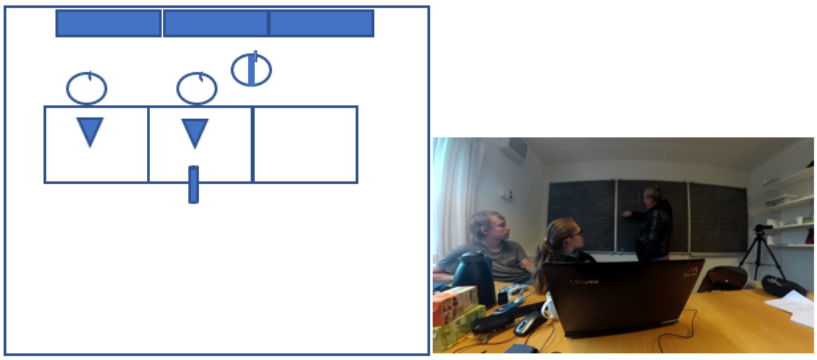
Figure 1. Layout of the room.

A 360-degree camera was placed in the middle of the room. As McIlvenny (2020) reports, a 360-degree recording 'allows a viewer to see a flat 2D visual representation of the *totality* of a scene from a single location but in all directions at once' (p. 3, original emphasis). In other words, the researchers can view the interaction taking place from different angles and can zoom in on specific participants in the recordings. When using 360-degree video recordings, it is important to be aware of the reproduction of spatial relations, which differs on video from what an eye would see (McIlvenny, 2020). When we focus on embodied actions in our transcripts, we zoom in on that specific action; however, in some cases, we will show the whole room, but the picture's spatial relations will be distorted, as seen in the example below. In this first instance we are showing two pictures of a 180-degree view, and in the last picture we are showing the same instance in a 360-degree view:



Students, from left: Teitur, Franz, Patricia

Figure 2. 180-degree View of Room 1.



From left: Magnus, Stine, and the supervisor

Figure 3. 180-Degree View of Room 2.

Figure 4. 360-Degree View of Room.

We found that the last example, even though the dimensions are distorted, gives the best overview of the entire interactional scene, showing how the different participants orient towards each other. Thus, when we want to give an overview of the whole room, we will be using the last example.

The transcript is produced in accordance with the Jefferson Annotation system (Jefferson, 2004), and, when relevant, arrows will point towards screenshots of the embodied interaction with a short written description of the multimodal action. In other parts of the transcript, written transcriptions of multimodal features will be kept to a minimum, as they are not relevant to the analysis. According to Hepburn and Bolden (2012) transcripts are selective in the details represented which is further elaborated by Mondada's (2007) point stating it is impossible to include all potentially relevant aspects of the interactions. Thus, we solely focus on multimodal parts relevant to our analysis. As the group primarily communicated in Danish, the transcript will show both the Danish utterances and the English, as translated by the first author. In the English translation, emphasis was put on how one would frame the same sentence in English; it is thus not a direct word-for-word translation. The Danish word for supervisor is *vejleder*; in the transcript, the supervisor's utterance is indicated with a V.

The context for the specific video recording

The group comprised third-semester engineering students writing a project about private energy storage from solar cells, and whether it makes sense from an economic perspective to incorporate a battery to store energy from the cells in private households. The group had a meeting with their supervisor at which they discussed the group's proposals for different tests to conduct in their project related to their problem statement. During this meeting, two members of the group were absent due to illness. The supervisor went through the group's different test proposals and complimented the group on their suggestion for a particular test the group had suggested. He then spent 45 minutes explaining the details and merits of the test and the way the group should approach it. The next day, one of the absent group members was filled in on the meeting and the test they had decided upon. The absent group member, Magnus, could not understand why that test was chosen and kept questioning how the test was related to their problem statement. The group could not answer Magnus's questions. The next day, Magnus suggested they organise a new meeting with their supervisor to thoroughly understand the relevance of the test for their problem statement. The group agreed to do this and sent an email to their supervisor requesting such a meeting. It should be mentioned that during the first meeting they had with their supervisor this semester, the supervisor told the group not to complicate things too much as they were only third-semester students. The students were surprised they had

to 'keep it that simple'. Furthermore, it should be noted the supervisor is not natively Danish; sometimes creating language barriers with the students. We start our analysis from the point when the supervisor enters the room.

Results/Analysis

First, we want to show different examples of the students challenging the supervisor's epistemic claims, focusing on how that is done interactively. This part of the analysis will answer the research question concerning how the students challenged the supervisor. Then we focus on the ongoing dialogue to answer our research question concerning how the students and supervisor interactively handled these disagreements. To shed further light on how the disagreement was handled, we focus on the different learning trajectories produced in the interaction.

Challenging Epistemic Claims

```
1   ((vejleder kommer ind i rummet og sætter sig))
    ((supervisor enters the room and sits down))
2   M: ((færdiggør en joke med Stine de havde påbegyndt inden vejleder kom ind))
     ((finishes a joke with Stine they had started before the supervisor enters the
    room))
3   M: såeh
       so
4      (2.0)
5   M: vi har nogle spørgsmål til de her forsøg vi skal lave
       we have some questions regarding these tests we should do
6   V: jaeh
       yeah
7      (2.0)
8   M: jeg var nu var jeg der ikke sidste gang
       I was now I was not there the last time
9      (1.0)
10  M: [og såe:::::h kom jeg bagefter] og så var jeg måske lidt skuffet over det
11  forsøg vi så havde fået valgt
       [and the::::n I came afterwards] and so I was maybe a little disappointed
    over the test we had chosen
```

Figure 5. Transcript 1.

Magnus starts the meeting by stating 'so' in line 3. This creates a gap in line 4 where the floor is open, and others can initiate a turn. As no other person does this, Magnus self-selects and utters that they have some questions regarding the tests they should do (line 5). Notice how the supervisor replies only with 'yeah', creating the second gap. Magnus then self-selects as the speaker (line 8) and, instead of following up on his last utterance and explaining about the test they want to question, he provides some background information stating that he was

not present at the last meeting, creating another gap in line 9. Thus, we see three gaps (lines 4, 7, and 9) indicating there is trouble in the interaction. As stated earlier, the transition of speakership often happens fluently, and gaps within interactions are often evidence of trouble in the interaction. This trouble could be due to the fact the students know they are entering into an unfavourable situation, as the setup for the meeting is the students questioning the supervisor's proposed direction for their project. To legitimize the students' right to question this direction, we see how Magnus in lines 8 and 10 tries to explain why they don't agree with the direction. As such, one could state that line 8 is presented to legitimize why the students have the right to question the test discussed in the previous meeting with the supervisor. Also, notice how his criticism of the test is explained by a feeling of disappointment (line 10). This feeling is also downgraded with the utterance 'I was maybe' (line 11), again pointing to the fact they are entering into an unfavourable situation. To legitimize this, they try to explain how they feel about it, as a person's feeling is rarely something you can delegitimize. Thus, the way Magnus tries to challenge the supervision is through an "epistemic of experience" contrasted with the supervisor's "epistemic of expertise", West (2023) found a similar conversational pattern in her data of supervision meetings.

In the following discussion, we will focus on how the supervisor reacts to these utterances:

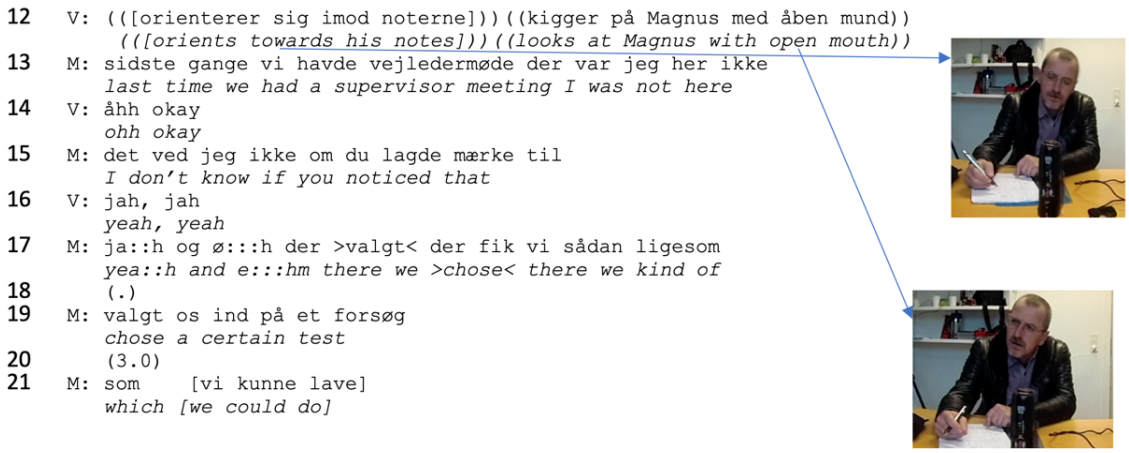
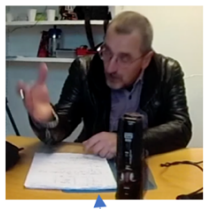


Figure 6. Transcript 2.

Line 12 corresponds to the second picture, where the supervisor might be interpreted to be surprised or confused by the statement. He changes his posture from orienting towards his notes with his pen, shown in the first picture, to directing his gaze towards Magnus with a slightly open mouth and squeezed eyes, likely focusing on what Magnus just stated. Magnus orients towards this changed posture by repeating he was not there the last time (line

13). In this way, he is through his epistemics of experience trying to legitimize why it is okay for him to feel disappointed about the selected test. The supervisor then replies, 'oh okay'. Whether he agrees with Magnus's way of legitimizing their right to be critical of the test or just acknowledges Magnus was not present at the last meeting, we don't know. However, we see how Magnus again orients towards the surprised facial gesture in line 14, where he states: 'I don't know if you noticed that'. This utterance can thus be evidence of how Magnus interprets the supervisor's surprise. Thus, Magnus interprets the surprised facial gesture of the supervisor as directed towards his uttering of his lack of presence at the last meeting, but it might also be oriented towards Magnus's feeling of disappointment towards the test. We interpret the facial gesture as oriented towards Magnus's feeling of disappointment, as this is not something usually connected with academic discourse. We also see how Magnus's words become more hesitant when addressing the test in line 17, a stance also shown in line 10 of the previous extract. A commonality in the content of these utterances is that they address a test the students do not want to do but that the supervisor has suggested they do. As such, he becomes hesitant when challenging the supervisor's epistemic claim. Notice how he states, 'we kind of', indicating with his use of a plural pronoun that he is presenting the group's opinion and not just his own. Additionally, there is a gap in line 20, where it would seem relevant for other people to initiate a turn but, as no one does so, he continues elaborating in line 21, 'which we could do'. However, an overlap happens in this instance; we focus on that next.



21 M: som [vi kunne lave]
which [we could do]
22 V: [det er ik simpelt] det er ik simpelt
[it is not simple] it is not simple
23 T: hvad
what
24 M: nej simpelt
not simple
25 V: ((løfter blokken og lader den falde ned på bordet igen)) okay ((række håndenimod M. og peger med kuglepennen på sin blok))
((lifts the block and lets it fall down on the table again)) okay ((gestures his hands towards M and then points with his pen towards his bloc))
27 M: nej vi fik valgt os ind på et forsøg som vi skulle lave til vores projekt
no we chose a test which we should do in our project
28 V: ja
yes
29 M: ja og det var jeg lidt skuffet over det blev valgt fordi jeg ikke kan se hvad
30 det har med vores
yes and I was a little disappointed over what was chosen because I could not see what it had to do with our
31 (1)
32 M: projekt at gøre
Project

Figure 7. Transcript 3.

Notice in line 21 the overlap by the supervisor in his comment 'it is not simple'. This statement seems to take by surprise both Teitur, who says 'what' in line 23, and Magnus, who repeats 'not simple' in line 24. Then we see some body language from the supervisor that can be interpreted as frustration: he lifts the papers, let them fall again with a loud sound, says okay, and nonverbally gestures to Magnus. Magnus tries to perform a repair in line 27, where he again states that they chose a test with their project—here Magnus emphasizes 'test' in his utterance. The supervisor offers minimal response (line 28), and then Magnus continues to elucidate how he was disappointed with this choice, and here he emphasizes the choice. Thus, we see how Magnus does not orient to the fact of the test being or not being simple but emphasizes the choice of the test as the relevant factor for the ongoing interaction. We now skip to the point in the interaction at which the supervisor again addresses the group's concerns:

50 V: ((flytter papirerne imod s))
((moves the papers towards s))

51 S: så vi havde bare svært ved at se hvordan vi sku
so we had a little difficulty seeing how we should
52 (.)
53 M: fordi [vi (utydeligt)]
because [we (unclear)]
54 S: [decideret bruge det]
[distinctivly use it]
55 V: [jeg har] skrevet visse dele op for den test
[I have] written some parts of the test
56 (.)
57 V: hvor faktisk I:::::::: til sidst
Where actually y:::::ou in the end
58 (.)
59 V: du skal have noget som den der ((peger på et specifikt sted på papirerne))
60 laver en øh model
you (in singular) should have something like that one ((points at a specific place on the papers))make an ehh model
61 M: ((rejser sig fra stolen og går imod papirerne))
((gets up from his chair and walks towards the papers))
62 (.)
63 S: ja:er
ye:ah
64 V: som ø:::h kan bruges for charging discharging
which e:::hm can be used for charging discharging

65 (1)
66 V: jaer((retter blikket imod M)) og det er ikke nemt
yeah ((looks towards M)) and it is not easy
67 (3.0)
68 M: NEJ de:::::t det er meget muligt øhm
NO tha:::::t seems very possible ehm

Figure 8. Transcript 4.

We see the supervisor moving some papers towards Stine while they are continuing their talk. The supervisor then starts an overlap in line 55, resulting in Stine and Magnus stopping their utterance. In line 55, he presents the content of the papers—some part of the test he has written. Then a TRP occurs, after which the supervisor initiates another turn and explains the end product of the test, pointing towards a model they should create. Magnus gets up from his chair and starts looking at the papers, and the supervisor again addresses the

fact that the test is not easy while looking at Magnus. Thus, Magnus's previous effort to focus the conversation on the choice of the test has still not succeeded, as the supervisor again orients towards the 'easiness' of the test. This creates the impression that the supervisor has a conviction that the students, especially Magnus, are critical about the test because they see it as simple, a concern the students have not explicitly stated in this meeting but was discussed in a previous supervision meeting about the project in general. In the next extract, we enter the interaction when Magnus again challenges the supervisor's epistemic claim:

86 M: men som vores problemformulering er lige nu
but as our problem statement is right now
87 (1.0)
88 M: der siger vi at vi gerne vil ((går imod sin plads igen og sætter sig ned))
we say we we want to ((walks towards his seat again and sits down))
89 V: ((læner sig tilbage og sidder med armene over kors))
((leans back and crosses his arms))

90 (1.0)
91 M: se om det kan svare sig
look at whether it makes sense
92 (.)
93 M: eller hvord
or ho
94 (.)
95 M: hvordan det kan svare sig at implementere et batteri i et solcellesystem
how it makes sense to implement a battery in a solar cell system
96 V: jaeh
yeah
97 M: for at se om det kan spare nogle penge på
to see if you can save some money
98 (1.5)
99 M: for forbrugerens side
from the consumer's side
100 V: jaeh
yeah
101 M: frem for ikke at skulle have det
compared to not having it
102 (1.0)
103 M: ø:::h hvis vi så laver et forsøg om hvordan
eh::m if we then test how
104 (1.0)
105 M: øh batteriets
ehm the battery's
106 (.)
107 M: discharging og charging er ift. temperaturen
discharging and charging is according to the temperature
108 (1.0)
109 M: så har jeg svært ved at se hvad sammenhængen skulle være
then I have some difficulty in seeing what the connection should be
110 (.)
111 M: den information vi får ud af forsøget hvor s::: hvad skal jeg bruge den til
the information we get out of the test what sho::: what should I use it for
112 (6.0)

Figure 9. Transcript 5.

In line 86 we see how Magnus starts orienting towards the problem statement. Notice how he emphasises the problem while walking towards his seat in the room. At the same time, the supervisor is leaning back and away from Magnus, crossing his hands. It is relevant that Magnus, with both his verbal statement and embodied behaviour, is distancing himself from the supervisor's previous utterances, and that the supervisor is doing the same by leaning back and crossing his hands. Magnus tries to address the relevance of the test for their problem statement. He does this by explaining the content of the problem statement, which could serve to ensure that the supervisor understands it. Thus, Magnus might operate from the perspective that the supervisor does not understand the content of their problem, and consequently, he does not realise how the test he is suggesting is not relevant to the specific problem. Again, we see numerous TRPs followed by gaps in the interaction (lines 98, 102, 104, 108, 112) pointing towards trouble, which we again argue is due to Magnus challenging the supervisor's epistemic claims. By questioning these epistemic claims, we argue Magnus is producing a different learning trajectory. Once again, he is using an epistemic of experience to challenge an epistemic of expertise.

Producing different learning trajectories

The group tries to produce a trajectory in which the supervisor does not understand the content of the problem and accordingly suggests the wrong test for them. However, as we saw earlier, the supervisor has produced a trajectory in which he thinks their resistance to the test is due to the group seeing the test as 'simple'. The challenge in the interaction is, then, for the different participants to agree on a certain trajectory. We see that the supervisor aligns himself with the content of the students' problem in lines 96 and 100; thus, the trajectory of the supervisor not understanding the content does not seem to be accurate. Magnus then details the aim of the test and talks about how that is connected to their problem statement. His use of pronouns is relevant: notice how in line 109 he uses the pronoun I—*then I have some.* Then in line 111 he switches to the plural pronoun—*the information we*—and later states *what should I use it for?* We can see that the plural pronoun is used for the actions the group has set out to do, and when he questions these actions, he switches to a personal pronoun. One could thus argue Magnus is distancing himself from the supervisor's proposed trajectory for the group with the test. Additionally, he produces a new trajectory in which he questions the relation of the test to their problem statement. As stated before, the challenge becomes for the supervisor and students to align their trajectories, which will be the last focus of this analysis.

Aligning different learning trajectories

The students have elaborated on how they cannot see the relevance of the test for their problem statement. The supervisor now chooses to use the blackboard to answer their questions. We enter the interaction after the supervisor is done; his drawings are on the table.

Figure 10. Transcript 6.

