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

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Welcome to the first issue of the tenth volume of the Journal of Problem Based Learning in Higher Education. This is our annual issue and contains 4 research papers and 5 case studies. It is nice to see so many case studies in this issue because an important mission of the journal is the presentation and exchange of practices. Educators that try and explore and develop PBL methods and designs across the palate of university educations serve as an encouragement for all of us.

In this issue, the case studies come from a wide range of faculties such as STEM-disciplines, medicine, social sciences, and humanities and they are from different parts of the world. Each case is a concrete example of how PBL may be implemented in practice, and reading them can be inspiring, and gives good insight into the pitfalls and limitations of such initiatives.

Research into PBL is equally important, and the core of any academic journal. This issue includes four scholarly papers. Each paper adds a valuable contribution to the research field of PBL in Higher Education. Their focus and methods are different, but core components of problem-based learning are addressed, such as group collaboration and supervision, and multidisciplinary challenges and opportunities. There are also more contemporary themes of transitions to online formats, and classic pedagogical tasks of course design addressed in the papers. It is our belief that these papers can both stir up some debate, as well as advance the theory and conceptualization of PBL.

In 2022 Aalborg University created the Institute for Advanced Study in PBL (https://www.iaspbl.aau.dk/), under the leadership of Professor Thomas Ryberg, the former editor-in-chief of this journal. IAS-PBL is gathering all researchers in the field across Aalborg University under one roof and hope to establish itself as an international beacon for top-quality research and development of PBL. Our journal is attached to the IAS-PBL, although our editorial strategy, principles, and management remain independent. We believe that our relation to IAS-PBL can increase our visibility and

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impact, and that it will strengthen the collaboration, unification, and daily management of the journal.

In November the editorial team of the journal met with our new editorial board for the first time. We have created a new editorial board, that will meet annually to discuss the development of the journal, primarily focusing on raising quality and awareness. The editorial board will be a sparring partner for us in the editorial team and provide valuable guidance for the journal. This initiative will serve the journal well. We are humble and proud to announce that the new editorial board consists of the following international members:

Professor Anette Kolmos, UNESCO chair at Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability, Aalborg University, Denmark

Professor Thomas Ryberg, Head of Institute for Advanced Study in PBL, Aalborg University, Denmark

Professor Yves Mauffette, Université du Québec à Montréal (UQAM), Canada

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We are most glad to announce that the journal has been approved for indexation in Scopus. Therefore this, the 15th issue of our journal, will be the first issue that finds its way into the database of Scopus. That is a big step for the journal in terms of increased visibility and potential impact, and the result of some fine work by all the editors, authors, and reviewers over the years.

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

Lone Krogh, Denmark
Erik De Graaff, Denmark
Stylianos Mystakidis, Greece
Ulla Konnerup, Denmark

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Temporary Transitions to Online Problem-based Learning: Advice for Tutors and Learners

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ABSTRACT

We provide a narrative review of the crucial elements for online Problem Based Learning (PBL) and a reflective overview of factors to consider when temporarily moving to online tutorials, forming a practical guide for educators in the health professions and beyond. We give general set-up advice based on the literature and our own recent experience (tutor and learner observational feedback, departmental meeting notes, newly-developed written resources and performance reports) of transitioning between temporary online PBL and face-to-face PBL but note that the majority of this advice translates easily to many types of virtual, interactive tutorial. We also include contextual evidence and theories from existing literature, with a focus on online PBL facilitation, learning and quality assurance. Despite widespread implementation of online teaching, there remain unanswered questions about whether deep learning occurs. The focus of this reflective paper is to better align online PBL practice with the principles of contextual, active, collaborative and self-directed learning and learning issues to be pursued.

Keywords: Interactive platform, Online learning, Resources, Support, Problem based learning

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INTRODUCTION

Problem based learning (PBL) is a well-established and studied pedagogy across many educational domains. This reflective paper considers the evidence for delivering PBL online and suggests practice points for online PBL to align implementation with theories. It focuses on PBL in medical education, but the authors emphasise that many elements can be exploited for collaborative learning in other contexts. Many medical schools have adopted PBL, most offering face-to-face facilitation, but the current Covid-19 pandemic has forced intermittent moves to virtual PBL sessions.

Though PBL online is not a new concept (Savin-Baden & Wilkie, 2006), many course providers, tutors and students have had to make a sudden leap from face-to-face PBL into the virtual environment. Social distancing requirements during the Covid-19 pandemic have propelled us all into accepting blended learning as a new norm arising from immediate necessity. We acknowledge variation in stakeholder skill-sets and confidence levels (Honicke & Broadbent, 2016). In this reflective paper we suppose that we should adapt the practice of PBL online to better align it with relevant theory.

We review the evidence relating to PBL practice and suggest how an online format can be modified to optimise the effective delivery of online, interactive PBL. This reflective paper contains three main parts. Part I explains the theories or principles that underpin PBL practice. Part II reviews the literature about online PBL in practice, and accompanying theory-based adaptations. Part III outlines how online PBL can be implemented to incorporate existing theories and research and possible future directions. The suggestions for implementation are based on a narrative approach following a literature review and consensus reached by the authors following analysis of written feedback collected informally from students and tutors and group discussions with tutors.

PART I: AN OVERVIEW OF THE PRINCIPLES OF PBL

We review the key elements of the PBL process in order to highlight which processes we believe should be faithfully adhered to during a switch from face-to-face to online PBL.

Contextual and active learning

PBL begins with a real-life problem. In healthcare education, the problem context is commonly based on a patient visiting a healthcare professional. In other settings for example, it may be a practical engineering, management or design problem to be explored, understood and solved. The theory is that learning is contextual, that is it is easier to learn material in the context of how it will be used, and it promotes the ability to use the information (Schmidt, 1983). Furthermore, the ‘messy’ nature of a PBL case encourages students to critically assess information and tasks and requires the integration of knowledge, skills and attitudes, rather than teaching each of these piecemeal (Dolmans, 2019). This is referred to as an active learning pedagogy. PBL is based on constructivist learning principles where activation of prior knowledge is used by learners to construct new knowledge (Barrows, 1984; Hendry, Frommer, & Walker, 1999; Merrill, 1991; Taylor & Hamdy, 2013).

Collaborative learning

Collaborative learning is another integral element of PBL. The students are focused on a common goal of solving the case and their success depends on each other's contributions (Kirschner, Paas, & Kirschner, 2009). PBL involves small group learning (Savin Baden & Wilkie, 2004), with group size typically ranging from 6 to 10 students.

Self-directed learning

PBL is based on the principles of adult learning, which implies the learner is self-directed in their approach (Merriam, 2001). In this situation, the role of the PBL tutor is to provide 'scaffolding' to give structure and support to students. This involves asking questions to prompt deep learning and managing group dynamics whilst allowing self-directed learning to take place (Doherty, Mc Keague, Harney, Browne, & McGrath, 2018).

In practice, these essential elements are incorporated into a structured tutorial where a case is introduced, students identify relevant information and unknown elements and develop a hypothesis. Further patient information is iteratively reviewed and hypotheses are refined, all the while leading to identification of gaps in knowledge to prompt learning. It is essential that learners are educated in the step-by-step process of PBL (Wood, 2003). Although PBL is widely implemented, there is a risk with a dramatic transition from face to face teaching to online teaching that poor PBL implementation can occur which will not prompt deep learning. In this reflective paper, we consider the evidence for delivering PBL online and suggest practice points for online PBL to align implementation with theories.

PART II: A REVIEW OF THE LITERATURE ABOUT ONLINE PBL

We review the literature describing the implementation of PBL in an online environment. Successful online delivery of PBL is dependent upon the creative use of technology to develop social and cognitive presence. There is large body of research reporting that PBL can be successful and worthwhile in an online environment (Car et al., 2019; Dennis, 2003; Jin & Bridges, 2014; McLinden, McCall, Hinton, & Weston, 2006; Tichon, 2002). However, the literature largely consists of single-site studies and small lessons, rather than significant modifications to curriculum delivery. The qualitative literature suggests that introducing PBL online is more difficult than many people assume given the changes to routines and processes required (Ardichvili, Page, & Wentling, 2003; Song, Singleton, Hill, & Koh, 2004).

Contextual and active learning online

In a hybrid curriculum model, PBL is used to deliver core concepts and is integrated with other teaching and learning activities (E.g. lectures, practical skills sessions and tutorials). In order to ensure a focused week of study on a PBL case with integrated activities, the timed release of lecture and tutorial materials helps to pace the week for students. As a synchronous learning activity, online PBL provides a valuable opportunity to scaffold students' other learning activities, including self-directed learning, during times of restricted face-to-face interaction (Gaur et al., 2020).

Active learning during face-to-face PBL typically involves the collaborative use of whiteboards to sketch diagrams and take notes. When moving online, these can be drawn on an electronic whiteboards or prepared by the students in advance and uploaded during the session (see examples in Appendix 2). Enabling the sharing and annotating of resources in an online setting is an important group activity as part of the activation and elaboration of prior knowledge that is key to the constructivist process in PBL (Henk G Schmidt, Rotgans, & Yew, 2011) and one that also underlines the student-centered pedagogy of PBL (Koh & Divaharan, 2013; Leng & Gijlers, 2015). During the tutorials, the students can annotate and modify the diagrams, using them to generate and critically discuss learning points.