We interpret the supervisor's switch to English as his realisation that there might be a language barrier between him and the students. The students don't react to this interactively but just continue their interaction, where they reply in Danish, and the supervisor replies in English. However, another relevant point is how the blackboard becomes an artefact that serves to teach the students relevant knowledge about their test. By using the blackboard, the supervisor adds a new method of mediation—drawing. Including drawing with verbal mediational means helps students visualise the way a typical household gets

energy and how their battery fits into this system. If we look at line 201, we see a relevant alignment. Magnus states, 'then I can of course see it,' overlapping with the supervisor, who says, 'you don't know jaer'. Jaer in this regard could be translated to 'yeah'. Thus, he corrects Magnus, stating they still don't have the correct knowledge Magnus states 'he can see'. We see later how Stine, through minimal response, is still able to follow the supervisor's explanations. Thus, the addition of the mediational means of the drawing on the blackboard makes it possible for the supervisor to point at exactly the visual that illustrates what he is describing. The blackboard also ensures a more embodied interaction, as he points to the relevant spots of his drawing, making sure the students can follow his train of thought, and the students keep giving him minimal responses (lines 191, 193, 196, 200, 201, and 209). These minimal responses ensure that the students follow the supervisor's line of argument. One could argue that continuing pointing at the drawing ensures the participants are on the trajectory set by the supervisor, and their minimal response gives them an option to state if they can no longer follow this trajectory. It is also evidence of epistemic claims from the supervisor to the students, which they acknowledge through their minimal response. Furthermore, it goes back to the definition of learning mentioned earlier, focused on the situated collective processes that involve the use of material objects to foster learning. Looking at the interaction, we cannot determine whether the knowledge is new for the students, but we can conclude they are interactively stating they can follow the claims produced by the supervisor. By the end of the meeting, they have understood each other, and the students can now see the relevance of the test for their project. Thus, the students seemed to have lacked a vital understanding of how energy was transferred in the household, which then led to the fact they could not see the relevance of the test for their project. It is relevant because this trajectory that the students lacked understanding of how energy was transferred in the household was not something the students or the supervisor seemed to realise in the beginning of the meeting. Our analysis thus points towards a meeting where both students and supervisor enter with different trajectories regarding what seems to be the issue: the supervisor with a trajectory of the students seeing the test as too easy and the students with a trajectory of the supervisor not understanding the content of their problem. However, both trajectories are 'wrong'. The students don't object to the test because it is too simple, they object because they cannot see the relevance of it to their problem; thus, they think the supervisor does not understand their problem statement. However, he does understand it and the trouble seems to be the students' lack of knowledge about private energy storage in households, which the supervisor eventually realises, after which he explains to the students how it works and how their test is related to private energy storage.

Discussion

Looking at the interaction, we see how Magnus is the primary speaker for the group occasionally backed up by Stine. This could provide the impression, that this is solely Magnus' agenda, and not the group's. As we see the supervisor often looks directly at Magnus (line 12, 26, 66) this might indicate he is of the same observation. However, have we had more space in this article we would have provided extracts from the interaction before and after the supervision meeting in which the group backs Magnus up, and supports him in his quest, and there are other instances of interaction in which some members of the group challenges Magnus, thus based on the group's interaction this is not a case of one member controlling what the group should or should not do. On the contrary, we argue that Magnus and Stine being the only ones able to confront and oppose the supervisor, is a testament to the fact, that this is not an easy thing for students to do. It further highlights the fact, that they are strong students, meaning they dare to confront a supervisor although it is not easy. As is evident in the analysis, Magnus is hesitant every time he challenges his supervisor; thus, it is not an easy thing to do, he is also the only one who directly confronts the supervisor, later with some assistance from Stine. In the institutional setup, the students know their supervisor is more knowledgeable about the content than they are; therefore, their trajectory is more focused on the fact that the supervisor might not have understood their problem well enough, and they challenge the connection of the test to their problem statement, thus we can see that when students challenge their supervision they talk out from an epistemic of experience, where supervisors want to talk from an epistemic of knowledge, thus creating confrontations between students and supervisors.

If we relate our findings to the theory of cognitive congruence. We can state the supervisor is not using any of the techniques related to cognitive congruence: he is not asking clarifying questions; he is not summing up or rephrasing the group's utterances. Regardless, the result is continuing elaboration from the students' side. Thus, the long gaps, in which he does not say anything, force the students to try to resolve their problem with his advice—and by coincidence, they use many of the communicative techniques mentioned about cognitive congruence: they rephrase what the supervisor has said regarding their problem and about the test (lines 88–112), they ask the supervisor questions (lines 15, 54, 111), and they formulate how they understand the supervisor's trajectory, even while questioning the relevance of it (lines 109–112). This results in the supervisor's change of strategy in his interaction with the students when he realises their level of knowledge. Thus, the supervisor becomes able to explain the knowledge on the students' level (lines 190–209), even though it is the students and not the supervisor asking the questions. A finding relevant for

several institutions of HE is that we can see supervision is a dialogical process with shared responsibility between the students and supervisor. As most research looks at the role of the supervisor (Acker et al., 1994; Benwell & Stokoe, 2002; Stokoe, 2000; West, 2020), an interesting perspective for future research could be looking at the role of students and educating students in ensuring a productive outcome for their supervision.

To answer our research question, we can see that students challenge their supervisor with an epistemic of experience which often conflicts with the supervisor's epistemic of knowledge. The challenge is thus to balance these two types of epistemics. The Aalborg PBL model was founded on the notion that students should solve problems they found themselves among other things because it was believed this would lead to better learning (Illeris, 1974; Servant, 2016; Velmurugan, 2022). Thus, in the model, there was an emphasis on students actively using this epistemic of experience. However, there is another perspective in this regard to pay attention to. This still has to be confined to the academic traditions for that specific degree. Thus, this conflict between these two discourses is something both students and supervisors have to deal with in this model, and maybe a solution could be to strengthen the dialogical techniques of both supervisors and students, so it is not only the strong students who can challenge their supervisor. Furthermore, as mentioned in the introduction the supervisor is not natively Danish, maybe this also led to some misunderstandings between the students and the supervisor, again arguing for the need to practice dialogical techniques. Here we want to highlight the fact, the issues were addressed in this meeting.

Ethical considerations

The video analysed in this paper has been shown at different meetings or research seminars, where the reactions are mixed. People who have a STEM background and teach in STEM often sympathise with the supervisor and feel the students are not treating him fairly. They highlight the fact that he has chosen a proposal for testing the students came up with themselves, he has prepared himself before the meeting with notes on the experiment they had to do, and of course, he is upset because he is now repeating himself for something he had already explained once, just because one student thinks he is the one running the show. On the other hand, people with a social sciences or humanities background often sympathise with the students. Perhaps this is because the students are doing things that are actively encouraged in social sciences and humanities, they are questioning the relation between things and remaining critical of things they don't understand, they do this by engaging in

a dialogue, thus they are actively trying to take steps into understanding what they don't understand. Perhaps these differences testify to a nuance in the difference of supervision in a STEM and Social Science/Humanities perspective, but that is beyond the scope of this paper to examine. However, the authors of this paper do want to highlight the supervisor is investing a lot of resources and time to help the students with their project.

References

Acker, S., Hill, T., & Black, E. (1994). Thesis Supervision in the Social Sciences: Managed or Negotiated? *Higher Education*, *28*, 483–498. https://doi.org/10.1007/BF01383939

Antaki, C., Biazzi, M., Nissen, A., & Wagner, J. (2008). Accounting for moral judgments in academic talk: The case of a conversation analysis data session. *Text & Talk*, *28*(1), 1–30. https://doi.org/10.1515/TEXT.2008.001

Arminen, I. (2005). *Institutional Interaction Studies of Talk at Work*. Ashgate.

Askehave, I., Prehn, H. L., Pedersen, J., & Pedersen, M. T. (Eds.). (2015). *PBL - Problem-Based Learning*. Aalborg University. https://www.aau.dk/digitalAssets/148/148025_pbl-aalborg-model_uk.pdf

Benwell, B., & Stokoe, E. H. (2002). Constructing discussion tasks in university tutorials: Shifting dynamics and identities. *Discourse Studies*, *4*(4), 429–453. https://doi.org/10.1177/1461445602004004020l

Bridges, S. M., & Imafuku, R. (Eds.). (2020). *Interactional Research Into Problem-Based Learning*. Purdue University Press. https://doi.org/10.2307/j.ctvs1g9g4

Clayman, S. E. (2013). Turn-Constructional Units and the Transition-Relevant Place. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 150–167). Wiley Blackwell.

de Saint-Georges, I., & Filliettaz, L. (2008). Situated trajectories of learning in vocational training interactions. *European Journal of Psychology of Education*, *23*(2), 213–233. https://doi.org/10.1007/BF03172746

Del Río, M. L., Díaz-Vázquez, R., & Maside Sanfiz, J. M. (2018). Satisfaction with the supervision of undergraduate dissertations. *Active Learning in Higher Education*, *19*(2), 159–172. https://doi.org/10.1177/1469787417721365

Derry, S. J., Pea, R. D., Barron, B., Engle, R. A., Erickson, F., Goldman, R., Hall, R., Koschmann, T., Lemke, J. L., Sherin, M. G., & Sherin, B. L. (2010). Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *Journal of the Learning Sciences*, *19*(1), 3–53. https://doi.org/10.1080/10508400903452884

Donaghue, H. (2020). 'Time to construct positive identities': Display questions in post observation teacher feedback. *Classroom Discourse*, *11*(3), 193–208. https://doi.org/10.1080/19463014.2019.1581626

Engin, M. (2015). Trainer talk in post-observation feedback sessions: An exploration of scaffolding. *Classroom Discourse*, *6*(1), 57–72. https://doi.org/10.1080/19463014.2014.919867

Garfinkel, H. (1967). *Studies in ETHNOMETHODOLOGY*. Prentice-Hall.

Goodwin, C. (1994). Professional Vision. *American Anthropologist*, *96*(3), 606–633. https://doi.org/10.1525/aa.1994.96.3.02a00100

Goodwin, C. (2004). Practices of Seeing Visual Analysis: An Ethnomethodological Approach. In *The Handbook of Visual Analysis* (pp. 2–30). SAGE Publications Ltd. https://doi.org/10.4135/9780857020062

Goodwin, C. (2013). The co-operative, transformative organization of human action and knowledge. *Journal of Pragmatics*, *46*(1), 8–23. https://doi.org/10.1016/j.pragma.2012.09.003

Goodwin, C. (2018). *Co-Operative Action*. Cambridge University Press. https://doi.org/10.1017/9781139016735

Gurr, G. M. (2001). Negotiating the "Rackety Bridge"—A Dynamic Model for Aligning Supervisory Style with Research Stud. *Higher Education Research & Development*, *20*(1), 81–92. https://doi.org/10.1080/07924360120043882

Heath, C., Hindmarsh, J., & Luff, P. (2010). *Video in Qualitative Research Analyisng Social Interaction in Everyday Life*. SAGE Publications Ltd. https://doi.org/10.4135/9781526435385

Heath, C., & Luff, P. (2013). Embodied Action and Organizational Activity. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis*. Blackwell Publishing Ltd. https://doi.org/10.1002/9781118325001.ch14

Hendry, G., Wiggins, S., & Anderson, T. (2016). Are You Still with Us? Managing Mobile Phone Use and Group Interaction in PBL. *Interdisciplinary Journal of Problem-Based Learning*, *10*(2). https://doi.org/10.7771/1541-5015.1600

Hepburn, A., & Bolden, G. B. (2013). The Conversation Analytic Approach to Transcription. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 57–76). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118325001.ch4

Heritage, J. (2012). Epistemics in Action: Action Formation and Territories of Knowledge. *Research on Language & Social Interaction*, *45*(1), 1–29. https://doi.org/10.1080/08351813.2012.646684

Heritage, J. (2013). Epistemics in Conversation. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 370–395). Blackwell Publishing Ltd. https://doi.org/10.1002/9781118325001.ch18

Heritage, J., & Raymond, G. (2005). The Terms of Agreement: Indexing Epistemic Authority and Subordination in Talk-in-Interaction. *Social*

Psychology Quarterly, *68*(1), 15–38. https://doi.org/10.1177/019027250506800103

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). https://doi.org/10.7771/1541-5015.1004

Hmelo-Silver, C. E., Bridges, S. M., & McKeown, J. M. (2019). Facilitating Problem-Based Learning. In M. Moallem, W. Hung, & N. Dabbagh (Eds.), *The Wiley Handbook of Problem-Based Learning* (pp. 297–321). John Wiley & Sons. https://doi.org/10.1002/9781119173243.ch13

Illeris, K. (1974). *Problemorientering og deltagerstyring*. Unge Pædagoger.

Jefferson, G. (2004). Glossary of transcript symbols with an introduction. In G. H. Lerner (Ed.), *Conversation Analysis Studies from the first generation* (pp. 13–31). John Benjamins Publishing Company. https://doi.org/10.1075/pbns.125.02jef

Kitzinger, C. (2013). Repair. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 229–257). Blackwell Publishing Ltd.

Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences makes knowledge*. Harvard University Press. https://doi.org/10.4159/9780674039681

Kolmos, A., Fink, F. K., & Krogh, L. (Eds.). (2004). *The Aalborg PBL model—Progress, diversity and challenges*. Aalborg University Press.

Kress, G., Jewitt, C., Ogborn, J., & Tsatsarelis, C. (2014). *Multimodal Teaching and Learning: The Rhetorics of the Science Classroom*. Bloomsbury Academic. https://doi.org/10.5040/9781472593764

Leyland, C. (2018). Resistance as a resource for achieving consensus: Adjusting advice following competency-based resistance in L2 writing tutorials at a British University. *Classroom Discourse*, *9*(3), 267–287. https://doi.org/10.1080/19463014.2018.1480966

McIlvenny, P. (2020). The future of 'video' in video-based qualitative research is not 'dumb' flat pixels! Exploring volumetric performance capture and immersive performative replay. *Qualitative Research*, *20*(6), 1–19. https://doi.org/10.1177/1468794120905460

McQuade, R., Ventura-Medina, E., Wiggins, S., & Anderson, T. (2019). Examining self-managed problem-based learning interactions in engineering education. *European Journal of Engineering Education*, 1–17. https://doi.org/10.1080/03043797.2019.1649366

Mead, G. H. (1934). *Mind, Self, and the Society*. University of Chicago Press.

Moallem, M., Hung, W., & Dabbagh, N. (Eds.). (2019). *The Wiley Handbook of Problem-Based Learning*. John Wiley & Sons. https://doi.org/10.1002/9781119173243

Mondada, L. (2007). Commentary: Transcript variations and the indexicality of transcribing practices. *Discourse Studies*, *9*(6), 809–821. https://doi.org/10.1177/1461445607082581

Sacks, H., & Jefferson, G. (1995). *Lectures on conversation: Volumes I & II*.

Blackwell.
Savin-Baden, M., & Wilkie, K. (Eds.). (2004). *Challenging research in problem-based learning*. Open Univ. Press.
Schmidt, H. G., & Moust, J. H. C. (2000). Factors Affecting Small-Group Tutorial Learning: A Review of Research. In D. H. Evensen & C. E. Hmelo-Silver (Eds.), *Problem-Based Learning A Research Perspective on Learning Interactions* (pp. 19–53). Routledge.
Scollon, R., & Scollon, S. W. (2004). *Nexus analysis—Discourse and the emerging internet*. Routledge. https://doi.org/10.4324/9780203694343
Scollon, S. W., & de Saint-Georges, I. (2012). Mediated discourse analysis. In M. Handford & J. P. Gee (Eds.), *The Routledge Handbook of Discourse Analysis* (pp. 66–78).
Servant, V. F. C. (2016). *Revolutions and re-iterations: An intellectual history of problem-based learning*. Erasmus University Rotterdam.
Stivers, T., & Sidnell, J. (2013). Introduction. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 1–9). Wiley Blackwell. https://doi.org/10.1002/9781118325001.ch1
Stokoe, E. H. (2000). Constructing Topicality in University Students' Small-group Discussion: A Conversation Analytic Approach. *Language and Education*, *14*(3), 184–203. https://doi.org/10.1080/09500780008666789
Todd, M., Bannister, P., & Clegg, S. (2004). Independent inquiry and the undergraduate dissertation: Perceptions and experiences of final-year social science students. *Assessment & Evaluation in Higher Education*, *29*(3), 335–355. https://doi.org/10.1080/0260293042000188285
Velmurugan, G. (2022). *Problem Construction in Problem-Based Learning How Students Deal with Disagreements in Decision-Making*. Aalborg University.
Velmurugan, G., Stentoft, D., & Davidsen, J. (2021). Disagreeing about the Problem in PBL: How students negotiate disagreements regarding the Problem in PBL. *Journal of Problem Based Learning in Higher Education*, *9*(1), 42–62. https://doi.org/10.5278/ojs.jpblhe.v9i1.6241
West, M. (2020). 'I'm Not Going to Tell You Cos You Need to Think About This': A Conversation Analysis Study of Managing Advice Resistance and Supporting Autonomy in Undergraduate Supervision. *Postdigital Science and Education*. https://doi.org/10.1007/s42438-020-00194-5
West, M. (2023). Advice Resistance in Undergraduate Supervision Meetings: The Competing Relevance of Expertise and Experience. *Journal of Language and Social Psychology*, *42*(5–6), 589–609. https://doi.org/10.1177/0261927X231185750
Yew, E. H. J., & Yong, J. J. Y. (2014). Student perceptions of facilitators' social congruence, use of expertise and cognitive congruence in problem-based learning. *Instructional Science*, *42*(5), 795–815. https://doi.org/10.1007/s11251-013-9306-1

[1] Aalborg University (AAU) uses Problem-Based Learning (PBL) at all its educations. However, the AAU PBL model is a little different than other versions of PBL. Here students write projects over the course of a semester instead of solving cases, thus the model is also called Problem-and Project Based Learning.

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Towards a Pedagogy of Organizational Change

PBL as a Lever for Organizational Development in Higher Education Institutions

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Abstract

The rapidly evolving landscape of higher education demands not only changes in teaching approaches but also organizational transformation. This paper explores the potential of problem-based learning (PBL) as a lever for organizational change, particularly within higher education institutions. Based on a comprehensive organizational development project involving 60 employees at a university library, this study examines the potentials and challenges of PBL in fostering a culture of continuous learning and innovation. Three focus group interviews reveal both opportunities and challenges in translating PBL principles into a professional setting. Key findings include deeper reflection, an appreciation of problem analysis skills, enhanced group collaboration, and the significance of management's role in guiding the process. However, challenges such as organizational culture barriers and the complexity of working life compared to student life highlight the need for tailored PBL approaches to succeed as an organizational change method. This study contributes to the limited literature on PBL's application in organizational contexts, offering insights for fostering sustainable change in higher education.

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Furthermore, the insights gained through the project allow us to revisit PBL in a higher educational setting to discuss which qualities in this pedagogical method could be further developed to promote student learning and development.

Keywords: PBL, Organizational Change, Higher Education (HE), Professional Development, University Library (UL)

Introduction

The Higher Education (HE) landscape is changing rapidly due to societal shifts, increased globalization, and the constant development of digital solutions (Dawo & Sika, 2021; Goh & Abdul-Wahab, 2020). Researchers are calling for HE institutions to change not only their approach to teaching but also their organizational structures to better address the challenges of a rapidly changing world (Geschwind, 2019; Vaira, 2004). The question is how to implement such changes and ensure they are sustainable over time (Hubers, 2020). Various approaches have been explored to govern possible futures for HE institutions. Baker and Baldwin (2015) demonstrate how organizational change in US HE institutions can be perceived from an evolutionary perspective, in which change progresses through a continuous process of feedback and adaptation. Lane (2007) explores the relationship between individual and organizational resistance to change and how to overcome such barriers from a Lewinian perspective. Other researchers examine organizational change in higher education through the lens of organizational learning theory (Boyce, 2003; Akhtar et al., 2011) or draw inspiration from Schein's (1985) work on organizational culture to explore how the distinct culture in HE can encourage or discourage change (Kezar & Eckel, 2002; Trowler, 2008). From an individual perspective, the role of managers as change agents has been the focus of many studies (Adserias et al., 2018; Nordin, 2012), while the importance of faculty as change agents has received less, albeit growing, attention over the last decade (Bond & Blevins, 2019; Geschwind, 2019).

A common theme among the studies mentioned above, and almost all other studies focusing on organizational change in HE, is that they start from organizational theory, treating HE institutions like any other organization. However, HE institutions are unique in that their primary objective and mode of operation are rooted in theories of pedagogy and learning. Penttilä (2016) argues that educational institutions must be understood on their own terms.

Successful change does in most cases require an inside perspective, meaning that the pedagogical foundation should not just serve as a subject of change but as a driver of organizational change as well. Following Penttilä's work, this paper seeks to investigate what happens when pedagogical theories form the basis of an organizational change process. More specifically, this study centers on the pedagogical method of problem-based learning (PBL), which is a central method for the HE institution involved in this study. Furthermore, we aim to acquire new or expanded knowledge about PBL that can be contextualized back to HE. Therefore, we will relate our analytical findings about PBL in an organizational change project to its original educational and pedagogical context and discuss what HE can learn from these new perspectives on PBL in an organizational context. This study contributes to the limited literature on PBL in organizational settings. PBL is a well-known pedagogical method that has proven to be useful and effective in formal educational contexts (Schmidt et al., 2011; Strobel & Van Barneveld, 2009). Equally, researchers have pointed to the effectiveness of the method in continuing education (Author et al., 2013; Hallinger & Bridges, 2017). However, not much research has been done regarding PBL as an approach for promoting organizational learning and change (Thomassen & Jørgensen, 2020), and the literature that does touch upon this topic often discusses how to change organizations by implementing a PBL approach in their organizational repertoire (Kolmos, 2010; Camacho et al., 2018), not how PBL can be used to bring about organizational change.

This study centers on the University Library (UL) at Aalborg University, Denmark. The UL participated in a comprehensive organizational development project based on the principles of PBL. For more than half a year, all employees worked with their peers to solve authentic problems relevant to the UL. During the process, employees received a general introduction to PBL as a pedagogical method and continuous supervision on their project work by experienced PBL researchers. Considering the unique theoretical scope of the organizational development project, this study explores the pros and cons of translating a pedagogical method for enhancing student learning into a method for creating organizational learning and development. The study is guided by the research question:

> What potentials and challenges arise from a PBL-based approach to organizational development, and what can higher education institutions learn from these expanded perspectives on PBL?

Three focus group interviews and author field notes formed the basis for the analysis, findings, and discussion. The study was conducted with the participation of 60 UL employees.

Conceptual framework

We approach the research question through a conceptual framework grounded in Problem-Based Learning (PBL) and organizational change theory. The linkage between these two domains offers a lens for developing and discussing how PBL can facilitate organizational change.

PBL was first introduced in the late 1960s by a group of doctors at McMaster University Medical School in Canada. These educational innovators, dissatisfied with their academic experiences as students, sought to create a new educational approach (Servant-Miklos, 2019). Over the following decade, other universities (especially medical schools) followed in the footsteps of McMaster University, implementing various pedagogical approaches either inspired by or direct copies of the approach developed at McMaster and made world-renowned by the influential teacher and researcher at this institution, Howard S. Barrows (Neufeld & Barrows, 1974; Barrows & Tamblyn, 1980). Today, PBL is an internationally recognized pedagogical approach adopted by universities worldwide within a wide range of professional subjects such as engineering (Chen et al., 2021), psychology (Wiggins et al., 2016), business (Hermann et al., 2021), and within the liberal arts (Hutchings & O'Rourke, 2002). Evidence for the effectiveness of PBL as a learning approach has been growing over the past decades (Schmidt et al., 2011; Condliffe, 2017). Although further research is still needed (Grant & Tamim, 2019) to strengthen the position of this pedagogical approach within the landscape of HE pedagogical practice, most scholars agree that PBL holds several advantages over more traditional methods when it comes to fostering 21st-century skills such as collaborative skills (Chen, 2021), creative and critical thinking (Camacho & Christiansen, 2018; Ulger, 2018), motivation for learning and study interest (Rotgans & Schmidt, 2019).

Along with the increasing popularity and widespread use across professional fields, the landscape of PBL has, not surprisingly, become increasingly diverse. Thus, pedagogical practices differ to such an extent that researchers argue that we are no longer talking about the same thing (Maudsley, 1999; Servant-Miklos, 2020).

The conceptual understanding of PBL behind this study is based on the definition by Savery (2006:12): "PBL is an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem." Furthermore, it encompasses the most common

characteristics of PBL practice, which can be identified by comparing some of the most influential texts within the PBL literature (Barrows, 1996; de Graaff & Kolmos, 2007; Hmelo-Silver, 2004; Savin-Baden & Major, 2004; Schmidt, 1983). As such, PBL can be characterized by the following principles:

- Learning is organized around real and complex problems that link theory to practice.
- The nature of the academic work should be as authentic as possible.
- Knowledge is constructed through active learning processes.
- Learning is a social phenomenon based on students' active participation and involvement.
- Learning is organized in small groups to achieve goals only reachable through collaboration.
- Teachers act as facilitators of learning.
- Students must take responsibility for identifying their own learning needs and organizing their own learning paths.

Organizational change

Organizational research has pointed to the difficulty of creating significant and lasting organizational change (Longenecker et al., 1999). According to Beer and Nohria (2000), most organizational change projects fail to reach their intended outcomes. This is also true within the educational field, where implementing major development reforms sometimes seems virtually impossible (OECD, 2018; Sahlberg, 2016). Organizational change projects are often described as being either based on a top-down (Ryan et al., 2008) or a bottom-up approach (Yi et al., 2017). Both approaches have pros and cons, and neither has proven especially successful within HE (Fullan, 1994; Mazon et al., 2020). As Hargreaves and Ainscow (2015, p. 94) state, top-down change in education can work when the purpose is straightforward, the results are easily measured, and there is public confidence in the educational institutions—a combination seldom seen in today's educational landscape. Similarly, the success of bottom-up approaches is less than impressive (Loucks and Hall, 1977; Anderson, 2010). Due to these mediocre-at-best results of traditional change approaches, Hargreaves and Ainscow (2015) propose a new way for change projects in educational settings, integrating top-down and bottom-up approaches into a new approach they call Leading From the Middle (LFM). This approach is defined as "a deliberate strategy that increases the capacity and internal coherence of the middle as it becomes a more effective partner upward and downward, in pursuit of greater system performance" (Ibid: 24). LFM is a strategy that sees leadership as an activity instead of a position (Robinson et al., 2007). Thus, leadership resides not in the person but in the task, and therefore

leadership in the project organization can and must be distributed among organizational members (Hamel & Zanini, 2020). Furthermore, LFM practice is aligned with Fullan's (2011) four drivers for whole systems change:

1. Cultivate the intrinsic motivation of teachers and students.
2. Engage teachers and students in continuous improvement of teaching and learning.
3. Inspire cooperation and teamwork.
4. Be sure to involve all teachers and students.

The LFM approach corresponds well with the core principles of problem-based learning (PBL), which requires collaboration, active participation, and self-directedness within project groups. Therefore, the management team at UL and the research group agreed upon a design for organizational development based on a combination of the core PBL principles and the theory of LFM.

Context of the study

The proposed conceptual framework presented above serves as a foundation driving the organizational development project and the research design in the context of the UL. The UL is a service organization within Aalborg University with little less than 60 employees handling a wide range of administrative and practical tasks for the university. Over the last five years, the UL management team had become increasingly aware that the character of the tasks that the UL undertakes has changed from primarily being individual, linear, and instrumental to still more collective, complex, and reflexive. Their conclusion was that the organization needed to change itself into a project-oriented organization (Huemann et al., 2007) to be able to respond to the demands the organization was facing. A project-oriented organization is conceptualized by Gemünden et al. (2018) as an entrepreneurial, future- and stakeholder-oriented innovating organization, which uses projects as temporary, task-focused organizations, to define, develop, and implement its strategies. Furthermore, such organizations are typically characterized by groups of small teams, that work independently, coordinating and collaborating with other teams within and outside of the project matrix (Pedersen et al., 2024). Teams within project-oriented organizations often work quite autonomously, when seeking to identify and implement solutions that can move the project towards its completion (Thesing et al., 2021).

Furthermore, the UL is part of a research-intensive university at which PBL plays a central role as the pedagogical foundation for all educational programs and the UL management shared an ambition to align the organization with the AAU-PBL-model (Fink & Krogh, 2004). Management therefore contacted the research team consisting of PBL researchers with multiple years of experience from practice and research in PBL within formal education (Ryberg et al., 2016; Velmurugan et al., 2021; Stegeager et al., 2013; Scholkmann et al.,2023). An organizational change design based on the principles of PBL was developed. The basic idea was to use the university PBL-model from ordinary education as the basis for the organizational development project. Thus, employees were to learn about their organization and PBL by engaging in a PBL-project under the supervision of experienced university academics.

All UL employees were divided into project groups based upon their primary obligations within the organization and assigned a supervisor. After an introductory PBL course, each group was presented with a problem defined by the managerial team and with specific relevance to group members professional responsibilities. Problems varied from quite open-ended questions such as "What kind of UL services do students actually need and how can the UL improve their ability to provide such services?" to more linear and instrumental "How can we make sure that academic staff actually follows the required journaling procedures?". The task for each group was to work on solving the problem under guidance from their supervisor and their respective line manager. The project was finalized at a joint one-day seminar at which each group presented a product representing their solution to the problem.

Data collection

The study received ethical approval from the Institutional Review Boards (IRBs) of AAU and has been registered in the General Data Protection Regulation (UE) 2016/679 GDPR. All participants were informed that their participation was entirely voluntary, and they were required to give their consent by signing a consent form.

Two months after the end of the project, three focus group interviews were conducted with 5-7 UL employees. Participants were recruited based on random sampling. The interviews were based on an interview guide prepared by the researchers based on the conceptual framework of the study. Interviews lasted approximately an hour. All interviews were recorded and transcribed subsequently by the first author. Only employees were interviewed as the study sought to explore the perspectives of this group. In hindsight it would have

been valuable to interview management as well, since managerial actions and decisions were an often debated subject in the interviews.

The analysis of the data is inspired by thematic analysis procedure (Braun & Clarke, 2006). Interviews were transcribed and coded by the first author based on an inductive approach (Coffey & Atkinson, 1996). The primary inspiration for the coding is a four- phase matrix model developed by Glaser & Strauss (1967): Conceptualization of the overall theme, rough division of data into general categories, division into subcategories and further division into finer categories. In this case, data were categorized into four broad categories, 17 subcategories, and 38 finer categories. Furthermore, the finer categories were analyzed based on Boeije's (2002) five-step comparative approach, in which he emphasizes the importance of patterns and combinations of categories and codes (Ibid., p. 397). Themes and categories were subsequently examined and discussed amongst the group of authors until consensus was obtained.

Apart from the interviews, the authors wrote field notes during the process period. Notes were taken after each meeting with library members (employees and/or management). The foundations of the notes were a thorough description of authors experiences and reflections during meetings and seminars. Field notes are used in the paper as background material and are thus not directly part of the analysis.

Findings

In the following section, we will examine the potential challenges of PBL as a method for fostering organizational development. This analysis begins by delving into the perspectives of employees, focusing on the knowledge and competencies they have acquired throughout the project period and how they find that these newly developed skills contribute to the improvement of their execution of everyday tasks. The results are structured around four themes:

- Problem analysis – reflection before action.
- Group work and supervision.
- Barriers to PBL in an administrative unit.
- Managerial roles and responsibilities

Problem analysis – reflection before action

In the focus group interviews, employees describe their practice as characterized by high working tempo, quick decision-making, and a high probability of missing important aspects of the issue they currently are engaged in due to limited time that can be attributed to each task. In this regard, the PBL project forced them to face old habits and reflect upon their traditional approach to problem-based work. This is reflected in the statement below, in which an employee reflects upon the differences between their ordinary practice and their experience during the PBL project period.

> "When we face problems, our discussion is about finding a solution. 'You could do it this way or that way'. But during this project, we had to spend more energy simply focusing on the problem itself: 'How to understand the problem? Is this the right way to frame it? Is this what we want to work on?'. Finding peace in staying with the problem is very different from what we usually do[1]." (Participant D, Group 1)

Even though several employees report that they found it difficult to remain in the analytical phase, a frequently mentioned outcome of the project is that the process prompted an increased appreciation for the analytical and investigative part of their work. A newfound appreciation for a prolonged reflective period before jumping to solutions. Furthermore, employees enjoyed the experience of working 'around the issue', as it made them aware of how their task performance and work in general could be enhanced by spending more time on reflection and incorporating other perspectives.

> "[...] I think we sometimes walk around in our own bubbles thinking we know what the students need. But during this process we gave ourselves the challenge to actually involve them thereby getting their perspective. The solution we landed upon was of a kind we definitely had not thought of before." (Participant 4, Group 1)

Apart from asking students, UL employees noted that in some situations, they also found it beneficial to involve teams or colleagues from the UL or even from other areas of the university in the problem analysis. Insisting on the inclusion of multiple perspectives not only improved the problem analysis and the eventual solution but also created openings for developing mutual understanding—a common language of PBL. Several employees state that they have acquired a more nuanced understanding of the challenges that students face when engaged in project work after going through a similar process themselves, thereby gaining insight into workflows they were not familiar with before.

Despite these positive experiences regarding the exploratory and reflective approach to problem-solving, most employees agree that the time-consuming nature of this method necessitates a thorough analysis of when, in a busy workday, to engage in the slower PBL approach. Generally, employees describe the approach as meaningful for innovative processes but acknowledge that the process can become protracted and unfruitfully time-consuming when dealing with practical problems and operational tasks. Thus, many respondents asked the managerial team to determine how and when (and thus when not) PBL should be the preferred working method in the department.

Group work and supervision

As described earlier, group work and collaboration with a supervisor are fundamental activities in PBL. In an organizational context, teamwork and collaborative activities are likewise a natural part of working life. Even so, UL employees were somewhat surprised by the impact – both positive and negative – that group work in the PBL project had on their learning and understanding of their organization. By and large, most employees describe the group work experience as pleasant, motivating, and enlightening.

Participants report that they have gained increased awareness of areas for possible organizational development, especially regarding feedback and knowledge sharing across teams. Furthermore, even though some groups were based on the existing team structure, other groups were formed across different teams in the organization. This provided employees with the opportunity to see different competencies within their colleagues' repertoires that they did not previously know existed.

Several respondents reported that teams based on the existing structure often found that they lacked an 'outside' perspective that could help move their professional discussions along. In these groups, the supervisor played a crucial role, contributing with new perspectives and “annoying questions, which would help open our eyes to new possibilities” (Participant C, Group 3). In this way, the supervisor could pose questions to the existing order and challenge perceptions of what is possible and not.

Although most employees found the group work to be a pleasant and stimulating activity, some experienced the challenges that is often a part of the PBL experience. Several groups encountered internal tensions during the project period regarding such things as alignment of expectations, distribution of responsibilities, and variations in the level of engagement among group members.

> "Sometimes discussions came down to 'who has the ball?' We all had our "real" work on top of the project. And sometimes, someone felt pressured by the amount of chores on their table, forcing them to prioritize something else than the project, and maybe it didn't quite sit well with the rest of the group that not everyone could move at the same pace." (Participant B, Group 2)

In addition to tensions arising from discussions centered on tasks and responsibilities, several groups reported not having the necessary project management tools to help structure the group process and facilitate effective meetings. Although some employees had received training in project management, they found it quite difficult to apply their skills in this particular context, where their colleagues were part of the project. These challenges were often addressed in supervisor meetings, as almost all groups found that an external supervisor with no attachment to the workplace was a valuable asset.

However, groups with higher conflict levels especially found it difficult to transfer the working spirit from supervisor-facilitated group meetings to everyday working life.

Barriers to PBL-implementation in an administrative department

Working with complex and authentic problems is a fundamental element of PBL. In this project, each UL group was presented with different problems, providing a defined framework for their project work. Some groups instantly found the problem meaningful and engaging, resulting in constructive processes and useful outcomes. Other groups experienced problems getting started, as they found it difficult to agree on how to approach the project, requiring guidance to make the problem more concrete. According to the statements of the employees, it appears that some problems are easier to work with than others. Generally, good projects emerged from development-oriented problems necessitating new initiatives and new collaborations. Problems that encouraged dialogue with users or collaborators outside the UL were especially perceived as meaningful. However, if the problem was more instrumental at its core—often focusing on changing or optimizing already existing processes in the unit—various challenges arose. In particular, employees experienced challenges when working with internal operational problems that concerned specific functions and existing workflows.

> "We were presented a problem we all were deeply involved in. We had established roles, both in terms of work distribution, but also on a more personal level in relation to each other." (Participant A, Group 1)

When employees are personally involved in a specific problem, they might experience the group work as an intrusive act, with people stepping over some hidden organizational boundaries. Thus, the project work risks becoming quite personal, raising questions not only about future organizational procedures but also about core elements of the participants' working lives and professional identities. For such projects to succeed, the group must establish high levels of psychological safety. This means creating an environment of openness and mutual trust, where a willingness to show more vulnerable aspects of oneself is a norm within the group. Some groups worked very explicitly to establish such a "space of confidentiality," discussing the requirements for group cohesion when working with internal issues.