Taking this a step further, interactive case materials have been designed for the online environment. This could be using digital tools related to authentic professional; scenarios e.g. accessing online drug formulary in healthcare education (Ellis, Goodyear, Brillant, & Prosser, 2008). This has also been implemented where virtual patients describe case information (Savin-Baden et al., 2011) or using real digital information such as patient's x-rays. Often this material is available in-house or free of charge from open-source providers (Bridges, Green, & Botelho, 2015).

Collaborative learning online

The interaction between the tutor, students and task is central to tutorial success and effective management of the socio-emotional well-being of the groups, as well as achieving learning outcomes (Edmunds & Brown, 2010). The tone and time limit of the discussion should be set by the tutor. While experienced tutors may be skilful at managing group dynamics in a classroom, managing an online group can present different challenges. Difficulty engaging reticent or passive students was the most common issue reported by our tutors. Icebreaker activities during the introductory stages can help to create a safe learning environment by encouraging engagement, interaction, teamwork and relationship building. A variety of online icebreaker activities are available, with most focusing on personal interests and hobbies. Rapport, trust and social presence emerge as students learn about each other (Dixon, Crooks, & Henry, 2006). In preparation for the 2020/2021 academic year we brought students together to work on a group CV/resume. Students' relationship with and perceptions of their facilitator are important factors influencing their learning from PBL (Henk G Schmidt & Moust, 1995) and are, therefore, important to attend to in the online environment. Regular opportunities for informal interaction, such as 'virtual coffee breaks' may help students build relationships with their peers and allow tutors to build social congruence with their groups (Yew & Yong, 2014). This is a key factor in effective facilitation, reducing the sense of distance to enable better critical thinking and depth of discussion (Samy A. Azer, 2009; Chng, Yew, & Schmidt, 2015). Natural inclinations to move / stretch / look around your own environment are acceptable, and better for your health than feeling glued to the screen, with hydration breaks good for concentration.

Perhaps surprising, increasing the use of students' first names when teaching online is a straightforward way that has been shown to increase interactivity and engagement (Evans, Knight, Walker, & Sutherland-Smith, 2020). Ground rules are designed to promote respectful interaction and professional behaviour during tutorials. Using the code for appropriate 'netiquette'(Shea, 1994), we have used this opportunity to develop students' awareness of the concept of digital professionalism (Ellaway, Coral, Topps, & Topps, 2015).

Self-directed learning online

Self-directed learning (SDL) requires students to take the initiative to determine their own learning needs, set goals and strategies to achieve these goals and evaluate their learning. The sharing of learning materials and options such as notes, images, and videos can enhance online learning but also increase ownership of learning and motivation for self-directed learning (Geng, Law, & Niu, 2019). Visual cues are known to complement information obtained from the trigger text and reinforcing new information (S. A. Azer, Peterson, Guerrero, & Edgren, 2012). While motivation is one of the success factors for learning in any context, there is evidence that, for online learners, technology readiness is a determining factor in their engagement with blended learning (Geng et al., 2019). Further research is required to better understand the impact of technology readiness and individual behaviour on academic performance in the context of online PBL.

Learners frequently self-organise virtual activities outside of the online classroom, either purely social or with mixed social and learning purposes. Such supports to self-directed study in the literature were online quizzes (Rossiter, Petrulis, & Biggs, 2010). Some learners draw motivation and morale from their fellow students and will favour these types of activities. Academic advising sessions typically include encouraging peer engagement. Some institutions have also employed learning analytics to monitor students' online engagement and identify at-risk students (Foster & Siddle, 2020) however, there are concerns that such use of students' data should be guided by ethical practices and policies (Ahern, 2018). This is not something we are currently implementing, but may consider.

Working remotely requires extra effort to engage socially with others online, bridging the distance to create a sense of community and belonging (Chiu, Hsu, & Wang, 2006). Self-directed learners tend to search the online learning platform for resources and research suggests that their perception of collaborative online environments can enhance their self-directed learning (Geng et al., 2019). The literature on social capital and social cognitive learning strongly suggests that the expectations of both the learner and the community will dictate the successful sharing of knowledge online, affecting the formation of learning communities (Chiu et al., 2006).

PART III: AN OUTLINE FOR TRANSITIONING TO TEMPORARY ONLINE PBL

In this section, we describe some of the additional steps, beyond the immediate PBL process, to transition to online PBL delivery. Switching to online PBL is not a simple task and requires technology readiness and educational expertise, staff training, written information for staff and students, troubleshooting, reflection, and fine-tuning.

Establishing a collaborative and inclusive virtual environment with training

Multiple interactive platforms exist for online teaching. Institutions can promote inclusivity and collaboration during online teaching (Downes, 2019) by investing in appropriate technologies and toolkits have been suggested in the literature to help with learning platform selection (Daniela & Rūdolfa, 2019). For online collaboration, use of webcams might be expected to promote effective communication, however, individual choice over the use of platform video function is a contended point. Opinions vary over whether seeing each other enhances engagement or causes distraction (Castelli & Sarvary, 2021). Tutor and learner feedback, provided locally via online meetings and surveys, suggested that being able to see all members of the group enhances the virtual experience, and literature on techniques to encourage the use of cameras is emerging (Castelli & Sarvary, 2021).

The importance of creating a psychologically safe learning environment to promote students' engagement and learning in PBL is recognised (Bate, Hommes, Duvivier, & Taylor, 2013) and must also be a consideration for online learners. Issues such as accessibility to technology at home may be a barrier and students' economic and geographic contexts should be considered during the planning stage (Erickson, Neilson, O'Halloran, Bruce, & McLaughlin, 2020). In the early days of the pandemic, across Ireland and many countries, existing infrastructure was used to quickly implement online teaching which resulted in some students having appropriate equipment and internet connectivity, whilst others were left poorly prepared (Hall et al., 2020). Since then society has witnessed a massive jump in online teaching skills from teachers and students, heart-warming teamwork and also the provision of devices from libraries and schools. Even in advanced digital economies, connectivity issues prevail for staff and students alike (Besche, Schwartz, & Cockrill, 2021). At our institution, tutors have raised concerns during online PBL meetings about students studying from home in relation to individuals with specialised teaching needs and those working in difficult home situations.

Even though most students and tutors are familiar with IT systems, switching to online tutorials requires the allocation of set-up time to ensure that several basic steps are completed. We recommend the following key measures, based on departmental technical team guidance for tutors and learners:

- Internet connection – users will typically be asked to test internet speed so that the technology team can understand the user system capacity and functionality. Within the institution there are bandwidth limitations. In our case, priority bandwidth was allocated as per our teaching schedule.
- Ensure software is up to date and meets requirements. For example; choice of browser influenced the functioning of the teaching platform, so we asked tutors to install a preferred browser.
- Ensure hardware is in place, installed and functioning (laptops, iPads, webcams, speakers etc.)
- Optimise upload speed. This may require disabling other applications running in the background such as back-up programmes. Also, optimise file sizes for upload by ensuring that resources / tutorial materials are in pdf format where possible and do not exceed acceptable limits)

Comfort with online technologies has been shown to positively impact upon online learning success (Song et al., 2004). Streamlined, quick-reference guides should be created for pre-session training on an online platform. Video demonstrations of platform features and practice sessions with worked examples can help to enrich understanding and assist in troubleshooting queries. Tutor behaviour and facilitation skills are central to the success and effectiveness of tutorials (Boelens, De Wever, Rosseel, Verstraete, & Derese, 2015; De Grave, Dolmans, & Van Der Vleuten, 1999; Doherty et al., 2018) and even very experienced tutors may feel the need to adopt new approaches to preparing for and facilitating online tutorials. Our written preparation advice to tutors, based on challenges encountered and reported within the department, includes:

- Just before your teaching session time, check the connection
- Video communication can feel less fluent and there may be glitches (e.g. blurry picture)
- Inform the students when you are otherwise occupied e.g. uploading a resource
- Make written notes as you would in any other teaching setting
- Be available for one-to-one meetings: Students still have pastoral and academic questions and occasionally still 'arrive early' or stay back for a chat; tutors can verbally acknowledge and facilitate informal query resolution
- Be aware that video communication can also be harder for the students so set an appropriate tone and encourage participation

Good internal communications between tutors, technical and administrative teams and academic staff are essential during online switches. Communicating effectively is important to achieve and maintain global commitment and performance (Saqr, Nouri, Vartiainen, & Malmberg, 2020). We would recommend the following:

- Online training and how-to videos/guides. Technical assistance tailored to the needs of tutors e.g. succinct guides that specifically address relevant online tools and functions avoid extraneous detail found in generic guides.
- Regular group emails to all tutors/faculty with important updates to procedures
- Use of an 'open door' platform (a forum that is accessible and flexible) with dedicated contacts for directed queries. Specific email addresses that are closely monitored can direct tutor queries to the relevant staff and ensure prompt responses to resolve issues.
- Information-sharing and tutor peer support can be facilitated by a social platform (E.g. a WhatsApp group) with clear boundaries for use.