> "In our group, we didn't have to create something new in that way, since our task was to improve existing procedures. However, the "newness" was our approach to the optimization process. This meant that we had to look into each other's working obligations and professional roles. Simply speaking, we had to cross some boundaries during the process." (Participant B, Group 3)

Through the project, many participants experienced how challenging it can be to do project work in their own organization, focusing on very authentic problems—namely, their own working life and tasks related to their professionalism. Such processes often provoke group tension and insecurity and can sometimes lead to open conflict between employees. Even though group dynamics are part of the "PBL experience," and participants had been informed about this before engaging in the project, several employees with prior PBL experience from their own formal education pointed out the significant discrepancy between doing PBL within an educational setting with fellow students and doing it at a workplace with colleagues with whom they are professionally connected and expected to maintain a relationship with after the end of the project. As one employee said, "You cannot change to a new group after the summer break."

In the focus group interviews, participants further discussed why they experienced difficulties allowing others into discussions regarding their own work obligations, especially in situations involving challenges and possible mistakes. Based on these reflections, it seems as though many employees in this particular organization perceive it as a sign of weakness to ask their colleagues for professional advice. Perspectives on this vary among the groups, but a narrative regarding "professionalism," suggesting that if you are an experienced employee, you should be able to solve your work tasks independently seems to exist. This perspective could indicate that the

organization promotes a culture where independent decision-making is highly valued. Based on these reflections, employees in the focus group interviews began to discuss the obstacles the organizational culture might have set in place for a PBL project that requires a curious and experimental approach to learning.

> "You are in some ways exposed in a group setting. I mean, you have to acknowledge that you do not know everything about the subject even though it is your specialty. I think for some, that can be difficult. I mean, displaying that kind of uncertainty. I think many of us are like that, we just want to have things under control." (Participant F, Group 1)

Managerial roles and responsibilities

During the interviews, the role of the management team was frequently discussed, even though they were not represented in the focus groups. It is quite obvious from the statements of the employees that management plays a crucial role, if PBL pedagogy is to be successful as a tool for organizational development. Throughout the project period, the supervisors acted as the primary support for the project groups. However, some employees stated that the group work and the projects themselves might have been more impactful had the management team from the onset clearly communicated intentions and purpose of the project. Especially, a more thorough understanding of the long-term desired impact of the project was a common request in the interviews.

Employees were left speculating about the role PBL should play in the organization moving forward: "Are we practising PBL because this is the new way to structure all or most organizational activities, or is this a method that is only relevant in certain areas and at special times?" This perceived lack of clarity made it difficult for some employees to engage fully in the process, as it created uncertainty about the seriousness of the project, indirectly raising questions about whether it was actually worth investing time and energy in the process.

> "For such a process to succeed strong leadership is required. Management must be aware that PBL simply works differently in a workplace than it does in the classroom. It is a very important managerial task, clearly to communicate intentions and expectations to us as employees: "'What are we to do? What is the goal of the project?' and most importantly, 'Where does the project lead?'" (Participant B, Group 3)

Furthermore, many employees voiced concerns regarding the retention of their newly acquired skills and competencies. As mentioned above, almost all employees felt that the projects had provided them with useful skills and

insights, but the interviews also revealed a fear that this knowledge might fizzle out over time. Skills need to be continuously practiced over a prolonged period to become part of the employees' repertoire. Thus, management must ensure ample opportunities to revisit tasks that require the use of a PBL skillset.

In relation to securing retention, some employees pointed to the opportunities that a common course for all employees could hold. They perceived it as a clear organizational advantage that everyone had come to possess the same knowledge, having all been participants in the same course. However, some ask how the organization can move from individual knowledge (where all employees know the same) to organizational knowledge (where employees are able to collectively use their knowledge to help the organization improve performance goals).

> "I am actually a strong advocate for all of us acquiring the same skills, so we all understand what each other is talking about. I think that's really great. But I think what's crucial for something like this to succeed is that the management team must say: 'This is how you need to work now, so we can make progress.'" (Participant A, Group 3)

Even though management plays a crucial role in ensuring the course will leave a permanent mark on organizational practice, some employees recognize that management cannot do it alone. While employees call for managerial action, they are also aware that not everything that comes from management is immediately accepted by the staff. As one employee mentioned, top-down decisions are easy to implement but hard to love. This poses an interesting dilemma: On the one hand, employees call on management to make decisions, point out directions, and set clear targets; on the other hand, these same employees ask for independence and autonomy.

Discussion

Integrating PBL into a workplace setting shifts its application from an academic training ground to a complex environment where real-world problems directly impact professional roles, identities, and the organization's operational efficiency. This shift necessitates a nuanced discussion centered around several themes that highlight the challenges and opportunities of interpreting PBL as a pedagogy for organizational development. Based on the findings presented in the previous section, we now discuss the central themes emerging from this study and relate them to PBL-pedagogy in higher education.

Transition from Educational to Professional Context

The move from viewing projects as a form of "play" or "training" in an educational setting to addressing real problems in the workplace marks a significant transition. In student life, the primary focus is on learning, exploration, and learning-how-to-learn, often within a safe and controlled environment where mistakes are part of the learning process.

Conversely, in the workplace, problems are not hypothetical scenarios but real issues that affect daily operations, professional relationships, and the organization's overall success. This transition underscores the need for PBL approaches that acknowledge the stakes involved and adapt to the complexities of professional life, including the pressures and responsibilities that come with it.

Although, as we saw in our analysis, this extra layer of seriousness seems to multiply the stakes of the PBL work and thus the potential for destructive group processes, it also creates enormous motivation to succeed, striving for the best result possible as project success is directly connected to professional success. In this regard, it could be beneficial for educational planners to consider how the “playfulness” in an educational setting can, in some ways, resemble the seriousness of the workplace to increase motivation and effort in PBL work.

Group Work in the Workplace

Group work in the workplace transcends the concept of project groups in an academic setting. It involves ongoing collaboration and communication, with team members often working together on a series of projects or continuous operational tasks. The dynamics of workplace group work require a balance between individual responsibilities and team goals, with a focus on long-term relationships and organizational objectives. Effective group work in this context relies on clear roles, shared goals, and a culture of mutual respect and support. Group work in a workplace setting can also lead to conflicts, given the diverse backgrounds, expertise, and professional stakes involved. Unlike academic projects, workplace conflicts can have immediate implications for job performance and organizational culture. Addressing these conflicts requires a mature and open approach to collaboration, emphasizing communication, empathy, and conflict resolution skills.

Leadership and facilitation become crucial in navigating these challenges, ensuring that group dynamics contribute positively to problem-solving and team cohesion. The diversity within a workplace encompasses a broader range of experiences, expertise, and perspectives than typically found in academic settings. This diversity can potentially enrich the PBL process, bringing a wealth of ideas and solutions to the table. However, it also requires careful consideration of group dynamics and the inclusion of diverse voices to ensure

that all employees feel valued and heard. Leveraging this diversity effectively can lead to more innovative and comprehensive solutions to problems.

When experiencing PBL in an organizational context, factors that we might take for granted in an educational setting become apparent. Among these are the importance of frameworks for group work and tools for project management, all of which are significant skills to have in group work, whether it's project work in a workplace or in HE. Even though time is often scarce in an educational context, the findings from this project remind us to prioritize a continuous focus on the process of PBL rather than rushing toward a certain and desired end state (the product). While every pedagogical intervention should be based on a desired learning outcome, it is important to remember that the process and the outcome are tightly interconnected and thus should be seen as two sides of the same coin.

Supervision in PBL

Supervision proved essential in supporting the employees as they adapted to the PBL approach. This was especially true for those who were accustomed to more traditional, directive work environments. The support that a mentor can provide might include training sessions, mentoring, and presenting participants with resources that can guide them through the PBL process. Supervision should help employees build the skills and confidence needed to navigate complex problems, encouraging autonomy while providing the necessary support structures to ensure success. It is also evident that staff do not have the same freedom to explore methods and alternative tracks in their project work compared to students in HE. In higher education, students often have the opportunity to engage in 'serious' and 'playful' learning contexts, allowing them to experiment more freely with different approaches. In contrast, employees working on organizational projects must adhere to more structured and goal-oriented processes, limiting their scope for experimentation. Even though the supervisor plays an important role in HE as well, literature often stresses that one of the most important tasks of the supervisor is to facilitate student meta-learning. However, the concept of learning to learn is clearly different in the two contexts. In higher education, meta-learning involves helping students develop their ability to understand and regulate their own learning processes, fostering independence and critical thinking. In an organizational context, learning to learn is more focused on practical application and immediate problem-solving within the constraints of the workplace. Understanding these differences could provide valuable insights for future developments of PBL.

The Complexity of Working Life vs. Student Life

> "The problem-based learning of the 21st Century needs to move away from standardization, striation and repression; it needs to move out of the shadows." (Savin-Baden, 2020: 4)

The complexity of working life, compared to student life, presents unique challenges in applying PBL in the workplace. In formal education, the problem-based project is the only activity that the participants perform together, whereas the staff in this project had to carry on with all their other activities and tasks. Furthermore, while students can take a break from their group activities, employees are forced to continue their work and daily tasks. In the workplace, problems are multifaceted, often requiring interdisciplinary knowledge and collaboration across different employee groups. The stakes are higher, with solutions impacting the organization's bottom line, employee morale, and customer satisfaction. This complexity calls for a sophisticated application of PBL, one that can accommodate diverse perspectives and the realities of organizational constraints.

For quite some years, educational developers have strongly suggested that educational activities, learning goals, and assessment methods are aligned (Biggs, 1996). Thus, education should be structured following a clear and obvious logic easily explained to the students, and students should know from the onset of a semester what is expected of them and which actions they should take to reach and demonstrate the overall intended learning outcomes. Even though we acknowledge that such clarity can often lead to beneficial learning, it is important to remember that "real-life problems" almost never provide such a stringent sequence of logic. Thus, if we only teach our students to operate under conditions governed by clearly formulated rules and demands, their learning will, in some ways, become limited. Sometimes education needs to be complex — even chaotic (Trowler, 2015). As an educational designer, one might not become very popular among either students or fellow educators when insisting on increasing the complexity in the educational context. Students often appreciate clarity and well-structured courses.

However, learning does not always spring from what we find pleasing but rather from reflection caused by the surprises (sometimes more and sometimes less pleasant) that arise when we experience something unexpected. This is the power of PBL; it allows for complexity, uncertainty, and frustration, and in this way, it opens up other forms of learning potentialities.

Conclusion

In conclusion, adapting PBL to the workplace involves recognizing the significant differences between academic and professional settings. It requires tailored approaches that consider the complexity of work life, the diversity of the workforce, and the need for scaffolding to support employee development. With thoughtful implementation, PBL can become a meaningful and effective approach to solving real-world problems and fostering a culture of continuous learning and innovation in the workplace.

This study underscores several key themes essential for successful integration of PBL into organizational contexts. First, the transition from educational to professional settings marks a critical shift, where problems impact daily operations, professional relationships, and organizational success. This shift necessitates PBL approaches that acknowledge the higher stakes and adapt to the complexities of professional life. Second, PBL can significantly contribute to employee development by fostering a culture of continuous learning, critical thinking, and innovative problem-solving. Employees engaged in PBL can develop a deeper understanding of their work, enhancing their professional competencies and bridging the gap between theory and practice. However, it is crucial to recognize the varying degrees of ease with which different employees can integrate PBL into their daily practice, influenced by individual and organizational structures. Third, group work in the workplace differs from academic settings, involving ongoing collaboration and communication with long-term relationships and organizational objectives. Effective group work relies on clear roles, shared goals, and a culture of mutual respect and support. Addressing conflicts and leveraging the diversity within the workplace is vital for enriching the PBL process and ensuring all voices are valued.

Fourth, supervision plays an essential role in supporting employees adapting to PBL, especially those accustomed to traditional, directive work environments. Supervisors must help employees build the skills and confidence needed to navigate complex problems, balancing autonomy with necessary support structures. Additionally, the complexity of working life compared to student life presents unique challenges for applying PBL in the workplace. The multifaceted nature of workplace problems requires interdisciplinary knowledge and collaboration, demanding a sophisticated application of PBL that accommodates diverse perspectives and organizational constraints. Finally, this study highlights some of the themes often taken for granted in formal education, such as the focused nature of student projects. In the workplace, employees must juggle multiple responsibilities alongside PBL

projects, necessitating frameworks for group work and project management tools. Emphasizing the process of PBL rather than rushing toward outcomes is crucial for meaningful learning and development. Overall, while integrating PBL into the workplace presents challenges, it also offers significant opportunities for enhancing organizational development and employee growth. By understanding and addressing the differences between educational and professional contexts, organizations can harness the power of PBL to drive innovation, improve problem-solving capabilities, and cultivate a culture of continuous improvement.

References

Adserias, R. P., Charleston, L. J., & Jackson, J. F. (2018). What style of leadership is best suited to direct organizational change to fuel institutional diversity in higher education? In Tate, S. A., & Bagguley, P. (Eds.), *Building the anti-racist university*. Routledge, 26-42. https://doi.org/10.4324/9780429444234-3

Akhtar, S., Arif, A., Rubi, E., & Naveed, S. (2011). Impact of organizational learning on organizational performance: Study of higher education institutes. *International Journal of Academic Research*, *3*(5), 327-331.

Anderson, S.E. (2010). Moving change: evolutionary perspectives on educational change. In Hargreaves, A., Fullan, M., Lieberman, A. and Datnow, A. (Eds), *The Second International Handbook of Educational Change*, Springer, Dordrecht, pp. 65-84. https://doi.org/10.1007/978-90-481-2660-6_4

Baker, V. L., & Baldwin, R. G. (2015). A case study of liberal arts colleges in the 21st century: Understanding organizational change and evolution in higher education. *Innovative Higher Education*, *40*, 247-261. https://doi.org/10.1007/s10755-014-9311-6

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New directions for teaching and learning*, (68), 3-12. https://doi.org/10.1002/tl.37219966804

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education* (Vol. 1). Springer Publishing Company.

Beer, M., & Nohria, N. (2000). Cracking the code of change. *Harvard business review*, *78*(3), 133-141.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher education*, *32*(3), 347-364. https://doi.org/10.1007/BF00138871

Boeije, H. (2002). A purposeful approach to the constant comparative method in the analysis of qualitative interviews, *Quality and Quantity*, 36, 391-409. https://doi.org/10.1023/A:1020909529486

Bond, M. A., & Blevins, S. J. (2020). Using faculty professional development to foster organizational change: A social learning framework. *TechTrends*, *64*(2), 229-237. https://doi.org/10.1007/s11528-019-00459-2

Boyce, M. E. (2003). Organizational learning is essential to achieving and sustaining change in higher education. *Innovative Higher Education*, *28*, 119-136. https://doi.org/10.1023/B:IHIE.0000006287.69207.00

Braun, V, & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, 2006, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Camacho, H., & Christiansen, E. (2018). Teaching Critical Thinking within an Institutionalised Problem Based Learning Paradigm – Quite a Challenge. *Journal of Problem Based Learning in Higher Education*, *6*(2), 91-109. https://doi.org/10.5278/ojs.jpblhe.v6i2.2308

Camacho, H., Coto, M., & Jørgensen, K. M. (2018). How Does Organisational Culture Influence the Process of Change towards PBL? *Journal of Problem Based Learning in Higher Education*, *6*(2), 32-57. https://doi.org/10.5278/ojs.jpblhe.v6i2.2140

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: a review of literature. *European Journal of Engineering Education*, *46*(1), 90-115. https://doi.org/10.1080/03043797.2020.1718615

Chen, R. H. (2021). Fostering students' workplace communicative competence and collaborative mindset through an inquiry-based learning design. *Education Sciences*, *11*(1), 17. https://doi.org/10.3390/educsci11010017

Coffey, A., & Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies*. Sage Publications, Inc.

Dawo, J.I., & Sika, J. (2021). Higher education in evolving world: accelerating the pace of change in teaching for learning. *European Journal of Educational Studies*, *8*(12), 223-236. https://doi.org/10.46827/ejes.v8i12.4029

De Graaff, E., & Kolmos, A. (2007). *Management of Change: Implementation of Problem-Based and Project-Based Learning in Engineering*. Sense Publishers. https://doi.org/10.1163/9789087900922

K. A., Fink, F., & Krogh, L. (2004). *The Aalborg PBL Model: progress, diversity and challenges*. Aalborg Universitetsforlag.

Fullan, M. (1994). Coordinating top-down and bottom-up strategies for educational reform. *Systemic reform: Perspectives on personalizing education*, 7-24.

Fullan, M. (2011). *Choosing the wrong drivers for whole system reform*. Seminar Series Paper No. 204. Victoria: Centre for Strategic Education.

Fullan, M. (2015). Leadership from the Middle. *Education Canada*, *55*(4), 22-26.

Gemünden, H. G., Lehner, P., & Kock, A. (2018). The project-oriented organization and its contribution to innovation. *International Journal of Project Management*, *36*(1), 147- 160. https://doi.org/10.1016/j.ijproman.2017.07.009

Geschwind, L. (2019). Legitimizing change in higher education: Exploring the rationales behind major organizational restructuring. *Higher Education Policy*, *32*(3), 381-395. https://doi.org/10.1057/s41307-018-0088-6

Goh, P.S.C., & Abdul-Wahab, N. (2020). Paradigms to drive higher education 4.0. *International Journal of Learning, Teaching and Educational Research*, *19*(1), 159- 171. https://doi.org/10.26803/ijlter.19.1.9

Hallinger, P., & Bridges, E. M. (2017). A systematic review of research on the use of problem-based learning in the preparation and development of school leaders. *Educational Administration Quarterly*, *53*(2), 255-288. https://doi.org/10.1177/0013161X16659347

Hamel, G., & Zanini, M. (2020). *Humanocracy: Creating organizations as amazing as the people inside them*. Harvard Business Press.

Hargreaves, A., & Ainscow, M. (2015). The top and bottom of leadership and change. *Phi Delta Kappan*, *97*(3), 42-48. https://doi.org/10.1177/0031721715614828

Hermann, R. R., Amaral, M., & Bossle, M. B. (2021). Integrating problem-based learning with international internships in business education. *Journal of Teaching in International Business*, *32*(3-4), 202-235. https://doi.org/10.1080/08975930.2022.2033667

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

Hubers, M. D. (2020). Paving the way for sustainable educational change: Reconceptualizing what it means to make educational changes that last. *Teaching and teacher education*, *93*, 103083. https://doi.org/10.1016/j.tate.2020.103083

Huemann, M., Turner, R., & Keegan, A. (2007). Managing human resources in the project-oriented company. *The Wiley guide to project organization and project management competencies*, 117-142.