PBL practice online

The practical considerations in delivering PBL online must be made with the aim to promote and support the collaborative, active learning processes that are central to PBL. Decisions about teaching online must also be based on local context: broadband strength, available hardware (webcams, headsets/mics, etc.), time zone differences, the academic calendar, and the turnaround time to make this transition. Using a platform that supports equal access during tutorials for all participants to upload resources, annotate whiteboards and share notes without the need for an appointed moderator reflects the learner-centred approach and student autonomy that is expected for self-directed learning in PBL (Loyens, Magda, & Rikers, 2008).

Having analysed collaborative feedback, we suggest that a platform suitable for PBL should allow:

- a group of up to 12 people to see each other on video camera
- the scribe to take online notes visible by all
- students to post, draw and annotate diagrams
- multiple document uploads for tutorials in various file formats (PDF, JPEG, PowerPoint etc.)

PBL practice online: Roles and Process

It is essential that learners are educated in the step-by-step process of PBL (Wood, 2003). Key aspects of PBL can be explained through an introductory e-learning module. It is imperative that students develop a clear understanding of roles within the online group (reader, scribe, facilitator etc.) and recognise the importance of live participation (Saqr, Fors, & Nouri, 2018). As with face-to-face PBL, "the amount of support required is inversely related to the students' prior learning and understanding of the PBL process" (Davis & Harden, 1999).

PBL practice online: Ground Rules

Ground rules, designed to promote respectful interaction and professional behaviour during tutorials, are central to the PBL ethos. Using the code for appropriate 'netiquette' (Shea, 1994), we have used this opportunity to develop students' awareness of the concept of digital professionalism (Ellaway et al., 2015). The examples below demonstrate ground rules (an unpublished written resource used within our school) agreed amongst our own PBL groups:

- Please join the session using a recommended browser and ensure you are in a quiet space within Wi-Fi range
- To begin at the agreed time, allow 10 minutes beforehand to login
- Please keep your microphone on mute when not speaking
- Keep all other electronic devices at least 2 metres away from the device you are using to connect, this will avoid audio interference
- We are trusting you not to read from any other information sources as you participate
- It is your professional responsibility not to record any of the sessions. Do not make a copy of any institutional resources shown during the session
- Normal attendance rules apply, if you cannot attend for any reason you should inform your tutor/admin contact by email
- You must not write any inappropriate notes / draw doodles on the platform - please keep all contributions strictly relevant

- We must start at the standard time (this was an IT systems requirement in our institution)

PBL practice online: Troubleshooting

Efficient and successful contingency planning relies on the expertise of technical officers working with faculty. Technical officers have an astute overview of technology resources and opportunities. Having selected our preferred online platform, an alternative online platform to teach on was also considered as a backup scenario.

Troubleshooting FAQ documents are useful to address individual access failure / session disruption. We have used WhatsApp to alert tutors to common troubleshooting solutions arising periodically. Over time, we created a forum for tutors to bring up issues requiring technology team support. Most platforms have an option to dial-in via phone to overcome poor laptop microphone audio and ‘Hotspots’ are a work-around for internet connectivity problems. Uploads sometimes fail if resource files are too large, requiring re-load in a different format. Screen-share tools work as an alternative but short delays can occur. Video clips can be shared but may require a tool in which to input the video-link.

PBL practice online: Progress evaluation

Just as we aim to promote self-regulation and reflective learning in our students, we must also reflect on and evaluate on how a transition to online PBL meets its intended outcomes. Our students complete a regular formative self-assessment on their progress and performance in PBL. They review their assessment and receive individual feedback in one-to-one meetings with their tutors that can also be done securely online.

Collecting student and tutor feedback on the learning environment is essential to improve teaching quality, allow curriculum development, and to rationalise and introduce new practices. There are several frameworks for evaluating blended learning curriculums covering; technical issues, learner issues and service issues, however, no structure has yet emerged as clearly preferred evaluation method (Bowyer & Chambers, 2017). We suggest the following questions for use in a formal evaluation process:

- What devices do you use to study/connect to teaching sessions?
- Has your internet connection made it difficult to access learning material?
- In general, were your instructors confident in using technology to teach?
- Which of the online tools did you most prefer and why?
- Which of the features (e.g. video, chat function, quiz, forum) did you most prefer for communicating and why?
- How easy was it to navigate VLE and find learning material?
- Are all resources (uploads) clearly visible during your sessions?
- Can you access your tutor for 1:1 academic advice and feedback?

- Does anything specific limit the quality of online discussion / how could interaction be improved?

Future directions

In this paper, we found many successful experiences of delivering contextual and collaborative PBL online. The was a scarcity of literature focused on technology readiness to transition to online delivery so Part 3 describes steps to implement PBL in practice. We found tools and practices to encourage collective brainstorming and critical thinking as learners report back on gaps in their knowledge would be welcome similar to Verstegen et al. (Verstegen et al., 2016). How long to allow for the norming and forming stage in online PBL and how often to reshuffle student groupings was something we were unable to find literature on. The interactive tools we describe typically change the interactions and there is some risk that they may take too much attention, becoming a distraction rather than an enabler. Moreover, standardising the resources used by students may also limit the scope of discussion if all students use the same resources. Further research on the impact of these tools on group dynamics and learning outcomes is required. There is some concern that academic advising such as chats directly after a PBL tutorial happen less online and the impact of the change in tutor support is unknown.

CONCLUSION

Successful online tutorial delivery is dependent upon the effective use of technology to develop social and cognitive channels for learning(Carrillo & Flores, 2020). The training and activities described above give practical advice, backed by current evidence, on how to improve the online learning experience. Many of the usual challenges and solutions presented are broadly applicable to collaborative learning beyond the field of medicine, so the authors encourage further discussion and interpretation beyond the healthcare education environment. We refer to how PBL principles can be preserved in translating a traditional ethos to a quality online format, allowing temporary transitions as required. We also explore the challenges that come with using technologies, in the context of a temporary switch to online PBL. User engagement and adaptability, such as student-led creation of resources and 'virtual coffee breaks', were also instrumental in creating an effective temporary switch to interactive online learning.

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APPENDIX 1

Links to two videos of online PBL at the University of Limerick School of Medicine

Video 1: https://www.youtube.com/watch?v=BYgXGZqa9ds
Video 2: https://vimeo.com/412076616

APPENDIX 2

Student-made images for online PBL case (with kind permission of Stephanie Walls, BMBS Year 1, University of Limerick, School of Medicine, 2020).

Students uploaded unlabelled images for annotation using editing tools during online tutorials.

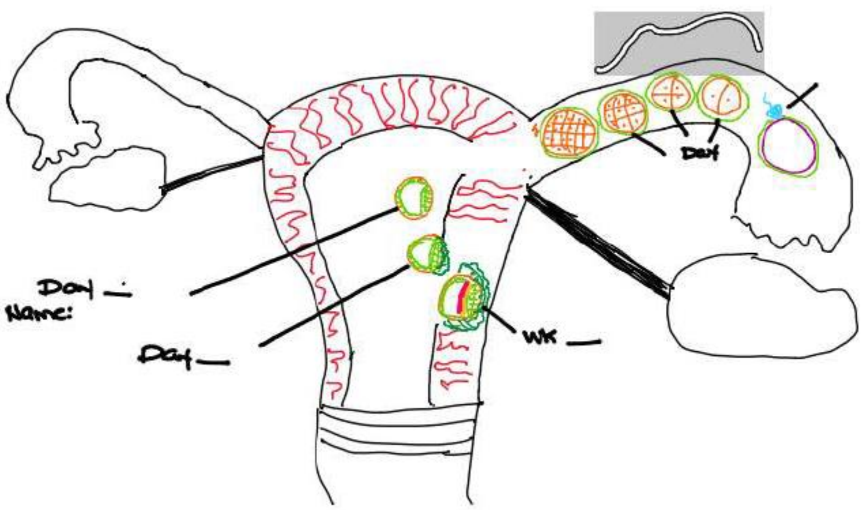

Figure 1. Example of student-made images for online PBL case.

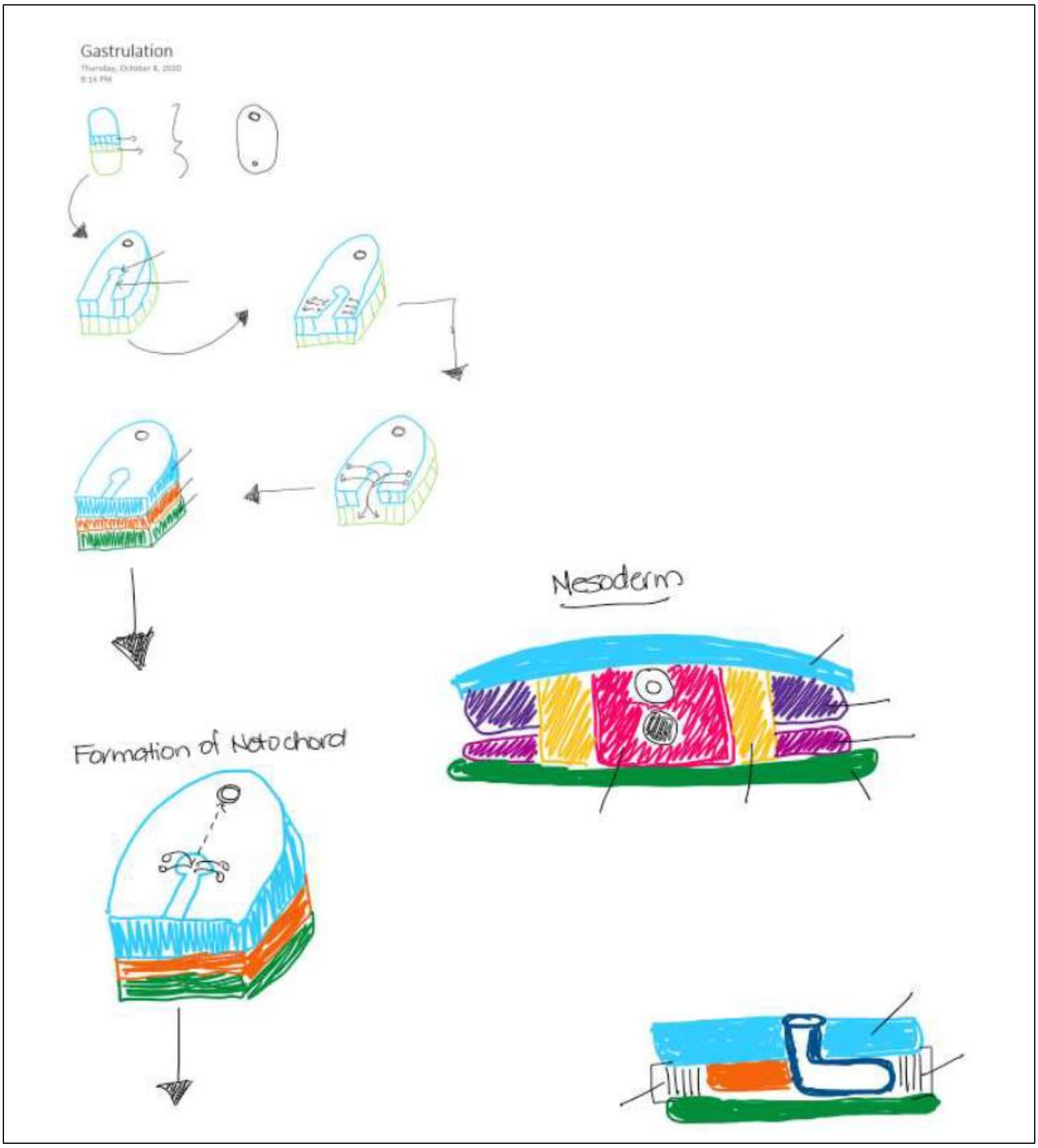

Figure 2. Example of student-made images for online PBL case.

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Students' Perceptions of Problem-Based Learning in Multidisciplinary Groups When Seeking to Solve an Engineering Grand Challenge

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ABSTRACT

This paper presents findings from a small-scale research study eliciting students' perceptions of benefits and challenges of working in interdisciplinary groups to solve an engineering challenge using problem-based learning. Penultimate and final year undergraduates and postgraduate MSc students in the School of Engineering and Physical Sciences at a Scottish university, studying Robotics, Mechanical, Chemical, Electrical and Software Engineering worked in interdisciplinary groups of five on a project to provide solutions to the United States National Academy of Engineering Grand Challenges (NAEGC). Students were surveyed twice, using closed and open questions before and towards the end of the project. Data were analysed using a thematic approach. Findings showed that most students saw benefits to problem-based working with students from other disciplines, citing increased awareness of approaches, future 'real world' professional preparation and efficiency in problem solving. However, challenges around scheduling meetings and concerns around cross-discipline collaboration indicate that universities should provide training for students before undertaking such problem-based projects, to ensure maximum educational benefits. In addition, greater emphasis needs to be put on students' awareness of the added benefits of development of the 'soft skills' needed for future professional practice.

Keywords: Problem-based learning; interdisciplinary group work; students' perceptions; preparing for professional life

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INTRODUCTION

This paper presents the findings of a small-scale research project which explored engineering students' perceptions of working collaboratively across disciplines on a problem-based learning (PBL) project to address a United States National Academy of Engineering Grand Challenge. Students worked in small interdisciplinary groups and responded to two questionnaires, one before the group project started and one towards the end of the project, noting their perceptions concerning a number of areas related to collaborative working in responses to a mix of closed and open questions. The findings indicate that, while students recognised many benefits to working as part of an interdisciplinary team to resolve a problem, a number of negative comments indicated that it could be helpful to provide training for students before they start working collaboratively to maximise educational and future professional outcomes. The findings will be of interest to those responsible for organising problem-based courses in Engineering Faculties where an increasingly integrated approach is being encouraged (Mora et al., 2019).

Working collaboratively

Collaborative learning is based on Vygotsky's constructivist principles (1978, 1986) which emphasise the importance of the co-construction of knowledge through discussion with a 'more knowledgeable other' who can be a teacher or a peer, underlining the social aspect of learning through dialogue (Mercer, 2000). It has been suggested that the social interaction taking place during the implementation of a task may be an important part of learning (Bransford, Brown, and Cocking 2000). Mattessich, Murray-Close and Monsey (2001, 7) define collaborative learning *as 'a mutually beneficial and well-defined relationship … to achieve common goals. The relationship includes a commitment to … shared responsibility, mutual authority and accountability for success, and sharing of resources and rewards'.*

As far back as the 1980s, it was argued that collaborative learning is more effective than more didactic approaches, because students are likely to learn more and retain the information longer through the discussions they have to solve problems (Collier 1980; Cooper 1990). In the present day, experiential learning, where students' knowledge and understanding are developed through the process of the learning experiences taking place within a social-constructivist setting which provides feedback and problem solving, is increasingly recognised as advantageous to learners across disciplines and sectors (Kolb and Kolb, 2006), particularly in the Higher Education sector. Peer Assisted Learning '... *teaching and learning strategies in which students learn with and from each other without the immediate intervention of a teacher'* is considered beneficial to enable students to take responsibility to ensure that teamwork results in positive outcomes for problem solving (Boud et al., 1999: 2, Topping 2005; Keenan 2014) and is increasingly used in courses throughout UK Higher Education institutions (Capstick et al., 2004). Since the end of last century, collaborative learning has been increasingly used to resolve hypothetical issues in medical and engineering studies, where students work together in what has become known as Problem-based learning or Project-based learning (Kolmos and De Graaff, 2015).

Considering STEM subjects specifically, Tytler et al. (2019: 52) argue*: 'increasing emphasis on inquiry, problem solving and creativity in STEM curricula'* provides a way to better train students to engage with each other, as they would in the real world of work. Students may be set a task, the resolution of which may be accomplished in small groups, each person sharing responsibility for contributing to the finished product. The active learning which results mirrors professional practice in industry and is therefore seen as beneficial on an educational, practical and professional level (Göl and Nafalski 2007). Van den Beemt et al. (2020) in their review of interdisciplinary engineering education literature between 2005 and 2016, found that projects involving real world scenarios were motivational for the students who took part. McNair et al.'s research (2011) suggested that learning from other disciplines increased students' respect for what they had to offer in a team, underlining the changes in '*thinking, acting and being'* that Adams et al. (2010: 558) suggest take place as a result of working across disciplines. It appears clear that the future of engineering education will need to be interdisciplinary to prepare learners for the work environment (Kapranos, 2019). Our study hoped to explore whether students had indeed felt motivated by collaborating with others and whether as a result they questioned their beliefs regarding interdisciplinary working within a problem-based scenario.

Within PBL links between theory and practice can be strengthened by reflective discussion by students in their groups (Cooper, 1990) as they focus on a product to be constructed collaboratively. Through discussion students may also develop 'soft' skills such as interpersonal skills and negotiation (Crichton and Templeton, 2013). Stigmar's critical literature review (2016) agreed that students who took part in problem solving collaborative learning developed critical thinking and communication skills. *'Learning to work together in a group may be one of the most important interpersonal skills a person can develop since this will influence one's employability, productivity, and career success'* (Johnson and Johnson, 1989: 32). In addition, working in small groups can enhance intercultural understanding (Slavin 1990) which is important when one considers the cultural mix often found in universities, and the increasingly global contexts within which future engineers will be working (Sharma et al., 2017). The university in which the study was conducted had, in fact, a number of campuses across the world (Europe, Middle East and Southeast Asia) which made the prospect of students working together even more relevant to future practice. We were interested to see whether students would mention other cultures' ways of approaching challenges.