Hutchings, B., & O'rourke, K. (2002). Problem-based learning in literary studies. *Arts and Humanities in Higher Education*, *1*(1), 73-83. https://doi.org/10.1177/1474022202001001006

Kezar, A., & Eckel, P. D. (2002). The effect of institutional culture on change strategies in higher education: Universal principles or culturally responsive concepts? *The journal of higher education*, *73*(4), 435-460. https://doi.org/10.1353/jhe.2002.0038

Kolmos, A. (2010). Premises for Changing to PBL. *International Journal for the Scholarship of Teaching and Learning*, *4*(1), 4. https://doi.org/10.20429/ijsotl.2010.040104

Lane, I. F. (2007). Change in higher education: Understanding and responding to individual and organizational resistance. *Journal of Veterinary Medical Education*, *34*(2), 85-92. https://doi.org/10.3138/jvme.34.2.85

Longenecker, C. O., Simonetti, J. L., & Sharkey, T. W. (1999). Why organizations fail: the view from the front-line. *Management Decision*, *37*(6), 503-513. https://doi.org/10.1108/00251749910278023

Loucks, S.F. and Hall, G.E. (1977). Assessing and facilitating the implementation of innovations: a new approach. *Educational Technology*, *17*(2), pp. 18-21.

Maudsley, G. (1999). Do we all mean the same thing by "problem-based learning"? A review of the concepts and a formulation of the ground rules. *Academic Medicine*, *74*(2), 178-85. https://doi.org/10.1097/00001888-199902000-00016

Mazon, G., Pereira Ribeiro, J. M., Montenegro de Lima, C. R., Castro, B. C. G., & Guerra, J. B. S. O. D. A. (2020). The promotion of sustainable development in higher education institutions: top-down bottom-up or neither? *International Journal of Sustainability in Higher Education*, *21*(7), 1429-1450. https://doi.org/10.1108/IJSHE-02-2020-0061

Neufeld, V. R., & Barrows, H. S. (1974). The "McMaster Philosophy": an approach to medical education. *Academic Medicine*, *49*(11), 1040-50. https://doi.org/10.1097/00001888-197411000-00004

Nordin, N. (2012). Assessing emotional intelligence, leadership behaviour and organizational commitment in a higher learning institution. *Procedia-Social and Behavioral Sciences*, *56*, 643-651. https://doi.org/10.1016/j.sbspro.2012.09.699

Organisation for Economic Co-Operation and Development (2018) *The Teaching and Learning International Survey*, OECD, Paris

Pedersen, L. S., Stegeager, N., & Elmholdt, C. W. (2024). *Self-organized pockets of agile in a hierarchical financial world: A qualitative study of leadership challenges, consequences, and contingencies when agile and hierarchical organizing intersect*. 1-11. European Group for Organizational Studies 2024, Milan, Italy.

Penttilä, T. (2016). Developing educational organizations with innovation pedagogy. *International e-journal of Advances in Education*, *2*(5), 259-267.

Robinson, V. M., Hohepa, M. & Lloyd, C. (2007). *School leadership and student outcomes: Identifying what works and why*. Winmalee: Australian Council for Educational Leaders.

Rotgans, J. I., & Schmidt, H. G. (2019). Effects of problem-based learning on motivation, interest, and learning. In Moallem, M., Hung, W., & Dabbagh, N. (Eds.), *The Wiley Handbook of Problem-Based Learning*, 157-1. https://doi.org/10.1002/9781119173243.ch7

Ryan, N., Williams, T., Charles, M. & Waterhouse, J. (2008). Top-down organizational change in an Australian Government agency. *International*

Journal of Public Sector Management, *21*(1), 26-44. https://doi.org/10.1108/09513550810846096

Ryberg, T., Davidsen, J., & Hodgson, V. (2016). Problem and project-based learning in hybrid spaces: nomads and artisans. In *Networked Learning Conference 2016: 10th International Conference on Networked Learning 2016* (pp. 200-209). https://doi.org/10.54337/nlc.v10.8864

Sahlberg, P. (2016). The global educational reform movement and its impact on schooling. In Mundi, K., Green, A., Lingard, B., & Verger, A. (Eds.), *The handbook of global education policy*, 128-144. https://doi.org/10.1002/9781118468005.ch7

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows*, *9*(2), 5-15. https://doi.org/10.2307/j.ctt6wq6fh.6

Savin-Baden, M. & Major, C. H. (2004). *Foundations of Problem-based Learning*. McGraw-hill Education.

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

Schein, E. (1985). Organizational culture and leadership: A dynamic view. San Francisco: Jossey Bass

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. (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

Scholkmann, A., Stegeager, N., & Miller, R. K. (2023). Integrating the Integration: The Role of Problem-Based Learning in Bringing Together Social Science and Humanities (SHH) and Science, Technology, Engineering and Mathematics (STEM). *Journal of Problem Based Learning in Higher Education*, *11*(1), 98-123. https://doi.org/10.54337/ojs.jpblhe.v11i1.7371

Servant-Miklos, V. (2020). Problem-oriented project work and problem-based learning: "Mind the gap!". *Interdisciplinary Journal of Problem-Based Learning*, *14*(1). https://doi.org/10.14434/ijpbl.v14i1.28596

Servant-Miklos, V. F. (2019). Fifty years on: A retrospective on the world's first problem- based learning programme at McMaster University Medical School. *Health Professions Education*, *5*(1), 3-12. https://doi.org/10.1016/j.hpe.2018.04.002

Stegeager, N., Thomassen, A. O., & Laursen, E. (2013). Problem Based Learning in Continuing Education - Challenges and Opportunities.

Journal of Problem Based Learning in Higher Education, *1*(1), 151-175. https://doi.org/10.5278/ojs.jpblhe.v1i1.280

Strobel, J., & Van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary journal of problem-based learning*, *3*(1), 44-58. https://doi.org/10.7771/1541-5015.1046

Thesing, T., Feldmann, C., & Burchardt, M. (2021). Agile versus Waterfall Project Management: Decision Model for Selecting the Appropriate Approach to a Project. *Procedia Computer Science, 181*, 746-756. https://doi.org/10.1016/j.procs.2021.01.227

Thomassen, A. O., & Jørgensen, K. M. (2020). John Dewey and continuing management education: problem-based learning for organizational sustainability. *Journal of Workplace Learning*, *33*(3), 229-242. https://doi.org/10.1108/JWL-05-2020-0080

Trowler, P. (2008). *Cultures and change in higher education: Theories and practices*. Bloomsbury Publishing.

Trowler, V. (2015). Negotiating contestations and 'chaotic conceptions': Engaging 'non-traditional' students in higher education. *Higher Education Quarterly*, *69*(3), 295-310. https://doi.org/10.1111/hequ.12071

Ulger, K. (2018). The effect of problem-based learning on the creative thinking and critical thinking disposition of students in visual arts education. *Interdisciplinary Journal of Problem-Based Learning*, *12*(1). https://doi.org/10.7771/1541-5015.1649

Vaira, M. (2004). Globalization and higher education organizational change: A framework for analysis. *Higher Education*, *48*(4), 483-510. https://doi.org/10.1023/B:HIGH.0000046711.31908.e5

Velmurugan, G., Stentoft, D., & Davidsen, J. G. (2021). Disagreeing about the Problem in PBL: How students negotiate disagreements regarding the Problem in PBL. *Journal of Problem Based Learning in Higher Education*, *9*(1), 42-62. https://doi.org/10.5278/ojs.jpblhe.v9i1.6241

Wiggins, S., Chiriac, E. H., Abbad, G. L., Pauli, R., & Worrell, M. (2016). Ask not only 'what can problem-based learning do for psychology?' but 'what can psychology do for problem-based learning?' A review of the relevance of problem-based learning for psychology teaching and research. *Psychology Learning & Teaching*, *15*(2), 136-154. https://doi.org/10.1177/1475725716643270

Yi, Y., Gu, M. & Wei, Z. (2017). Bottom-up learning, strategic flexibility and strategic change. *Journal of Organizational Change Management, 30*(2), 161-183. https://doi.org/10.1108/JOCM-12-2015-0241

[1] All interview quotations are translated by the authors.

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Individual Reflection Papers as a Means to Support Individual Assessment in Group Examinations in Problem-Based Learning

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Abstract

Even though using group examinations aligns well with the epistemology of problem-based learning (PBL), the dilemma of using joint learning while simultaneously fulfilling individual assessment requirements in higher education make group examinations difficult to use. In this study, the aim was to explore whether an individual reflection paper (IRP) can act as a means to support individual assessment in group examinations in PBL. 152 IRPs were used to assess whether a particular group of students had acquired theoretical and analytical knowledge that would affect results on a group examination. Overall, completed IRPs clearly showed a concurrence between the students' acquired and requested theoretical and analytical knowledge on the examination, except on a few occasions. These findings are promising and suggest that IRPs can act as a means to support individual assessment in group examinations in PBL and that it is possible to combine joint learning in tutorial groups with individual group work assessment.

Keywords: Individual reflection paper, group exams, problem-based learning, group work assessment

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Introduction

This study is based on the idea that tutorial groups in problem-based learning (PBL) offer valuable opportunities for in-depth learning with others (Azer & Azer, 2015; Yew & Goh, 2016) but that the requirement for teachers to assess students' engagement and knowledge contributions individually may result in counterproductive competitive processes (Hammar Chiriac & Forslund Frykedal, 2023; Orr, 2010). The facilitation of joint learning while simultaneously fulfilling the requirements in higher education of individual assessment results in a dilemma entailing that group examinations become challenging to use. Managing this paradox and exploiting the potential of group examinations, depends on finding methods or tools that can contribute to more justifiable group work assessment. One of these tools might be individual reflection papers (IRPs; Abrandt Dahlgren et al., 2016; Johansson et al., 2012; Johansson & Svensson, 2019), a structured method requiring a student's written reflections on knowledge acquired and aspects of it to discuss at the student's next tutorial meeting. Against this backdrop, the aim of this study was to explore whether an IRP can act as a means to support individual assessment in group examinations in PBL.

Collaborative Learning and PBL

Collaborative learning is an effective pedagogical tool that provides students with knowledge and skills they will need in their future professional activities (Barnett, 2012; Johnson & Johnson, 2014; Tan et al., 2017). This aligns well with the fundamental principle of using PBL which is to equip the students with an investigative approach and to develop a greater sense of responsibility for their own learning (Jones, 2013; Wiggins et al., 2016). The main processes of PBL are problem-solving, self-directed learning, and group interaction (Moallem et al., 2019; Savin-Baden & Howell, 2004). PBL uniquely provides opportunity for collaborative learning in small tutorial groups. Well-functioning tutorial group work promotes both subject theoretical and analytical knowledge and encourages the development of collaborative skills. In PBL, students use the tutorial group both as a means (a base for learning and academic achievement) and an objective (learning collaborative abilities; Hmelo-Silver, 2004; Rosander & Hammar Chiriac, 2016). Because the tutorial groups provide valuable opportunities for in-depth learning with others, the conditions match well with the possibility of using group examinations given that such examinations not only serve as a basis for assessment but also provide additional opportunities for joint learning (Hammar Chiriac & Forslund Frykedal, 2023).

Group Work Assessment in Tutorial Groups

When tutorial groups are used in PBL in higher education the teachers are obliged to assess the students' individual knowledge, which is constructed in interaction with others. A recurring challenge for teachers is to be able to distinguish and collect evidence to assess individual students' knowledge from the tutorial group's jointly produced knowledge (Dijkstra et al., 2016; van Aalst, 2013). The requirement for teachers to assess students' individual may result in counterproductive competitive processes (Hammar Chiriac & Forslund Frykedal, 2023). Students sometimes also experience group work assessment as problematic because it is often associated with the experience of injustice and unequal contribution (Orr, 2010). Combining group work assessment with collaboration and joint learning in tutorial groups is therefore problematic for both teachers and students. In fact, some researchers have questioned whether well-functioning group work linked to individual assessment exists at all (Steel et al., 2014). The dilemma of facilitating joint learning while fulfilling the requirements of individual assessment means that group examinations become difficult to use. Managing this dilemma, and to take advantage of the potential of using group examinations in PBL, depends on finding methods or tools that can contribute to more justifiable individual group work assessment. One of these tools might be IRPs (Abrandt Dahlgren et al., 2016; Johansson et al., 2012; Johansson & Svensson, 2019).

Individual Reflection Papers in PBL

An IRP is a structured method intended to support the development of the student's active approach to learning and ability for reflection and to facilitate their learning process (Abrandt Dahlgren et al., 2016; Johansson et al., 2012; Johansson & Svensson, 2019). The use of IRPs has successfully been implemented in PBL programmes and concerns knowledge acquisition and processing on both individual and group level. The IRP processes include three steps where the first two steps concern students' preparations and learning at the individual level between the tutorial group meetings, and the third step regards the discussion and in-depth learning at the group level at the meeting (Johansson & Svensson, 2019, p. 99). More specifically, in the first step of the IRP process each student, individually between the tutorial meetings, documents and compiles a written shot text including (a) their subject theoretical acquired knowledge based on the group's jointly formulated learning needs and question, (b) reflections on their own learning process and (c) aspects of it to discuss at the next tutorial meeting (analytical knowledge). In the second step, all students in the tutorial group individually read each other's IRPs. In the third step, the students meet in the tutorial group and conduct a collective discussion based on the group's jointly gathered knowledge expressed in the IRPs (i.e., develop subject theoretical and analytical knowledge

and collaborative skills on group level). Previous experience and research on PBL have shown that the use of IRPs can act as a support for students' preparation for and learning in tutorial groups on both individual and group level (Johansson & Svensson, 2019). It also appears that IRPs can facilitate tutors' assessments and examinations of students' individual engagement and contributions in tutorial groups (Johansson et al., 2012).

In sum, an IRP is an individual written elaboration of theoretical and analytical knowledge acquisition. It serves as a preparation for tutorial group discussions because each student summarises how they understand the theories and research findings that they want to discuss at the next group meeting.

The Present Study

This study is based on a few years' experience using IRPs as a tool for supporting group work assessment in group examinations in PBL. The aim of the study was to explore whether an IRP can act as a means to support individual assessment in group examinations in PBL.

Materials and Methods

The context of this study was the psychologist programme (Master of Science in Psychology) at a large university in Sweden that uses PBL. IRPs was implemented in the last of four group and social psychology courses in the programme. The current course was structured around three themes corresponding to important research areas in group and social psychology: (a) conflict management and conflict escalation, (b) bullying and abusive treatment in the workplace, and (c) group development. The purpose of using IRPs in the course was two-folded; firstly, to give the students an opportunity to try a new tool to support their learning process and promote their ability to reflect on their own understanding and learning (cf. Abrandt Dahlgren et al., 2016; Johansson & Svensson, 2019) and secondly to facilitate teachers individual group work assessment in PBL. The use of the IRPs was a part of the regular coursework and included students' individually writing three IRPs, one for each of three themes in the course. Each IRP contained a written short and concise description of the student's acquired subject knowledge, theories and research findings linked to references and an elaboration of the understanding of theories and research findings that they wanted to discuss at the next tutorial meeting (Abrandt Dahlgren et al., 2016). The students' IRPs were submitted prior to the tutorial group meeting and served as an individual preparation for

the collective group discussions (group level). Because the IRPs were restricted to 2,000 words, excluding references, the students had to choose what they thought was most important to convey and therefore be included. The submitted IRPs, as well as the students' active participation in the tutorial group were assessed by the tutors. In this way, both individual understanding and processual reflections were captured. What was new and tried for the first time was that one of each student's submitted IRPs was reused in connection with the group examination. As far as I know this is the first study focusing on exploiting the possibility of reusing submitted IRPs as a means for supporting group work assessment in group exams.

Group Examinations in the Tutorial Groups

At the end of the course, the students' theoretical and analytical knowledge acquisition was assessed through a group examination that was carried out over the course of a day (8:00–17:00) on site at the university. The group examination was based on one of the three themes in the course (i.e., conflict management and conflict escalation, bullying and abusive treatment in the workplace, or group development). Which theme was addressed in the examination was predetermined by the teacher and revealed to the students in the task description on the day of the examination. The task consisted of the tutorial group jointly solving a task based on a vignette. On the basis of the vignette and the instructions (Figure 1), the group jointly selected and defined a problem formulation or question that should be processed, analysed, and applied on the basis of chosen relevant group and/or social psychological theories and research findings regarding the 'theme' addressed in the examination.

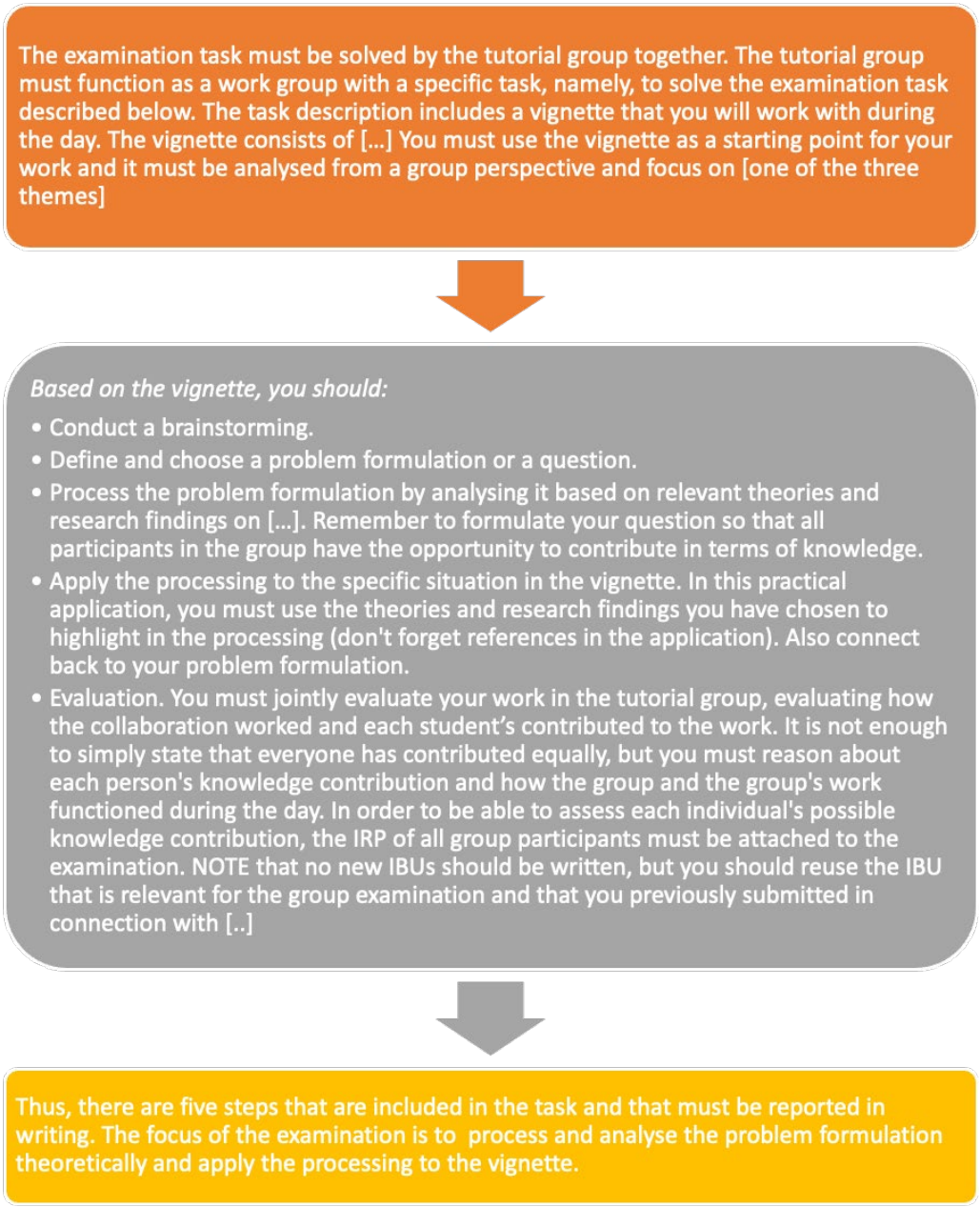

Figure 1. Task description and framework for the group examination.