Challenges to multidisciplinary learning

While it appears that collaborative problem solving is generally viewed as beneficial for students, some challenges have been noted. Working across disciplines results in challenges including student engagement, unequal motivators, abilities and group maturity (Hubbard and Gregory, 2011; Agyeman et al., 2019). Soares et al. (2013) noted a need for greater support for students than their lecturers had assumed they would need. Issues around 'free-loaders' and subsequent lack of trust have also been identified (Borrego et al., 2013), resulting in some students' viewing group PBL without enthusiasm. Richter and Paretti (2009) talk of 'negative relatedness' which refers to students' limited ability to recognise either the contribution that they can make to problem solving drawing on their own discipline, or that of others. Practical issues such as timetabling across different disciplines are also viewed as potentially causing students to struggle to find a time to meet (Gombrich, 2018). Students' time management skills may also be under undeveloped (Sharma et al. 2017) exacerbating difficulties of finding a time to meet together. Our study aimed to identify any challenges that students experienced, with a view to addressing them in future project-based tasks.

THE STUDY

As already noted, this small-scale research study aimed to gain students' perceptions of working in interdisciplinary groups as they collaborated to propose a solution to a United States National Academy of Engineering "Grand Challenge for Engineering". Although originating in the United States, the fourteen Grand Challenges are supported by the national engineering academies of the United Kingdom (the Royal Academy of Engineering) and the People's Republic of China (the Chinese Academy of Engineering), thus giving them global relevance.

As the Grand Challenges are very broad in their overall scope, a subset of eight Grand Challenges was used to better reflect the individual subject disciplines taking the course. The Grand Challenges were randomly allocated to the groups. The interdisciplinary PBL project therefore provided an opportunity for students from the subject disciplines to apply their discipline-specific knowledge and skills to a common project.

Participants

This course, entitled Professional and Industrial Studies, was mandatory for all participating students. The 220-strong cohort under study comprised undergraduate Integrated Masters students from Robotics, Mechanical, Chemical, Electrical and Software Engineering and postgraduate Mechanical Engineering students. The students not only came from a wide variety of STEM disciplines, but also a variety of locations, as some were based at the university's overseas campuses, or in overseas partner universities.

The course is led by academics from Chemical Engineering and Mechanical Engineering. The course leader had extensive industrial experience before joining academia, and redesigned this course, including introducing the interdisciplinary PBL project, to help better prepare students for the types of work they may experience in a professional engineering environment after graduation.

All of the students taking this course were from subject disciplines which are accredited by professional engineering bodies in the United Kingdom, for example the Institution of Chemical Engineers, the Institution of Mechanical Engineers and the Institution of Engineering & Technology. The programme learning outcomes defined by these accrediting bodies have a strong focus on open-ended PBL projects, teamwork, communication (see for example IChemE 2021). Chemical engineering students, for example, undertake subject-specific group-based PBL projects in all five years of their integrated masters programme, with 20% of the final degree award based on two major group-based projects in years 4 and 5 of the programme.

The majority of the cohort had therefore had experience of working in groups as part of their subject discipline studies, however, few had prior experience of working in interdisciplinary groups on a problem-based project. Our initial aim in conducting the study was to collect data which could indicate directions we might pursue to improve the course for future cohorts. We were keen to determine which benefits, if any, students perceived from working in such diverse groupings of disciplines and what they saw as challenges or potential barriers to successful collaboration. Our research questions, therefore focused on the students' experiences of the course:

- What do students see as advantages of working together across disciplines in the Professional and Industrial Studies course?
- What challenges do students perceive to working collaboratively on a problem-based project?

Data Collection

All the students were emailed, telling them the purpose of the research and asking them if they would be willing to participate by completing two questionnaires, one at the beginning and one towards the end of the course when students were coming together to finalise their response to the task, to gain their perceptions of working in interdisciplinary groups, before and after doing so. Ethical approval was sought from the university before conducting the survey. We were aware of our responsibilities as the students' tutors and the potential power issues that may arise when conducting research with one's students. We bore in mind Mitchell's (2004) assertion: *'… the sorts of data collection that require student assent are very likely to fail to give useful data if there is any perception (let alone reality) of coercion'*. (p. 1430). Students were assured that they were not obliged to participate and could withdraw at any time. They were promised that every effort would be made to ensure their anonymity as the research would be conducted according to the British Educational Research Association guidelines (BERA, 2019) which stresses the rights and well-being of participants. It was also stressed that non-participation would have no influence on grades.

Out of the 220, 30 students responded to the first survey (14%); 45 responded to the second survey (20%). 11 students responded to both surveys (5%). While the response rate might be considered disappointingly low, student responses can be as little as 14% (Porter and Umbach, 2006). It is possible that the low numbers of respondents to the first questionnaire were because they felt unable to answer what to them were hypothetical questions about working in groups than the greater number who responded to the second questionnaire after doing so for six weeks. Details of the surveys are discussed below.

The Questionnaires

Surveys have been described as *'the collection of information from a sample of individuals through their responses to questions'* (Check and Schutt, 2012: 160). The questionnaires comprised a mix of closed and open questions which centred round students' perceptions of the importance of different aspects of interdisciplinary teamwork. The questionnaires were sent to the students in week 2 of the course and then again in week 8, towards the end of the course. We used Online surveys (onlinesurveys.ac.uk), an online survey tool created for academic research, to design the survey. One of the advantages of using this platform was its availability to academics in different institutions, as well as being GDPR[1] compliant. Aware of the demands on their time, we designed the questionnaires to be relatively short so that students would not be put off by a lengthy survey (Lowe and Zemliansky, 2011). Students responded to the five closed questions about the perceived importance of different aspects of teamwork, such as academic ability, enthusiasm, topic, group members' discipline etc. by selecting a point on a 5-point Likert agreement scale (Likert 1932) which ranged from 'not at all important' to' very important'. The final three open questions were related to students' perceptions of benefits or disadvantages of interdisciplinary teamwork and required them to respond in their own words. Care was taken to ensure that the language of the survey was objective and non-leading (Fink, 2002), so that students would respond without any influence.

Analysis

The survey data were analysed qualitatively, despite the use of Likert scale items, which might be considered more appropriate for quantitative analysis . *'If one uses numbers,* *interpretation is still involved.'* (Bazeley, 2004:2). *'...simple counting techniques can offer a means to survey the whole corpus of data ordinarily lost in intensive qualitative research. Instead of taking the researcher's word for it, the reader has a chance to gain a sense of the flavour of the data as a whole'.* (Silverman, 2006:52). While counting the number of responses in each category for each item gave a picture of the general trends, by scrutinising the open questions, which often appeared prompted by the responses to the closed questions, we were able to interpret the graphs generated by the Likert scale responses to gain a more nuanced picture of the students' perceptions related to their experiences.

The analysis aimed to detect common themes arising from students' reflections on their experiences of PBL considering their different perspectives (Willis, 2007). General inductive approaches are often used by researchers in the social sciences (Thomas, 2006) but were deemed appropriate for this study which was conducted in an engineering context, as it focused on student perceptions. After continuously rereading the data before agreeing a coding frame, we individually identified recurring patterns, which were then reviewed and refined into clear themes. We hoped that, by interrogating the data individually in the first instance, no important insight might be lost and that all relevant categories identified could be justified within the discussions taking place subsequently, so a collaborative interpretation of the data could be agreed (Cornish et al., 2014). We used Braun and Clarke's Thematic Approach to thematic analysis (2006) in order to be able to provide as much detail of the participants' realities as possible in such a small-scale study, constantly revisiting the data before identifying, reviewing and defining the themes and patterns occurring which allowed us to make sense of the Likert-related graphs.

Although the sample could be considered small and the students came from a wide variety of disciplines, the responses indicated some clear themes regarding their perceptions of interdisciplinary working which will be discussed in the findings section below.

FINDINGS

As we were interested to find out whether students' perceptions of collaborative working within a PBL environment changed over the course of the project, findings from both surveys will be discussed where appropriate. There were some areas which showed little change in perception from the beginning of the course, however, there were some findings which demonstrated a significant change in students' mindsets after working collaboratively. Each area of the questionnaire will be discussed below, with quotes from the open questions to support our interpretations of the data.

Benefits of interdisciplinary working

One of the most positive aspects of the findings was that the majority of students who responded in both the initial and second surveys said that working together across disciplines was beneficial. 80% of students in the second survey indicated that they had found PBL working across disciplines very or somewhat beneficial. Interestingly, when they had been asked in the first survey whether they thought that group work was beneficial in their courses 91% agreed. The dip in percentage points may have been because mostly different students responded to the second survey than to the first but may also have reflected challenges that the students had faced in the practical organisation concerned in this particular course. The 11 students who completed both surveys indicated very little difference in perception from the first to the second survey. In the open questions in both surveys, students cited the importance of sharing different perspectives to problem-solving: '*Different sets of skills from different principles helped solve problems that could not be solved from one discipline'.* A large number of responses to the open questions referenced future career prospects: *'…it felt like an actual working environment'; 'this multi-disciplinary group project is an ideal course for final year engineering students as it the most similar a course could be to real industrial engineering projects, … before heading into our careers'.*

Most students expressed confidence in working collaboratively to solve a problem (79%). This may have been because a large majority had already done so previously in their university studies (89%), professional placements (29%) and/or personal activities (42%). It seemed that they were already accustomed to working as part of a team, and therefore were well-disposed to the task they were assigned.

Ease of collaboration

In the first survey, students were asked to compare the prospect of multidisciplinary PBL collaboration with previous group work they had undertaken in their studies. 50% said they thought it would be harder. However, after the collaboration had taken place, this had dipped to 38%. The number believing that there would be no difference between working in an interdisciplinary team as regards a subject specialist team stayed relatively stable (31% in the first survey to 29% in the second). In the first survey only 17% of students thought it would be easier. However, in the second survey 33% stated that it had been much or somewhat easier than they had anticipated. Responses to the open questions indicated that the mix of disciplines had been useful in the completing the task: *'I feel that we are more efficient in the multi-disciplinary group'. 'The opportunity to work with people from other backgrounds helped with having a range of knowledge to source from…'* Some students stated that they had gained in knowledge from working with other disciplines: *'A wider range of knowledge across the group is achieved'.* Clearly a shared responsibility for the task with each group member influencing decisions according to their knowledge had contributed to a feeling of satisfaction in the process. As noted above, benefits for students working together on problem solving and/or providing peer feedback are widely recognised (Boud et al. 1999, Topping 2005; Keenan 2014). Lower levels of anxiety, increased confidence and communication skills are seen as a result of collaborative group work (Keenan 2014).

Contributing factors to success of PBL interdisciplinary working

The students had been asked specifically what they felt contributes/contributed to effective groupwork, as this was an area that we were keen to explore with a view to improving provision for subsequent cohorts undertaking PBL. An overwhelming majority of students cited the importance of individual academic ability in the first survey (90%) along with individual enthusiasm for the project (96%) as main contributors to effective group working. However, in the second survey these figures had dropped to 49% and 76% respectively. While individual enthusiasm was still rated relatively highly, group members' academic ability was seen as much less important after the task had been completed. It is possible that the students' discussions had made them assign greater importance to taking different perspectives into account, allowing them to think more laterally, than relying on a purely academic approach. Nonetheless, responses to the open questions showed that group members' academic ability was still valued: '*Better variety of specialist knowledge.' 'Some technical details can be better understood when explained by a group member that has seen it before'.*

In both surveys, students appeared to agree that the focus of the problem to be solved was an important indicator of potential success. The mix of group members' disciplines were also seen as contributing to the success of the project: '*Different sets of skills from different principles helped solve problems that could not be solved from one discipline.'* In the open questions most students praised the teamwork and commitment of their group members, who had worked to build good relationships and communication skills when sharing knowledge. Although the students made the link to future working practices, when they would be expected to work across disciplines, they did not appear to recognise that the assignment could also be seen as developing those qualities so important for teamwork in the work environment. It seemed that they were more focused on completion of the project, rather than connecting it to their own development of 'soft skills' so valuable for successful collaborative problem solving.

Perceived challenges to PBL interdisciplinary working

Although the overwhelming response by the students was positive, there were important challenges to meeting the brief of the project that students identified. Approaching the task from different perspectives was generally seen as a good thing. However, when it restricted people's thinking regarding processes and procedures, some students experienced frustration*: '... disagreements on methods to solve an issue due to different* *perspectives.' 'The main difficulty I have found in multi-disciplinary group work is trying to prevent group members input being too technically focused on their own discipline fine details and not the more general project objective.'* One student noted that they were the only one in their discipline in their group and therefore felt their suggestions were overridden by others, while two students observed that their groups appeared biased towards one particular discipline, which also created a perceived imbalance of power within their groups with regard to decisions.

Some students mentioned the need to organise other, less focused students: *'I have to work harder than ever to get my group to talk to each other'. 'I have to push my team members to give their opinions in meetings'*. While drawing other students' views out may have seemed onerous to those students, although they had not recognised it, they were developing the type of leadership skills necessary for project completion, which they could take forward in the workplace.

One of the biggest challenges for students appeared to be finding a time to meet to discuss their project: *'there can be several timetable clashes between all the courses.'*. Almost all the students mentioned issues with scheduling meetings. Some students had competing deadlines, so prioritised what they saw as more important: *'Some people may prioritise other subjects over this one'*; the multiple campuses in different time zones, as well as students' other commitments also created scheduling challenges: *'our group is working over 4 timetables and 2 time zones and several part time jobs'*. It should be noted that this course was undertaken remotely under lockdown conditions, as a result of the Covid-19 pandemic, so it is possible that students actually had greater flexibility to arrange meetings at times which suited everyone. It might be argued that agreeing a schedule of group meetings could be beneficial for the development of students' time management skills (Costa et al., 2019), as well as the negotiation skills necessary for working effectively in industry (Gray, 2016).

Development of their negotiating skills was also deemed essential by a small number of students who had felt frustrated by some members' insularity. Despite favourable comments about the range of academic backgrounds from most of the students, it seemed that the mix of disciplines could also result in discord: *'There are disagreements on methods to solve an issue due to different perspectives'*.

A further challenge was presented by those students who might be considered what Aggerwal and O'Brien term 'social loafers' (2008), that is, those who contribute little to the project: *'not pulling their weight'*. Sometimes this appeared due to the conflict of students' perceived priorities and poor time management, as noted above: *'... sometimes group members would not do their assigned parts because of deadlines'*, but some students cited a lack of their group members' engagement which was discouraging*: 'At the moment it honestly feels like a solo project'*

DISCUSSION

It could be argued that the very name of the course, Professional and Industrial Studies, suggests links to industry and the professional workplace and it is therefore no surprise that the majority of the students themselves made the links, for the most part approving of the course and its interdisciplinary, PBL nature. While they acknowledged that each discipline had different ways of approaching problem-solving and report writing, they also appreciated the opportunity to try different ways to tackle the brief: *'... experience of group work and report writing varies from discipline to discipline meaning that this brings variation to the project approach in terms of research, presenting and reporting.'* Despite the strong positive responses from most students, who cited future career benefits and wider understanding of problem-solving strategies among other advantages, it seems clear that there were some issues arising from the multi-disciplinary project, which proved frustrating and discouraging for some of those who responded. As can be seen in the findings, problems with collaboration occurred in the face of intransigence or work avoidance on the part of some group members.

Mattesich, Murray-Close and Monsey (2001) identified six factors which they claim influence collaboration positively. These include a common purpose, shared governance and joint decision making, clear understanding of roles and responsibilities and open and frequent communication, as well as trust and adequate resources. It seems that assumptions may have been made not only by university staff when setting up the course, but also by the students themselves regarding student engagement and the understanding of their roles and responsibilities. Subsequent interdisciplinary projects would benefit from a clear set of explicit expectations, based on Mattesich et al.'s factors, that are shared with both participating students and supervising staff and discussed before the project starts, so that everyone is aware of the importance of their role as well as their responsibilities to their group. While wishing to encourage autonomy in collaborative teams, regular 'check-in' opportunities may also be beneficial for students to provide an update of their progress, in the form of a running report, for example, which could be monitored by supervising staff and also be seen as motivating those students less inclined to contribute fully. Issues which were mentioned regarding subject bias within groups could be easily addressed by creating a simple formula to ensure that one discipline does not constitute a majority of group members, so that decisions may be more democratic and 'cliques' of disciplines are not created (Bacon et al., 2001).

CONCLUSIONS

A large majority of students approved of the interdisciplinary PBL collaborative project, citing advantages for their future working environment as one of the main benefits. Most of them also said they enjoyed working in partnership with other students from a variety of disciplines, as it developed greater understanding of different approaches to achieve resolution to challenges. Although they also mentioned some frustrations, only one of all the students who responded felt that they had gained nothing from the course. Interestingly, although students commented on the difficulty of arranging meetings across time zones with regard to those studying in the overseas campuses, there were no comments about cultural issues regarding understanding or ways to approach a problem. It seemed that the only cultural element which arose in the groups related to the culture of the actual discipline that students were studying, which appeared to influence how they approached the brief.

It was clear from the students' comments that the majority of them had developed the soft skills of interpersonal communication and negotiation, so important to the successful conclusion of any problem-based project, to work through frustrations to find solutions. Some had felt compelled to take a leadership role encouraging others' contributions, while others had had to be more organised with regard to time management. However, very few of the students mentioned the growth of these interpersonal aspects of teamworking as a positive factor in their development, preferring to focus on the final product. It may be that greater work needs to be done to make students aware of the wider social and professional benefits of interdisciplinary PBL collaboration, so that they can actively practise their interpersonal communication and negotiation skills in this type of project, seeing this as an important consequence of their discussions, which they can also take forward in their future careers.

This study was small-scale and cannot be held as representative of the wider STEM cohort in universities who take part in interdisciplinary PBL collaborative projects. The disappointingly low number of students who responded to both questionnaires means that a valid comparison regarding perceptions before and after the course cannot be made. However, our research does raise some interesting points which would benefit from further larger scale investigation.

The questionnaires did not identify whether the students who responded were final year undergraduate or postgraduate students, and thus we were not able to determine whether there was a difference in perceptions, perhaps as a result of greater experience or maturity (Hubbard and Gregory, 2011).

In planning the research, we were aware of students' workloads and time pressures and decided not to ask them to participate in focus groups or individual interviews. With hindsight, the findings could have been more rigorously validated had we done so and certainly in future research into collaborative interdisciplinary PBL working, we will use the findings from this study as a basis for further exploration of the issues arising.

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[1] General Data Protection Regulation (GDPR) refers to European Union legislation enacted in 2018 that protects consumers' and private citizens' data.