Note: […] is omitted text that corresponds to concepts that vary for the specific examination.

The students were reminded about the importance of formulating a problem or question that all participants in the group had the opportunity to contribute in terms of knowledge. This working method was well known to the tutorial group because it was created by means of the same problem-solving process that the tutorial groups usually used at their meetings. Notes and optional literature were allowed to be used during the work. The group examination was graded on a two-part scale: pass or fail. (To gain a higher grade, pass with merit, the student had to take an individual written examination as well.)

Data Sources

The use of IRPs as a means to assess group examinations was implemented in a course in the psychology programme 2020 and is still used. The data for this study were taken from the years 2020–2022. In total, 11 tutors assessed and approved 465 IRPs submitted by students. One hundred fifty-two (152) IRPs were reused in 21 group examinations, of which there are seven per year. A requirement for passing the group examination was active participation in and contribution to the common product of the tutorial group. To show possible individual knowledge contribution of relevance to the examination, all students were obligated to attach the IRP produced for the theme that the examination addressed. No new IRPs were written, but the students reused one of their previously submitted IRPs. In sum, 152 pre-assessed and approved IRPs were reused as a basis to assess whether the student had acquired theoretical and analytical knowledge that could contribute to the examination. To further conceptualise the tutors' and students' apprehension of using IRPs as a means for supporting group work assessment in group exams, evaluations from tutors (2021) and the students' regular course evaluations (2020–2022) at course level were used as supporting documents.

To ensure all participants' integrity, the project was guided by an approach based on responsibility, reliability, honesty, and respect. Informed consent was retrieved from the 11 tutors included in the current cohorts. Because the data for this study were retrieved from the students' regular examinations in the course and not collected for research purposes, great importance was placed on their integrity and anonymity in all parts of the written report, both emphasising the concern for students' interests and their right to confidentiality (cf. British Psychological Society, 2014; Swedish Research Council, 2017). All findings that may be derived from the students' examinations, or their evaluation, are provided at group or course level and anonymised. The focus is not on describing the opinions or experiences of individual students but on describing an innovative and new approach to group examinations and group work assessment in PBL.

Findings

The findings are mainly based on my evaluation of the outcome of using IRPs as a means to support individual assessment in group examinations in PBL in higher education. In connection with assessing the group product, I read through all the attached IRPs and assessed whether the individual student had written about acquired knowledge aligned with theories and research findings processed in the joint (tutorial group) product. By focusing on the individual level of the IRPs consisting of the students' short and concise description of their

acquired subject knowledge, theories and research findings linked to references and their reflection on their own understanding and learning reported in the IRP, I could compare each student's reported own theoretical and analytical knowledge contribution (IRP) with the tutorial group's joint product. Figure 2 depicts an anonymised and simplified example of how an analysis of individual participants' reported knowledge matched the knowledge the tutorial group jointly presented in the examination task regarding group development. The students in the tutorial group had each, in their respective IRP, reported acquired knowledge on a variety of group development theories (illustrated in the figure with the names of the originators). Some of these theories and research findings (but not all) were then reused to solve the examination task. In the left part of the figure, the students' acquired knowledge and research findings on group development theories are presented on the basis of the originators of each theory. The arrows depict how the knowledge from each student partially matches the theoretical and analytical knowledge needed to answer the group's problem formulation.

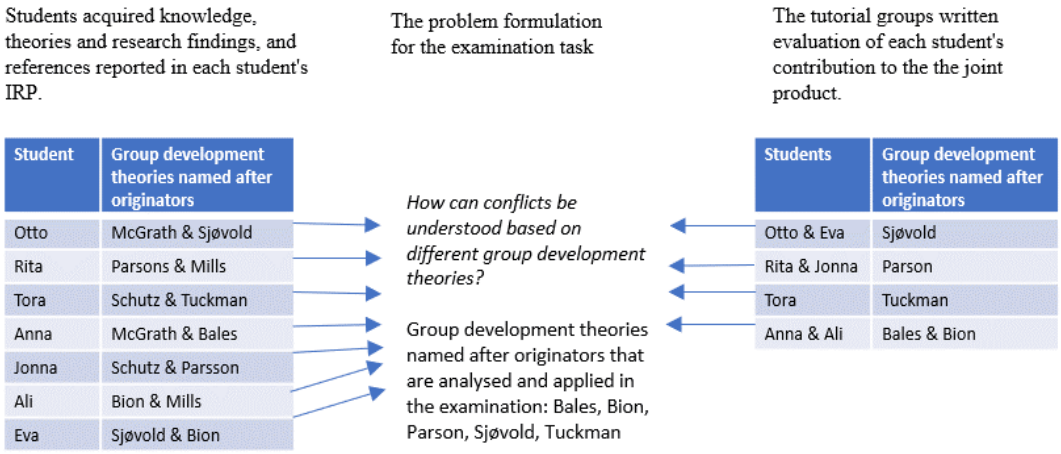

Figure 2. Assessment process, including information from students' individual reflection papers (IRPs) and the tutorial group joint evaluation (modified to maintain integrity for the participants).

In that way, I was able to determine the extent to which each of the group members had opportunity to contribute newly acquired knowledge to the content of the examination.

Overall, the completed IRPs clearly showed concurrence between the students' acquired and requested knowledge on the examination. On a few occasions, however, it was difficult to find the connection between single IRPs and possible knowledge contributed to the examination. On these occasions, I turned to the group's written evaluation of the group's work and process during the day (i.e., the last part of the task; see Figure 1). The group's

evaluation generally included a brief account of how the work was structured; whether there were any formal roles and, if so, who held the role; and, if the task had been divided, who contributed with which part and how the collaboration worked during the day. A discussion of each person's knowledge contribution and how the group and the group's work functioned during the day was also included. The following excerpts are examples from three anonymous tutorial groups.

> We started by appointing a chairman and secretary to facilitate the brainstorming and the design of the question. The IRPs from the previous vignette were the basis for formulation of the question and distribution of the tasks during the day, so that everyone would be able to contribute with the knowledge we [had] gathered during the course. (Anonymous Tutorial Group 1)

> The cooperation in the group has been perceived to have worked well, with clear and open communication which facilitated layout and structuring. Everyone in the group was well prepared which made the writing itself efficient as not too many new sources were needed . . . we had elaborated and informative IRPs available. (Anonymous Tutorial Group 2)

> In the theory part, everyone contributed with a paragraph on selected theories and models. Otto and Eva described Sjøvold's theory, Rita and Jonna wrote about Parson's theory, Tora described Tuckman's theory and finally, Bales and Bion's theory was defined by Anna and Ali. The division was determined based on what each individual member had chosen to focus on in his IRP around the theme. (Anonymous Tutorial Group 3, modified to match the example in Figure 2)

The right column in Figure 2 shows how the tutorial group in the example divided the work of analysing and writing relevant theories and research findings reported in the examination task into subgroups. Each of the subgroups contributed knowledge based on their own experience in the course (illustrated by the arrows), and together all four subgroups added to the joint knowledge contribution and thereby completed the assignment.

The evaluations from tutors (2021) and the students' regular course evaluations (2020–2022) at the course level mainly concerned findings about the use of IRPs in general in the course. However, there were a few relevant feedback statements from teachers and students. For instance, the tutors highlighted that 'the students' knowledge contribution to the discussions in the tutorial groups could be more extensive than is addressed in the IRP'. The students were more frustrated with the connection between individual IRPs submitted during the course and the group examination: 'There was a lack of clarity about how [the

IRPs] should be connected to the group examination'. The students expressed that how clearly linked the IRPs would have been to the examination was a bit unclear.

Discussion

These results show that the use of IRPs can be a new approach to assess students' individual knowledge when using group examinations (Djikstra et al., 2016; van Aalst, 2013). Hence, this study shows that it is possible to manage the paradox of facilitating collaborative and joint learning while fulfilling the requirements in higher education of individual assessment (Hammar Chiriac & Forslund Frykedal, 2023). Having said that, I would like to point out that there are challenges using group work assessment regardless of the pedagogical method. A recurring challenge for teachers using group work assessment is to be able to discern and collect empirical evidence for individual students' knowledge from the group's jointly shared knowledge (Dijkstra et al., 2016; Forsell et al., 2021; Meijer et al., 2020). Other prominent challenges are the risk of creating competition instead of collaboration between the students or assessing student's participation or contribution instead of knowledge (Hammar Chiriac & Forslund Frykedal, 2023).

By evaluating each student's submitted IRP and the students' joint evaluation in the group examinations, where they problematise knowledge contributions, collaboration, and their work and progress during the day (cf. Hmelo-Silver, 2004; Johansson et al., 2012 Rosander & Hammar Chiriac, 2016; Underwood, 2003), I obtained empirical evidence from two different levels and sources: (a) on an individual level, from each student's IRP, and (b) on a group level, from the tutorial group's joint written account. Together, these provided a good foundation for determining each student's potential for engagement in theoretical and analytical knowledge contribution to the group's shared product. It is important to remember that I was able to determine only whether the student had the potential for individual engagement and knowledge contribution based on the knowledge reported in the IRP and the group examination, not whether the student actually had been engaged and contributed knowledge.

The few statements of feedback from teachers and students that conceptualised their apprehension of reusing IRPs as a means for group work assessment in group examinations highlight some considerations to keep in mind. Because the IRPs were restricted in length, the teachers were concerned that students' knowledge contribution could be more extensive than conveyed in the IRP. Theoretical and analytical knowledge that becomes visible in the collective

discussion and learning (cf. Azer & Azer, 2015; Yew & Goh, 2016) may not count in comparison between the submitted IRP and the group examination. The students were frustrated over the ambiguity about the link between individual IRPs submitted during the course and the group examination. A possible interpretation is that the students were worried about the fairness of the group work assessment (Orr, 2010) if their respective IRP as not considered in connection with the group outcome.

Conclusions and Significance

The findings from this study contribute to science with their implication that it is possible to combine joint learning in tutorial groups with individual assessment. These results are promising and suggest that IRPs can act as a means to support individual assessment in group exams in PBL and, by extension, facilitate the use of group examinations in PBL. A pedagogical implication from this study is that using tutorial groups as a pedagogical tool in PBL in higher education does not only give students an excellent opportunity for joint in-depth learning and helps them develop the collaborative skills demanded by society but also opens for the possibility of using group examinations as a basis for assessment and additional opportunities for joint learning.

References

Abrandt Dahlgren, M., Dahlberg, J., Ekstedt, M., Lind Falk, A., Sjögren, E., & Törnqvist, T. (2016). *PBL-guiden: En handbok för problembaserat lärande vid Medicinska fakulteten* [The PBL guide: A handbook for problem-based learning at the Faculty of Medicine]. https://docplayer.se/32808445-Pbl-guiden-handbok-i-problembaserat-larande-for-studenter-och-larare-vid-medicinska-fakulteten.html

Azer, S. A., & Azer, D. (2015). Group interaction in problem-based learning tutorials: A systematic review. *European Journal of Dental Education 19*(4), 194–208. https://doi.org/10.1111/eje.12121

Barnett, R. (2012). Learning for an unknown future. *Higher Education Research & Development 31*(1), 65–77. https://doi.org/10.1080/07294360.2012.642841

British Psychological Society. (2014). *Code of human research ethics*. https://www.bps.org.uk/news-and-policy/bps-code-human-research-ethics-2nd-edition-2014

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

Forsell, J., Forslund Frykedal, K, & Hammar Chiriac, E. (2021). Teachers' perceived challenges in group work assessment. *Cogent Education 8* (1). https://doi.org/10.1080/2331186X.2021.1886474

Hammar Chiriac, E., & Forslund Frykedal, K. (2023). Individual group work assessment in cooperative learning: Possibilities and challenges. In R. Gillies, N. A. Davidson, & B. Mills (Eds.), *Contemporary global perspectives on cooperative learning* (pp. 94–108). Routledge. https://doi.org/10.4324/9781003268192-10

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

Johnson, D. W., & Johnson, F. P. (2013). *Joining together: Group theory and group skill* (11th ed.). Allyn & Bacon.

Johnson, D. W., & Johnson, R. T. (2014). Cooperative learning in the 21st century. *Annals of Psychology*, *30*(3), 841–851. https://doi.org/10.6018/analesps.30.3.201241

Johansson, M., Sandén, P., & Johansson, A. (2012). Individuella basgruppsunderlag: Ett verktyg för synliggörande av individuell kunskapsinhämtning och bearbetning samt reflektion i basgruppsarbetet [Individual reflection paper: A tool for making visible individual knowledge acquisition and processing as well as reflection in tutorial group work]. In *CUL-Rapport 16* (pp. 122–136). Linköpings Universitet.

Johansson, M., & Svensson, T. (2019). Individual reflection paper—Supporting students learning in the critical phase of self-directed learning in PBL. *Journal of Problem Based Learning in Higher Education*, *7*(1), 97–106. https://doi.org/10.5278/ojs.jpblhe.v7i1.2418

Jones, S. (2013). Using problem-based learning for the acquisition of psychological knowledge and understanding. *Psychology Teaching Review*, *19*(2), 38–48. https://doi.org/10.53841/bpsptr.2013.19.2.38

Meijer, H., Hoekstra, R., Brouwer, J., & Strijbos, J. (2020). Unfolding collaborative learning assessment literacy: A reflection on current assessment methods in higher education." *Assessment & Evaluation in Higher Education 45*(8), 1222–1240. https://doi.org/10.1080/02602938.2020.1729696

Moallem, M., Hung, W., & Dabbagh, N. (Eds.). (2019). *The Wiley handbook of problem-based learning*. Wiley. https://doi.org/10.1002/9781119173243

Orr, S. (2010). Collaborating or fighting for the marks? Students' experiences of group work assessment in the creative arts. *Assessment & Evaluation in*

Higher Education, *35*(3), 301–313. https://doi.org/10.1080/02602931003632357

Rosander, M., & Hammar Chiriac, E. (2016). The purpose of tutorial groups: Social influence and the group as means and objective. *Psychology Learning & Teaching*, *15*(2), 155–167. https://10.1177/1475725716643269

Savin-Baden, M., & Howell, C. (2004). *Foundations of problem-based learning*. McGraw-Hill Education.

Steel, A., Higgins, A., & Laurens, J. (2014). Valuable learning, unwelcome assessment: What LLB and JD students really think about group work. *Sydney Law Review*, *36*(2), 291–221. https://ssrn.com/abstract=2484379

Swedish Research Council. (2017). *Good research practice*.

Underwood, J. D. M. (2003). Student attitudes towards socially acceptable and unacceptable group working practices. *British Journal of Psychology*, *94*(3), 319–337. https://doi.org/10.1348/000712603767876253

Tan, J. P-L., Choo, S. S., Kang, T., & Liem, G. A. D. (2017). Educating for twenty-first century competencies and future-ready learners: research perspectives from Singapore. *Asia Pacific J. Education 37*(4), 425–436. https://doi.org/10.1080/02188791.2017.1405475

van Aalst, J. (2013). Assessment in collaborative learning. In C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, & A. M. O'Donnell (Eds.), *The international handbook of collaborative learning* (pp. 280–296). Routledge.

Wiggins, S., Hammar Chiriac, E., Larsson Abbad, G., Pauli, R., & Worell, M. (2016). Ask not only "What can PBL do for psychology?" but "What can psychology do for PBL?" A review of the relevance of problem-based learning for psychology teaching and research. *Psychology Learning & Teaching*, *15*(2), 136–154. https://doi.org/10.1177/1475725716643270

Yew, E. H. J., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health Professions Education*, *2*(2), 75–79. https://doi.org/10.1016/j.hpe.2016.01.004

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How to Become the Instructive Fool

Supervising Planning Students at a PBL University

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Abstract

This paper explores how the concept of "the facilitator as a fool" can be used as a guiding principle for supervising students at universities adhering to problem-based learning pedagogies. With the example of students enrolled at spatial planning studies, the paper argues that students should learn how to face uncertainty and take matters into their own hands. For this purpose, the paper proposes that supervisors act as "fools" in their conversations with students, mimicking a reflective practice. The paper reflects on how this concept fares when applied to a real-life situation of supervising planning students at both Bachelor's and Master's levels at Aalborg University in Denmark. In the end, the paper concludes that the applied concept can work to a certain degree, but it also requires a supervisor who is familiar with the theoretical and methodological "landscape" that students need to navigate in, and through, to become professional and reflective practitioners.

Keywords: Sustainable education, urban planning, wicked problems.

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Introduction

The idea of problem-based learning (PBL) at Aalborg University (AAU) is manyfold, but some of the core ideas behind are student-directed learning through working collaboratively in groups with real problems (Askehave et al., 2015). Opposed to the idea of responsibility for own learning, there is, inherently at learning institutions, a natural process of cultivation and formation of students (Feilberg, 2018), towards becoming professionals within a specific field. The dichotomy between self-directed learning and intentional cultivation of "ways of thinking", could be considered paradoxical. However, it seems natural for the lecturer to provide knowledge and guide learning through courses. During group work however, the roles shift so "the students are largely free to choose the content of their own projects, and thus to determine key elements of their study programme" (Askehave et al., 2015, p. 5). This also implies that the supervisor respects this responsibility that the students have, which then poses new dilemmas for the supervisor and raises questions of how to supervise someone who is responsible for their own learning and should essentially be free to choose their own path? In addition, a lecturing approach to supervision is often not appropriate in PBL situations as knowledge and answers are not necessarily given a priori. An approach to supervision that motivates students to take responsibility for their own learning seems to be needed.

In this paper, I will therefore consider the question of how the concept of "the facilitator as a fool" (Savin-Baden, 2020a) can work as a supervision metaphor. A fool can resist norms and conventions and create emergencies that mobilize thought and action (Stengers, 2005) amongst students. For this reason, the concept of the fool seems appropriate to explore. I explore this question on two groups of civil engineering students enrolled at spatial planning programmes at Aalborg University's Department of Sustainability and Planning.