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An Academic and Personal Approach to Supervising Project Groups

Jesper Simonsen and Olav Storm Jensen *

ABSTRACT

This article investigates and exemplifies the personal side of our supervising skills. This is inspired from psychotherapeutic research specialized in investigating open-minded contact and authentic meetings. The article is based on our experiences supervising project groups at Roskilde University. Supervision is sometimes a challenging task that may manifest and confront personally-related issues. We advocate combining an academic and personal approach to supervising project groups. We provide a range of empirical examples from the supervising project groups, illustrating the type of personal challenges we meet. These challenges are characterized and conceptualized, and some concrete ways to deal with them are proposed.

Keywords: Project groups; supervision; personally-related issues and challenges; negative self-relations; performance pressure or anxiety; psychotherapeutic research; body-oriented awareness; grounding; the Sensethic Approach

INTRODUCTION

The practice of working in and supervising project groups at the university level involves multiple activities in which the participants – the students and their supervisor – must meet and maintain contact with each other. Supervising project groups constitutes significant numbers of communicative interactions and social dynamics. The students and their supervisor need to establish, develop, and maintain constructive contact relationships throughout the course of the project. This relationship may be characterized from both an academic and a personal perspective.

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This article investigates supervision from the perspective of the *quality of the contact relationship* in the communicative interactions between the supervisor and the students in the project group (Simonsen & Storm Jensen, 2016). We focus on situations where the contact quality is compromised because of one or more of the participants, that is, the students or the supervisor, face personal challenges, such as, for example, performance pressure or anxiety. Inspired by body-oriented psychotherapeutic research, we highlight the personal perspective and its importance in maintaining open-minded contact during the supervision of its academic discourse.

The background for this article comes from the authors' experiences with two levels of supervision. The first author is a professor at Roskilde University and has 30 years of experience supervising project groups. All empirical examples given in this article are drawn from this extensive teaching portfolio. The second author is a psychologist and a private practitioner, who is also a former adjunct professor at Roskilde University, where he supervised professors and other academic staff experiencing related personal issues that challenge their work life. The authors have collaborated for one and a half decades, supervising project groups and university staff in the practice of supervising project groups, themselves. Part of the background for this article comes also from workshops on teaching participatory design (Andrews et al., 2014; Simonsen & Storm Jensen, 2015) and a conference paper aimed at participatory design researchers (Simonsen & Storm Jensen, 2016).

We provide our empirically-based knowledge and examples as inspiration and as an interdisciplinary contribution to the literature on problem-oriented project-based learning in general (Andersen & Heilesen, 2015; Jensen et al., 2019), and add to the literature with a focus on supervising project groups (e.g., Macfadyen et al., 2019; Woolhouse, 2002; Murray-Harvey et al., 2013; Coelho, 2014). More specifically, this article adds to the body of literature on topics such as group processing (Lachowsky & Murray, 2021); observing the supervisor as "a social mediator, listening actively to what kind of psychological dimensions are taking place among the group members" (Nielsen & Danielsen, 2012, p. 263); acknowledging that "supervisors involve group dynamic processes as an important aspect of their supervision" (Andersen & Dupont, 2015, p. 132); and that it might be "necessary as supervisor to take an interest in the student's motivation and academic problems from a process-related and psychological perspective" (Feilberg, 2015, p. 42, translated from Danish).

We have written this article with our fellow supervisors in mind, that is, university professors, external lecturers, PhD-students, and others. PhD students might be a particular target group, as they experience a transition from being supervised students to becoming supervisors of graduate and undergraduate students.[1] This might lead the PhD student to implicitly demand more experience of him/herself than he/she actually has, which can lead to performance pressure or anxiety.

We encourage supervisors to use their basic research orientation in reflecting upon and responding to the challenges they might experience when supervising project groups, that is, through a research-oriented approach, investigating what is at stake and responding appropriately. We hope a broader audience can also find this article valuable by relating to any type of interactive situations where an authentic, credible, attentive, and present contact is important, for example, when colleagues, friends, partners, and children come together and wish to communicate.

In the following, we characterize an academic and personal approach to supervision that we use as our analytical lens and from which we also propose ways to address personally related challenges. This is followed by two sections introducing challenging situations and providing a number of empirical examples (as short vignettes) on how these might unfold. The first section focuses on the situations where the supervisor meets the students being challenged. The second section focuses on situations where the supervisor experiences his/her own personal challenges. All examples are presented from the perspective of the supervisor. We end the article concluding our empirical and conceptual contribution.

AN ACADEMIC AND PERSONAL APPROACH TO SUPERVISION

The relationship between *profession* and *person* has been addressed within education and other disciplines that include significant human contact, such as in the work of educators, nurses, social workers, school teachers, and home caregivers (Weicher & Laursen, 2003). Within the field of social work, for example, the relation between profession and person is discussed as a specific competency (Posborg, 2009a), practical skill (Posborg, 2009b), and as an essential focal point of supervision (Fehmerling, 2009). Personal – in this respect – is different from being “private.” It is not about “becoming friends,” but realizing the fact that the personal side of our being should not be ignored when engaging in human contact. The personal part of human contact in a professional context “involves being able to share thoughts, feelings, knowledge, and opinions that are *[professionally] relevant* during the meeting” with the participant(s) (Posborg, 2009a, p. 146, translated from Danish).

Below, we elaborate on the profession-person relationship for university supervisors as an academic and personal perspective that may be combined in an approach to supervision. We focus the academic perspective on *academic reflections*, that is “using your head/brain" (intellect), while the personal perspective focuses on *body-related awareness*, that is "sensing our body/feelings."

Academic reflection may include professional knowledge and reflective capabilities expressed through logical thinking, analytic reflections, comparisons, and through conceptualizing and inductive, deductive, and abductive[2] reasoning. In general, supervisors develop academic abilities through comprehensive and year-long academic education, training, and career experiences. A special characteristic of academic reflection is the ability to imagine and envision what you think is going on, for example, during a supervision meeting. As a matter of fact, there is no end to what you can imagine and hypothesize. In some situations, this may challenge us by providing almost endless speculations and worries in our attempt to resolve a problematic situation (Storm Jensen, 2008).

Body-related awareness is grounded in the body's sensing apparatus, that is, what can be seen, heard, observed, and perceived through basic bodily assessments or sensations and feelings, for example, confusion, anxiety, disappointment, anger, relief, compassion, or sadness. Contrary to academic reflection, body-related awareness is not a core part of the academic curriculum. In fact, it might not be part of the curriculum at all, even for programs within psychology. A special characteristic of body-related awareness is that what is sensed is *actually* sensed and not imagined. While the head and mind may trick and lead one astray through the imagination, one's body cannot sense or feel anything but the actual state of emotion (Storm Jensen, 2008). The problem often faced concerning feelings is the inability to sense them because one has learned and adopted effective ways to oppress them during childhood (Juul, 2011). This is unfortunate, because what is sensed provides an important indicator and opportunity to investigate whether the contact quality is compromised by the participants' personal challenges.

The Sensethic Approach

As an academic and personal approach to supervision we introduce body-oriented psychotherapeutic research combining "sense" and "ethics," which in the following will be referred to as the "Sensethic[3] Approach" (Storm Jensen, 1998, 2002, 2008).

Supervising with the Sensethic Approach aims to establish contact quality in communicative interactions through genuine focused presence. "Sense" refers to a body-related awareness. A characteristic of the approach is it's appreciation of the profound significance of body-related awareness. To make verbal discussions a genuine part of a shared rational reflection on the issue at stake, this reflection must be consistent with sensations; that is, it must be consistent with the realities (including emotional realities) as perceived through basic bodily assessments – sensations and feelings. "Ethic" refers to genuine participation and authentic contact. Storm Jensen (1998, p. 278) defines this within the therapeutic dialogue/contact:

> [B]eing there *with* oneself and *as* oneself but *for* the client. It is thus about concentrated awareness or presence, about honesty or authenticity and that the agenda is unambiguous: the client's needs. (translated from Danish)

Within participatory design genuine participation has been characterized in a similar way where the agenda is not the needs from the client but the goals of the design engagement:

> Any user needs to participate willingly as a way of working both *as themselves* (respecting their individual and group's/community's genuine interests) and *with themselves* (being concentrated present in order to sense how they feel about an issue, being open towards reflections on their own opinions), as well as *for the task and the project* (contributing to the achievement of the shared and agreed-upon goals of the design task and design project at hand) (Robertson & Simonsen, 2013, p. 5; see also Luck, 2018; Østergaard et al., 2018).

Genuine participation and authentic contact characterize the well-functioning project meeting that we usually strive to obtain: a meeting where all participants can collaborate and engage in academic reflections in a trustful atmosphere, being present, engaged, and focused. The focus of attention is the content of the project approached by inquisitiveness and reflections, and may, for example, include discussions of the project's focus and research question, relevant literature and theoretical grounding, choice of methods, empirical analysis, design of processes or products, or the contribution or structure of draft chapters, to name a few.