Theoretical Concepts and Metaphors

A fool, or court jester in the Shakespearean sense, is a wise fool. On the outset, fools might seem like a simple feat of satire but are rather pointed comments on society and present different world-views than the dominant (Ellis, 1968). The fool does not show true colours but rather shapes personality according to context, to challenge perspectives or stay silent when needed. To Savin-Baden (2020a, p. 9) the fool supervisor, prevents "the sanitation of pedagogy" by being "background noise" and is both absent and present, contesting knowledge claims and by that prompting the students to engage in imaginative and

rigorous problem-making. The concept of liminal tunnels can offer additional perspective on the role of the instructive fool.

The Idea of liminal tunnels as a pedagogical concept describes how threshold concepts can act as gateways to learning processes consisting of liminal space (Land et al., 2014; Savin-Baden, 2020b). The emergence from the tunnel represents how the learner comes out on the other side with a shift in perspective and even on a deeper level, a shift in subjectivity and thereby a shift in the learners' ontology and epistemological nature. Only when new concepts are understood and transferrable to the context in which the student works, can they change the knowledge regime and change perspective on the landscape that students see and operate in. The transition phase is essential in this concept, it proposes a phase – a liminal stage – in which uncertainty and confusion arise. Because existing knowledge regimes have been challenged and the landscape is blurred, students are forced to reflect and learn to see anew before they can emerge from the tunnel and see clearly again.

Various forms of planning have lately been described as socio-ecological practices involving the negotiation of value and knowledge through processes of implementing solutions (Forester, 2020). This line of thinking started with Rittel and Webber (1973) who proclaimed that "planning problems are wicked problems". Among the main features of wicked problems, they find unique character, difficulty to define, symptoms of other problems and that there is no real solution. They contrast such problems to the "Newtonian mechanistic physics" which modus operandi is not readily adaptable to the planning arena, that is essentially social and political and consists of open systems (Rittel & Webber, 1973). Such problems require reflective planners who can, when faced with uncertainty and wickedness, alter course and deter from what was the proscribed direction from the beginning. Schön (1983) described this as reflection-in-action, which is the competence of thinking about what you are doing while doing it.

That there are no "fixed" or "right" solutions to a wicked problem, also reveals that supervision of planning students, or other students concerned with socio-ecological problems, should not and cannot be about telling students what to do, when to do it, how to do it, or why they should do it. These arguments should be put together by the students themselves, but the students need the supervisor to guide them in how to learn, and how to reflect-in-action. Being a fool means to question the students' approaches, make them reflect and to lead them towards threshold concepts. The approach is nevertheless unstructured in contrast to other questioning approaches. E.g. Wichmann-Hansen and Jensen (2015) propose a questioning approach structured through phases of clarifying, exploring, challenging, and evaluating. In their approach, supervisors need to

be clear academic authorities by among other correcting, arguing, and making use of clear scientific criteria and advice, when needed. Such "authority" would contrast the ambition of a facilitator as a fool, as it should rather confuse, spark reflection, instigate discussions and make students act as the authority. As wicked problems do not have fixed solutions, the right question of the fool is therefore not necessarily an invitation to dialogue in which the supervisor lecture or eventually give answers, but to make students question their own approach and discuss amongst themselves, forcing them to make their own decisions.

Method

During spring 2022, I supervised two groups, one group of four, writing their bachelor thesis in the Urban, Energy and Environmental Planning programme and another group of three, writing their second semester report on the master's programme in Urban Planning and Management. Both programmes are located at Aalborg University. On these two groups, I experimented with the concept of the supervisor as a fool. Both groups were made aware of the experiment at the start of the semester.

The experiment entailed a consciousness about being the fool, which in practice resulted in asking reflective questions rather than giving answers. Likewise, the idea of liminal tunnels was a background and something that I could rely on in supervision sessions – knowing that students would experience uncertainty and confusion in learning situations when grappling with and applying new gateway concepts (Land et al., 2014). After each supervision session, I wrote down my own reflections on how the approach fared.

After the project exam, the students were by email sent a questionnaire with open-ended questions, to make them reflect individually on the supervision process. This allowed the students to respond more freely and without fearing repercussions during the exam and thereby it heightened the quality of the data, and the quality of the data is thereby considered good. Seven students had the opportunity to answer and six returned the questionnaire. By asking questions related to students' opinions on being asked questions rather than given answers and how the uncertainty that might arise amongst students was experienced, the purpose of the questionnaire was to know more about how students perceived of this style of supervision.

Results

First, the results will be presented as a reconstruction of supervision sessions. The aim is to give a condensed example of how I acted in supervision sessions. The example should be considered "second-best" as I do not have recordings of supervision sessions. Length limits only allows me to include one reconstructed example. Second, some of the responses from the students will be shown.

Reconstruction of Supervision

Student: We are thinking about doing a project where we want to investigate the new Limfjord connection (road bridge across the local fjord). There has been a lot of debate about the crossing and many people really seem to be upset about it finally being approved, they complain about the loss of nature and increased car traffic and noise, but the politicians do not seem to be listening to these voices. It seems like a predetermined process. The politicians use these traffic models that tell of the need for the crossing, in terms of congestion and it also shows that the construction will be economic viable. The citizens can then complain through the official hearing period, but the politicians do not need to consider the complaints or the voices of the people. We even found some people that argue that the traffic models and socio-economic calculations are not right because they do not take into account CO2 emissions in a correct way and that it leaves out some consequences to nature, some of these arguments even come from experts, like there was a professor and also a road engineer who used facts to argue against the connection. So, do you think it is possible to write a project about this?

Supervisor: But what is it exactly that you want to write about? What do you consider to be the main problem?

Student: Well, we think there is something about the power relations between the citizens and the politicians or the different actors that are in favour of the new connection – this is mainly the businesses and there is also a business network set up by the municipality that are also in favour of the connection. So, it is mainly about the power relations…

Supervisor: Great, what is it that you think is at stake here, when we talk about power relations in planning?

Student: … ehm, well we think that…. it is a really complex case…. There are many actors who seem to argue against the connection, why are they not heard? And the planners seem to just follow what is decided by the politicians…

Student: Yeah, so maybe it is a democratic problem if the planners just decide something that people do not want…. …

Supervisor: You say it is a democratic problem, but since the politicians who are in favour of the connection, they are elected by the people, and I guess that they follow the regular procedures of planning, so I'm still a bit in doubt about what the problem actually is?

Student: It just seems like the politicians took the decision a long time ago and then they build their arguments to support this decision, disregarding other peoples' or even experts' arguments, based on facts…

Supervisor: Facts are the first victims in conflict! What does the planner do with facts in a democratic process?

Student: Well, I guess we need to think on this until next time we meet.

In the above reconstructed first supervision session, the students try to explain to the supervisor, what problem they are working with. It is often the case during the first supervision session(s) that the students are confused about the topic. They just started a new semester and are introduced to many new concepts, themes, methods, etc. and they struggle to grasp problems that should be defined or explained in concepts that are new to them. In this sense, they are already inside a liminal tunnel when the supervisor meets them the first time.

During the first sessions, the main task for the supervisor is to make the students think about what type of problem they are working with. Being students at a PBL university, the problem needs to be defined/described as it will be the guiding principle throughout the project. This might result in a feeling of uncertainty by the students, but the result will be that if they feel uncertain, and if they are ambitious students, they will try to resolve this uncertainty, by finding the answers through the project work.

When the students get stuck, as they are asked about how it is a problem that relates to power, the supervisor returns to the more commonly known problems about democracy but also about different opinions in a debate, or rather how different arguments are put forth by different actors in a planning process. In this project, the students will work with the concepts of power and discourse as gateway concepts. The supervisor might have an agenda of leading the students towards working with the problem of how planners deal with or create visibility of diverging discourses and agonistic agendas coming from different actors. It might not be the case that the students will choose this problem, but the supervisor knows this is "a way out".

Feedback from Students

In this section, I turn to the feedback that students were asked to do after they had their project exams. The purpose of this section is to better understand how students perceive of the style of supervision.

Much of the feedback revolves around the dilemma between having to take responsibility to answer your own questions, to solve your own problems and then the desire of having a supervisor who can give you the answers. Below is a quote that show this dilemma.

> "A supervisor who does not give answers can give more space for reflections and give the group a greater degree of independence because you realize that you cannot lean on the supervisor and therefore the group begins to carry and shape the project itself. On the other hand, it can be quite frustrating to work with because you don't get any real answers to your questions, I feel that it can sometimes seem more confusing than clarifying. Which may also be the point, but it's a frustrating way to work when you expect otherwise anyway."

As indicated in the above quote, some of the students also reflect on whether such supervision strategy is positive to their own learning process.

> "Yes, at the beginning it was ok since you had not defined the project, but as the project progressed and you felt that you as a group needed to make a choice between 2 directions and got questions back on your own questions, it was quite frustrating. In the end, I felt that the supervision meetings were a waste of time. Perhaps it is good because you have become more independent, which was probably the aim of the supervisor."

The students see the supervision where a question is met with a question as ambiguous. In the end, they seem to appreciate that this type of supervision might force them to take more responsibility towards their own project and learning. It nevertheless feels frustrating to some of the students and some even decide that the supervision sessions might not be very helpful.

> "Significantly less guidance than I have been used to before. This may be because the supervision style may have influenced our understanding and strategy in relation to how we intended to use our supervisor. As we did not receive concrete answers to our concrete questions, we agreed in the group that we had to try to answer these ourselves, which had both advantages and disadvantages. It would have been an advantage if we in the group had discussed and agreed on how

> the selected guidance style could best complement our project – instead, we down-prioritized guidance and had more internal discussions."

The above quote reveals that if the right premise about the supervision style were given from the start, it might have led the students to not expect a supervisor that gives the answers, and they might have utilised it more.

To some extent, the students also feel that the supervision leaves them insecure about what they must do. During the supervision sessions, they might feel "well dressed" but by the time they must follow up on the supervision, they again can feel confused, because there was no right direction given.

> "I don't think that you were left without being well dressed after the supervision meeting, but there were times when the guidance 'forced' us to reassess our material ourselves."

> "I think that you can feel a little uncertain about how to proceed. Often you come up with specific problems that prevent you from being able to continue in the project and an unspecific answer is of limited help. You often think in the supervisor meetings when you get these questions, it makes good sense, but when you have returned to the group, you become unsure of what it actually meant, and you end up in the same situation and have to test yourself."

Discussion and conclusion

Students who are faced with a "facilitator as a fool" seem to react with ambiguity in two ways. One is the fact that they must learn and take responsibility themselves, they must act as professional reflective practitioners. The students grow with their new role and their perceptions of being students and what it takes to become independent professionals are challenging and uncertain. This uncertainty additionally links to the idea of liminal tunnels, where concepts or problems are, at first, considered as dark places that might not lead anywhere, but, as the supervisor knows, the students will eventually find their way towards the light and define challenges, learn new concepts, and resolve problems. This type of frustration should therefore be considered positive and necessary. The second aspect is that this style of supervision is not clearly defined, and their own role is not clear to them. This might be considered as a negative frustration and should be dealt with by the supervisor by being clearer about this division of roles.

There might be different phases to supervision when the supervisor as a fool is more suitable than others. During the first semester of the Bachelor, some basic

concepts need to be learned and therefore the same intensity of the supervisor as a fool, as can be enacted at a later stage of the education, might not be possible. Likewise, this should also be considered during the semester from start to finish. At the beginning of the semester, when the problem is less well defined it might be suitable to question everything, which might not be the case a few weeks before hand-in.

By asking questions and forcing the students to take responsibility of their own thinking and choices, this type of supervision also serves as a formattable exercise towards the exam, when the students will have to defend their project and be able to answer the exam questions. However, it also requires a supervisor that is familiar with the theoretical and methodological curriculum that students need to navigate in, and through. Having a supervisor who forces the students to continuously work with and improving answering stupid questions, is a facilitation of the formation process towards becoming professional reflective practitioners who are comfortable and experienced in liminal tunnels.

References

Askehave, I., Prehn, H. L., Pedersen, J., & Pedersen, M. T. (2015). *PBL. Problem-Based Learning*. Aalborg University. https://prod-aaudxp-cms-001-app.azurewebsites.net/media/mmmjbthi/pbl-aalborg-model_uk.pdf

Ellis, R. (1968). The Fool in Shakespeare: A Study in Alienation. *The Critical Quarterly*, 10(3), 245-268. https://doi.org/10.1111/j.1467-8705.1968.tb01984.x

Feilberg, C. (2018). Skjulte kræfter og processer i vejledningsrummet - dannelsesperspektiver på projektarbejde og projektvejlederrollen ved universiteterne. *Psyke & Logos*, 38(2), 134-158. https://doi.org/10.7146/pl.v38i2.104013

Land, R., Rattray, J., & Vivian, P. (2014). Learning in the liminal space: a semiotic approach to threshold concepts. *Higher Education*, 67(2), 199-217. https://doi.org/10.1007/s10734-013-9705-x

Rittel, H. W. J., & Webber, M.M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences*, 4(2), 155-169. https://doi.org/10.1007/BF01405730

Savin-Baden, M. (2020a). What Are Problem-Based Pedagogies? *Journal of Problem-Based Learning*, 7(1), 3-10. https://doi.org/10.24313/jpbl.2020.00199

Savin-Baden, M. (2020b). Learning Ecologies - Liminal states and students transformation. In N. Jackson; R. Barnett (Eds.) *Ecologies for Learning and Practice - Emerging Ideas, Sightings, and Possibilities* (1st ed., pp. 46-60). Routledge. https://doi.org/10.4324/9781351020268-4

Schön, D. A. (1983). *The reflective practitioner*. Basic Books.

Stengers, I. (2005). The Cosmopolitical Proposal. In B. Latour & P. Webel (Eds.), *Making Things Public*, 994-1003. Cambridge, MA: MIT Press.

Wichmann-Hansen, G., & Jensen, T.W. (2015). Supervision: Process management and communication. In L. Rienecker, P.S. Jørgensen, J. Dolin, G.H. Ingerslev (Eds.), *University Teaching and Learning*. Samfundslitteratur.

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Revitalizing Pedagogy in a Medical Problem-Based Learning (PBL) Curriculum

Findings, Methodology, and Recommendations from a Systematic Self-Assessment

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Abstract

The Medical Programme at Linköping University, committed to Problem-Based Learning (PBL) and interprofessional education, confronted the necessity for pedagogical revitalization due to an upsurge in student numbers, alterations in national physician licensing criteria, and an organizational framework shift. In response to these challenges, stakeholders conducted a comprehensive systematic self-assessment to navigate a course toward a sustainable and contemporary pedagogical transformation.

The methodology employed in this assessment involved a systematic examination of scientific pedagogical literature, policy documents, educational materials, and schedules. Additionally, valuable insights were gathered through teacher and student surveys. Key findings underscore the importance of a balanced approach that grants students more time for self-study and reflection. Enhancing tools and methodologies for constructive alignment is

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crucial to achieve equilibrium in both theoretical and practical training settings. Moreover, establishing seamless collaborations between the university and teaching hospitals is deemed essential for faculty development and the long-term competence within both organizations.
The self-assessment underscored the critical importance of continuous evaluation in medical educational settings. The approach not only ensures the ongoing relevance of the curricula but also cultivates an environment conducive to student-centred teaching and learning. This, in turn, prepares students for lifelong learning and the diverse challenges in their future medical profession.

Keywords: Medical Education, Curriculum Development, Lifelong learning, Sustainable pedagogy

Pedagogical framework

History

Linköping University (LiU) was established in 1975, and its dynamic current vision is "LiU - with the courage to think freely and innovate" (https://liu.se/en/about-liu/vision-and-strategy). Since its foundation in 1986, the Medical Programme at LiU has consistently been at the forefront of adopting and promoting Problem-Based Learning (PBL) (Barrows, 1980; Boud, 1998) as a student-centred pedagogy in Sweden (Dahlberg et al., 2020). LiU was also the first medical faculty in Europe to implement student-led interprofessional training wards for undergraduate students (Wahlstrom et al., 1997). Interprofessional approaches are now deemed fundamental in international modern medical education ((WHO), 2010). As time progresses, it is imperative to continually adapt pedagogical methods to align with the evolving needs and values of the surrounding society.

Local Pedagogy

The pre-clinical semesters of the current PBL curriculum in the Medical Programme are organised around recurrent scenario-based tutorial group sessions. The tutorials serve as the nave of the learning process. Lectures, seminars, and other scheduled learning modalities are aligned, intended to support students' learning. Locally, the tutorials are referred to as *base groups,* signalling the importance of the groups as the homebase and backbone of students' learning. Tutorial groups meet twice a week, to support students' self-directed study towards intended learning objectives. Students become well-versed in PBL, and the Base group format transitions into weekly illustrative patient cases, during clinical placements. Examinations occur most often at the

end of the semesters and include formats that enable assessment of both basic medical knowledge and the ability for applied reasoning and problem-solving, which aligns well with the fundamental principles of the pedagogy (van der Vleuten & Schuwirth, 2019).

Medical Programme, Linköping University

- Founded: 1986
- Student capacity: 1200 (1300 in 2027)
- University employed teachers: 95
- Affiliated teachers: 80
- Number of clinical study sites: 4 campuses, 9 hospitals, 107 primary care units

Figure 1. Programme Specifications.

Current challenges

Currently, the Medical Programme is facing the impact of external frame factors that influence the curriculum and delivery of the programme. 1) European Union strategies to enhance student and academic mobility have led to a new licencing procedure in Sweden, adding an extra semester as well as the necessity for a comprehensive restructuring of the curriculum. 2) the student enrolment has quadrupled, while the number of teachers has not increased proportionally. These new requirements were the incentives for a restructuring of the organizational and pedagogical framework of the programme. The Medical Programme became subject to a process of regionalization 2017-2021, and three new campuses were established within the Swedish south-eastern healthcare region, aiming to provide the required number of high-quality clinical placements. Specifications of the medical programme are illustrated in Figure 1. These multifaceted challenges also called for a self-critical examination of the programme's educational design and delivery in a problem-based environment, to a) identify the impact of the current challenges on the conditions for learning, and b) suggest strategies for development and improvement. The structure of the process of the self-assessment, our findings and insights are discussed in this article.

Context and implementation

Theoretical framework

In this paper, the educational planning and professional learning in medical education involve several stakeholders. Faculty leaders and programme directors, students, teachers, researchers, and clinicians are deeply involved in the planning and delivery of the programme and are also immersed in the prevailing approach to teaching and learning. The theoretical framework for this self-evaluation of the educational arrangements in use in the medical programme can be described as combining two fundamental features. The first feature is the *problem-based teaching and learning approach* applied in all programmes of the Faculty of Medicine and Health Sciences. A problem-based approach has been in place since 1986, building on a social constructivist perspective on learning and educational reform, where knowledge is created in interaction between the learner and the social and cultural environment, including other learners (Doolittle 2014; Walker & Shore 2015).

The second feature is the one of *stakeholder engagement*, which is a construct stemming from business and society research (Kujala et a.,l 2022). Stakeholders are in this field of research widely understood as individuals, groups or organizations that affect or are affected by organizational activities. Kujala et al show that organizational activities can comprise many aspects, of which some examples are value creation, strategic planning and decision-making, innovation, learning and knowledge creation (2022). The forming of task forces and collaborative workshops during the process can be seen as a way of materializing our theoretical framework in practice.

Implementation

The leadership and key personnel of the Medical Programme initiated a structured and collaborative bottom-up approach to the self-assessment. The starting point for the collective examination of areas in need of improvement was a workshop, designed to ensure diverse and comprehensive representation and involving more than 50 participants within the faculty. Attendees included the Dean, programme and deputy programme directors, student representatives, teachers, course coordinators, and representatives of the medical subjects for the programme. A systematic approach was adopted starting with brainstorming sessions, problem identification, followed by subsequent prioritization. Through a structured process, a SWOT (Strength-Weakness-Opportunities-Threats) analysis was conducted, leading to the crystallization of the three prioritized areas of *Attractivity, Teacher perspective*, and *Content and Quality*. Under each of these prioritized areas several task forces with specified assignments were established and were collaborating within the

specific prioritized area. An executive board was assigned to design and oversee the self-assessment and define assignments for the task forces (Figure 2).

Faculty members and student representatives, with relevant expertise to each theme, were enlisted to the ten task forces involving 42 participants in total. The assignment was to conduct in-depth analyses of the three main prioritized areas and, based on available scientific evidence, suggest development strategies. Regular written reports were submitted to the executive board to facilitate transparent communication and decision-making. Feedback loops were established to ensure information dissemination to both faculty members and students. Each task force utilized a systematic approach where educational research, together with local policy documents, educational materials, schedules, and feedback from teachers and students in directed surveys and discussions were assessed. The methodology aimed to create a clear, academically solid strategy to sustainably develop the programme within the current context and the surrounding society. The bottom-up approach of the ten task forces, for instance, multiple instances of questionnaires and discussion to enhance the validity of the data, resulted in an average working time of 12 to 24 months extending from 2021 to 2023.

During the end of the working period, the task forces produced final reports of their findings including recommendations within their specific assignments. These recommendations were determined within the task forces based on consensus and thematic analyses (Braun & Clarke, 2006). The final reports were presented to the executive board. Due to the collaborative nature within the specific prioritized areas, several recommendations in the final reports were similar between the task forces. Accordingly, the executive board thematically grouped the task force results into recommendations within each specific prioritized area (Figure 3).

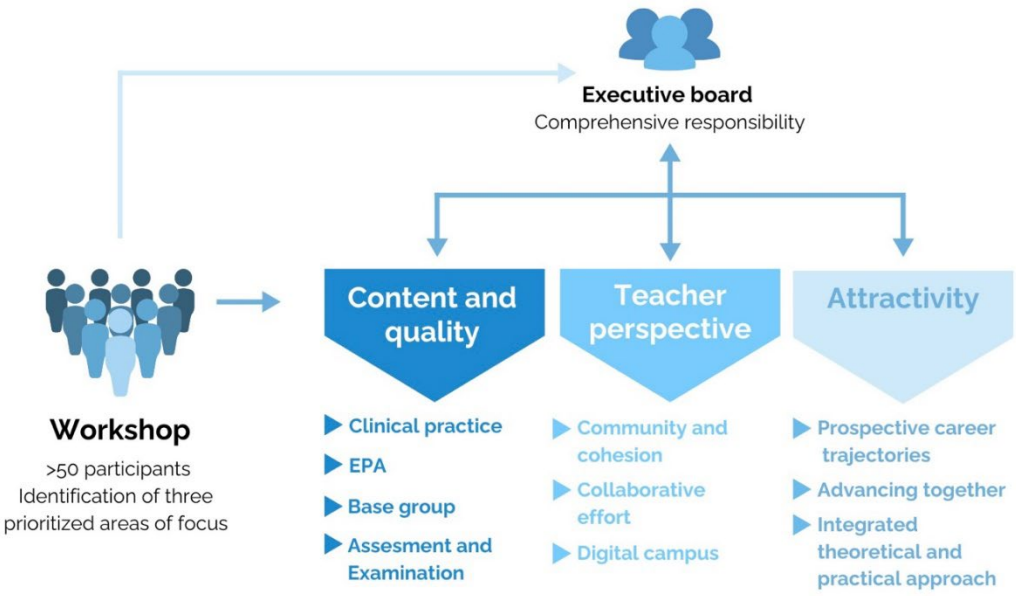

Figure 2. Structure of the systematic self-assessment. Under each of the three identified and prioritized areas, several important task forces were established and were collaborating within the specific prioritized area.

Evaluation and analysis

Key outcomes and recommendations from the systematic self-assessment within the task forces are summarized in Figure 3, areas according to the three main themes. In the following, the outcomes from the work with the three prioritized themes are exemplified.

Within the theme of *Content and quality*, an analysis of the scheduled time for complement learning modalities, especially in pre-clinical semesters revealed that students' time for independent study and reflection was delimited. A need of reducing teacher-lead modalities, such as lectures, within several subject-integrated themes of the pre-clinical semesters was identified. The need for a revised and clearly identifiable constructive alignment (Biggs, 1996; Biggs & Tang, 2011) between learning objectives, the problem-based learning activities and the assessments applied was also identified. This alignment would involve meticulously embedding objectives within the mandatory assessment components, ensuring that evaluations were both equitable and in tune with the educational content. An improved blueprint for learning objectives, enabling clarity and structure to facilitate alignment in the assessment process, was underscored. Furthermore, a broader spectrum of assessment formats, incorporating open-book tests, collaborative tasks, and realistic medical

scenario simulations, which would challenge students to apply their knowledge in diverse situations. In the context of clinical progression to national licensure level implementation of Entrustable Professional Activity (EPA) was due according to a national consensus (Gummesson et al., 2023). However, EPA have ((AAMC), 2014; Frank, 2015) to be thoroughly aligned with overarching learning objectives and integrated in the PBL framework. A steadfast communication strategy was suggested to disseminate assessment procedures and digital system guidelines, ensuring all parties are well-versed in the operational framework of the EPA system prior to and during implementation. To facilitate continuous pedagogical refinement, a dedicated faculty was proposed to oversee the implementation and evaluation of educational strategies, especially those pertaining to the clinical skills assessments. To compile these aspects, a new tangible model for formal assessment encompassing EPA, professional development, and clinical reasoning was proposed (Kogan et al., 2017). A new clinical mentorship program was also suggested to support students in learning to build a sustainable work-life balance.

Within the theme of *Teacher perspective*, the essentialness of the collaboration between LiU and the south-eastern healthcare regions was highlighted. The need for a joint process in recruitments and competence development to ensure that both the healthcare sector and the university benefit from recruitments was pronouncedly delineated, including clear career paths and career support regardless of employment. Furthermore, the importance of teaching experience being as meritorious as research was also distinctly highlighted. Enhanced support for key faculty members within the programme's pedagogical framework, such as improved training and assistance for base group facilitators, and the establishment of a more robust network and discussion forums for examiners, was also clearly emphasized. Additionally, digital competency and enhanced digital infrastructure harmonized with the programme's scaffolding and pedagogy were prominently highlighted.

In the theme of *Attractivity*, efforts within the program itself, including the creation of dedicated meeting spaces between teachers, students, and staff, were highlighted as essential to develop together and strengthen each other. In terms of the pedagogical principles, there was a clear indication that neither websites nor other sources of information sufficiently showcases the educational core values of the programme, both within the programme and to external parties and prospective students. The proposition that students should also wield greater influence and engage in discussion forums with the teaching hospitals, reminiscent of student participation in universities, was underscored as a distinct avenue for improvement. Similarly, the continual advancement of an integrated theoretical and practical approach was accentuated, serving as an

appealing aspect for the program per se and for the employability and self-reliance of the programme's graduating students.

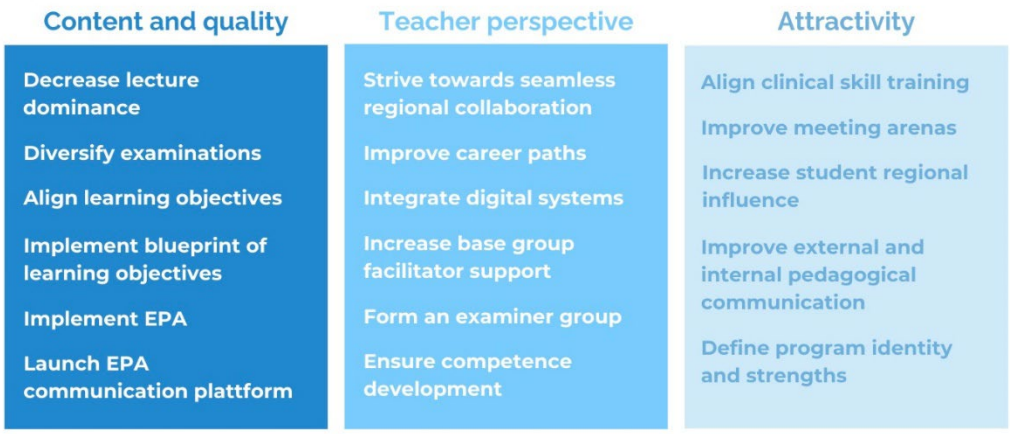

Figure 3. Resulting summarized key recommendations from the systematic self-assessment aligned with prioritized areas.

The undertaken self-assessment yielded significant insights into the programmes' pedagogical context and approaches and structural challenges.

One noteworthy finding pertains to the prevailing dominance of teacher-led learning activities within the programme's curriculum. An overloaded curriculum inevitably raises concerns regarding issues like restriction of self-reflection in a problem-based approach. However, while contributing to the overloaded curriculum, lectures and other teacher-led activities also offer crucial structured learning opportunities that facilitate understanding of essential complex subjects. The heart of the matter lies in striking a delicate balance between maintaining the flexibility of the curriculum and integrating lectures that reinforce rather than deteriorate PBL. An influential factor contributing to an imbalance could indeed be the strong influence of students within the university. The self-assessment revealed that an increasing number of lectures on specific subjects are frequently requested by students and their representatives. One plausible reason is when constructive alignment of the components of the programme is opaque, students might seek support for their learning merely within lectures, rather than relying on the intended problem-based learning design of the programme.

Lectures in a PBL programme should be a complement to the work in base groups, providing students the possibility to acquire knowledge presented by experts leading students to deeper discussions and problematization (Azer, 2009). Teachers' inclination to lecture intersects often with their own passion for the subject and with the student demands, potentially skewing the program towards a more teacher-focused layout. Acknowledging this paradox is critical

to be able to navigate towards a curriculum that benefits from both the educators' expertise and a genuine student-centred approach, without compromising the integrity of the intended PBL model. It is therefore essential to improve understanding of PBL and its effect on sustainability as a learner and as a future physician among both teachers and students.

To foster coherence and transparency in the curriculum for both students and teachers the knowledge and engagement in constructive alignment should be increased. The diversification of written assessments by incorporating open-book assessments, intricate group assignments, and simulated real-world scenarios demonstrates a commitment to evaluating students' capacity to apply their knowledge across varied contexts. In accordance, the problem-based approach becomes increasingly aligned all the way from Base group to assessments and examinations (van der Vleuten & Schuwirth, 2019). In clinical progression, the implementation of EPA, which is indicative of the competency-based medical education (CBME) model, harmonizes with the same principles in the realm of clinical skills assessment and progression toward licensure (Gummesson et al., 2023). However, the necessity of a robust communication strategy to effectively convey assessment protocols and digital guidelines highlights the complexity inherent in operationalizing the EPA framework within educational and clinical settings. It underscores the potential discrepancies that can arise when theoretical pedagogical models meet the practical realities of medical training and assessment. Moreover, the proposition of a comprehensive assessment model that integrates EPA, professional development, and clinical cases alongside an expanded supervisor program mirrors the literature's discourse on CBME (Hamza et al., 2023). The advantages of such integrative approaches are fostering a holistic and realistic assessment of a learner's capabilities, while also acknowledging the inherent challenges of implementing complex, multi-faceted educational strategies within diverse organizational contexts.

Problem-based learning and student-centred pedagogy, necessitate substantial expertise, a solid foundation in academic theory, and pedagogical proficiency amongst the faculty to ensure both a successful implementation and sustainment that addresses the complexities of educational challenges. The assurance of competence, and competence development, across the university, teaching hospitals, and faculty employment forms underscores the need for institutional support and interorganizational collaboration. Moreover, while easily advocating for several and improved fora, the mechanisms for sustaining such initiatives and the investment required in terms of time and resources frequently lead to organizational resistance to development. An increasing plethora of meeting fora across the organisational systems can prevent faculty and staff from working on core assignments and might play a significant role

in the challenge of unifying the organizations in collaborative development activities. It can be important to create explicit maps, matrices, and administrative flows detailing how decisions and discussions are taken between the university, teaching hospitals and students; and how all parties can ensure the highest possible quality of both future education and healthcare.

Recommendations

The analysis highlights several key observations that may prove valuable for institutions employing similar pedagogic principles or organizational history over a prolonged time span. The main conclusions from our critical self-assessment are: (1) PBL is challenging to grasp initially, but once students have acquired proficiency, they possess a tool that is (a) applicable throughout their entire professional career, (b) easy to apply in clinical contexts. (2) Significant deficiencies have been identified in (a) an overloaded curriculum that leaves little room for individual reflection; (b) lack of communication channels between the university and the teaching hospitals' management, impacting the quality of clinical supervision; (c) internal and external marketing, complicating community-building and student and faculty recruitment.

The conducted self-assessment underscores the critical importance of continuous evaluation in medical educational settings. While the findings have pinpointed several areas for refinement, they also emphasized the programme's strong commitment to a student-centred pedagogical approach. Based on the findings, we established new objectives for each area and began reshaping the profile of the medical program across all defined areas of interest. The significance of adopting a systematic approach to self-assessment for medical schools becomes apparent. The educational landscape is continuously evolving, shaped by technological advancements, social values, and the changing needs and characteristics of the modern learner. As such, educational institutions must remain agile and responsive to these shifts. By implementing systematic self-assessment approaches, institutions can ensure that all facets of their programme remain relevant and in tune with contemporary pedagogical needs. This approach guarantees that critical components are duly addressed and promotes consistency and thoroughness. By proactively determining their pedagogical standpoint, institutions can make more informed decisions that resonate with the contemporary educational landscape.

References

(AAMC), A. o. A. M. C. (2014). *The Core Entrustable Professional Activities (EPAs) for Entering Residency*. Retrieved 20 January 2024 from https://www.aamc.org/about-us/mission-areas/medical-education/cbme/core-epas

(WHO), W. H. O. (2010). *Framework for action on interprofessional education & collaborative practice*. Retrieved 20 January 2024 from https://www.who.int/publications/i/item/framework-for-action-on-interprofessional-education-collaborative-practice

Azer, S. A. (2009). What makes a great lecture? Use of lectures in a hybrid PBL curriculum. *Kaohsiung J Med Sci*, *25*(3), 109-115. https://doi.org/10.1016/S1607-551X(09)70049-X

Barrows, H. S. T., R.M. (1980). *Problem-Based Learning: An Approach to Medical Education*. Springer Publishing Company.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology. 3. 77-101. https://doi.org/10.1191/1478088706qp063oa

Biggs, J. B. (1996). Enhancing teaching through constructive alignment. Higher Education, 32(3), 347–364. https://doi.org/10.1007/BF00138871

Biggs, J & Tang, C. (2011). Teaching for Quality Learning at University. McGraw-Hill and Open University Press, Maidenhead.

Boud, D. & Felletti, G. (1998). *The Challenge of Problem-based Learning*. Routledge.

Dahlberg, J., Dahlgren, M.A., Ekstedt, M., Hammar, M., Falk, A.L. (2020). The Linköping Journey. In D. Forman, Jones, M., Thistlethwaite, J. (eds) (Ed.), *Sustainability and Interprofessional Collaboration.* Palgrave Macmillan, Cham. https://doi.org/https://doi.org/10.1007/978-3-030-40281-5_11

Doolittle, P. E. (2014). Complex Constructivism: A Theoretical Model of Complexity and Cognition. *International Journal of Teaching and Learning in Higher Education*, *26*(3), 485–498.

Frank, J. (2015). *CanMEDs 2015 physician competency framework. Royal College of Physicians and Surgeons of Canada*. Retrieved 20 January 2024 from https://www.royalcollege.ca/en/canmeds/canmeds-framework.html

Gummesson, C., Alm, S., Cederborg, A., Ekstedt, M., Hellman, J., Hjelmqvist, H., Hultin, M., Jood, K., Leanderson, C., Lindahl, B., Moller, R., Rosengren, B., Sjalander, A., Svensson, P. J., Sarnblad, S., & Tejera, A. (2023). Entrustable professional activities (EPAs) for undergraduate medical education - development and exploration of social validity. *BMC Med Educ*, *23*(1), 635. https://doi.org/10.1186/s12909-023-04621-6

Hamza, D. M., Hauer, K. E., Oswald, A., van Melle, E., Ladak, Z., Zuna, I., Assefa, M. E., Pelletier, G. N., Sebastianski, M., Keto-Lambert, D., &

Ross, S. (2023). Making sense of competency-based medical education (CBME) literary conversations: A BEME scoping review: BEME Guide No. 78. *Med Teach*, *45*(8), 802-815. https://doi.org/10.1080/0142159X.2023.2168525

Kogan, J. R., Hatala, R., Hauer, K. E., & Holmboe, E. (2017). Guidelines: The do's, don'ts and don't knows of direct observation of clinical skills in medical education. *Perspect Med Educ*, *6*(5), 286-305. https://doi.org/10.1007/s40037-017-0376-7

Kujala, J., Sachs, S., Leinonen, H., Heikkinen, A., & Laude, D. (2022). Stakeholder Engagement: Past, Present, and Future. *BUSINESS & SOCIETY*, *61*(5), 1136–1196. https://doi.org/10.1177/00076503211066595

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

Wahlstrom, O., Sanden, I., & Hammar, M. (1997). Multiprofessional education in the medical curriculum. *Med Educ*, *31*(6), 425-429. https://doi.org/10.1046/j.1365-2923.1997.00669.x

Walker, C. L., & Shore, B. M. (2015). Understanding Classroom Roles in Inquiry Education: Linking Role Theory and Social Constructivism to the Concept of Role Diversification. *SAGE Open*, *5*(4). https://doi.org/10.1177/2158244015607584