In well-functioning meetings, the participants only experience few or inconsequential personal confusions or challenges. Sometimes, however, the contact quality is compromised because the students or the supervisor experience personal issues and challenges, such as being distracted or inattentive, becoming tense or anxious, or experiencing a feeling of being "wrong." The theory behind the Sensethic Approach identifies *negative self-relations*, contributing to a confusion of perceiving oneself as being wrong, as the underlying core issue causing problematic human contact. In short, negative self-relations mean negative views of or attitudes towards oneself (for a psychological elaboration of the concept of negative self-relations, see Storm Jensen, 1998, 2002, 2008). The Sensethic Approach has origins in humanistic, phenomenological-existential, and body-oriented psychotherapy. The body orientation has its roots in Alexander Lowen's bioenergetics, especially the concept of grounding (Lowen, 1958, 1975). Bioenergetics is rooted in Wilhelm Reich's (1945) vegetotherapy.

While the Sensethic Approach has its origins in psychotherapeutic research and practice, supervising project groups is not meant to be therapy, or in any form to produce engagement in self-realization or a confessional discourse (Nielsen, 2005). Rather, the point is (a) to acknowledge that both students and supervisor sometimes might be personally challenged in ways that compromise open-minded contact and authentic supervision meetings, and (b) to help create and maintain constructive academic meetings and discussions where the participants may dare to fail and be insecure, and at the same time be open about it. This is in line with Feilberg arguing that "the supervisor's willingness for self-reflection is pivotal to the student's opportunity to acquire their own willingness for self-reflection regarding their scientific practice" (2015, p. 43, translated from Danish). The relevance of the Sensethic Approach in supervising project groups is, at least, threefold: First, negative self-relations might explain many of the personal challenges faced by the supervisor and the students (as exemplified in the following sections). Second, these challenges may be characterized and conceptualized by this approach (as demonstrated in the following sections). Third, some body-oriented, concrete, and relatively simple methods or techniques may support the supervisor in alleviating the challenges, and reestablishing a high-quality contact while supervising. As two key examples, we describe below: (1) a basic grounding exercise and (2) a technique to change the focus of the dialogue during a supervision meeting to face a disturbing personal challenge.

Grounding is a physical way to support your body-related awareness by focusing on breathing and sensing the gravitational pull on the body. Grounding may be supported through different concrete bodily and physical grounding exercises. One basic grounding exercise is illustrated in Figure 1. Grounding is a relevant method if the supervisor is challenged, for example, by feeling tension or anxiety compromising his/her contact with the students. In such a challenging state, we are typically restraining our breathing by squeezing the solar plexus and pelvic area, and we "go up" (in our head) and try to act mainly using our cognitive and academic resources. This corresponds to the basic/natural state of vigilance when facing some kind of (imagined or real) threat: protecting the soft vulnerable area of the stomach while staying alert against the perilous threat (ready to flee). The Sensethic Approach to meet such challenges is to "go down" by grounding, because the threat is not real (you are not in any real danger), rather, it is a confused imagination of a threat (Storm Jensen, 1998). Grounding exercises may also be introduced to the students (see Simonsen and Storm Jensen, 2016).

Position yourself with parallel feet, slightly bent knees. Take a deep breath. Let your head fall forward towards the chest, and let the weight of your head slowly drag the upper part of your body downwards until you are hanging down, standing on slightly bent legs with your hands touching the floor (see illustration).

Pay attention to your breathing with a special focus on the exhalation. Breathe using the lower part of your core, exhaling without interruption until you have no more air left. Sense that your upper part of your body is hanging loosely down while your legs are actively carrying the weight of your entire body. Sense the gravity and the contact of your feet with the floor.

After some minutes in this position, slowly rise by, first, pushing your knees forward, then the hip area, stomach, and chest (kind of rolling up the spine vertebrae-by-vertebrae), until you are upright: the front of the body arching forward with the head leaning a little backwards. After a few seconds, by pulling the pelvis backwards and simultaneously raising the head to a vertical position, turn the arch into a relaxed, balanced, upright position. The knees still slightly bent.

Figure 1: Basic grounding exercise. Originally suggested by Lowen (1958; 1977, pp. 11f); elaborated by Olav Storm Jensen.

Grounding can be done in all situations simply by drawing attention toward the sensing of gravity and your weight, whether you are standing or sitting down, and by paying attention to your breathing, especially exhaling without disruption. During a meeting it might be instantly alleviating just being open and expressing verbally that you somehow feel tension; this might again help your grounding. Grounding exercises are not physically difficult to do, and they can be practiced privately at home or at the university in your office or at another private space. If you experience problems being grounded during a meeting, you can ask for a break or just leave the meeting and take a break to do a short grounding exercise (see Figure 1).

The Sensethic Approach offers a simple yet effective technique supporting a supervisor's reaction once he/she senses that the quality of the contact has been compromised. The technique is *stopping* (Simonsen & Storm Jensen, 2016), followed by changing focus and paying attention to what is going on: that is, *from* a current discussion focusing on academic reflection *to* an emerged personal issue that disturbs the discussion. Stopping may be supported by focusing and going *three-times-down*: (1) Down in the *body*, that is, to the level of the senses, as qualified by grounding, assisting bodily presence, for example, by taking a deep breath, exhaling without interruption, paying attention to the feeling of gravity on the body, physically feeling the ground under your feet or bottom (when seated); (2) down in *tempo* (talking slowly), because sensation is a slower function than thinking, so that slowing down in mind and speech supports the cognition of sensed reality; (3) down into the *concrete*. This means breaking down the abstract descriptions, viewpoints, and proposed solutions at stake, into their most concrete appearances and exemplifications, thus making them accessible as material to be sensed and felt. Example

1 and Example 5 below provide a vignette with a simple description of how a supervisor uses stopping and three-times-down.

> Example 1 [Stopping and three-times-down]
>
> I [the supervisor] was very excited and enthusiastic when I explained one of my own great research points to the students. Then, I detected that I was talking over their heads and that they looked kind of uncomprehending and hesitant. I stopped myself, took a long breath and said, "OK. I can see that this is a bit abstract; maybe I could explain my point this way instead." I continued speaking much more slowly and by giving a concrete example.

Stopping and investigating the changed focus through a grounded, slow, and concrete approach may be supplemented by sharing what is sensed and observed, for example, by mirroring an observation of a students' behavior (e.g., specific utterance, repeating argument, or speaking quickly and loudly) or appearance (e.g., looking distant, touched, angry, etc.). The point here is to facilitate by mirroring what is seen and by sharing what is sensed. In some cases, it also helps to provide an interpretation (hypotheses) of what might be going on.

MEETING STUDENTS BEING CHALLENGED

Supervision is often characterized as a dual process of 1) supervision on the academic subject and 2) supervision related to the process aspects of the project work, including collaboration in the group and group and supervisor collaboration (e.g., Nielsen & Danielsen, 2012; Andersen & Heilesen, 2015). In this and the following sections, we characterize the latter and focus on situations where the collaboration is challenged by participants experiencing personal issues that may be related to negative self-relations. We also exemplify ways for the supervisor to address and alleviate such situations, thereby supporting a high contact quality.

In this section, we describe and exemplify situations where the supervisor meets students being challenged. When such situations occur, the students often become *distracted*, that is, challenged in ways that prevent them from being authentic, credible, attentive, and present. This might, for example, happen when it is difficult for them to relate a discussion to their own context and situation because it is too abstract or theoretical; see Example 1 given above and Example 2 presented below.

> Example 2 [Distracted]
>
> During a supervision meeting, I observe a student kind of "disappear." The student gets this distant look in his eyes where you can see that he mentally has "checked out" of the meeting and its discussion and "gone into" his own private mind somewhere far away. I get the impulse to wave my hands in front of the student and say: "Hello! Where are you? Won't you please come back to us and join our meeting?"

In Examples 1 and 2 the supervisor observes students withdrawing mentally and becoming inattentive. In some cases, the students are unwilling to engage in the meeting for other reasons than being personally challenged (being bored, reflecting on a text that just arrived, having troubles at home, thinking on their partner they're having issues with, etc.). But in other cases, it might be interpreted as students experiencing negative self-relations by perceiving oneself as being wrong because they are not "good enough" to follow the academic discussion and reflection – they feel inadequate and insecure. To shut down emotionally, thereby *disappearing* from any authentic contact with another person, is a common psychological response to (consciously or unconsciously) avoid something that provokes feelings of discomfort, tension, or anxiety.

Students might also become distracted and withdraw if they feel that they are pressured, stressed, or otherwise forced to engage in a discussion. They might also find themselves participating with others who act in dominant, manipulative, patronizing, aggressive, or otherwise unpleasant ways. Example 3 presents a situation where one student patronizes another by providing a *manipulated* conclusion from an earlier meeting (the group had not reached consensus on their focus). The attacked student does not speak up for herself (this requires a certain level of self-confidence) but withdraws, probably because she doubts herself due to low self-esteem.

Example 3 [Manipulating]

When the participants discussed the focus and research question, one of the students in the team was very dominant. When another student started to raise doubt about their focus and mentioned an alternative path, she was interrupted by the dominant student stating "but we did consider this issue; and it was not very perspicacious" The other student fell silent and looked down.

During a meeting, the students (and the supervisor) can participate in an authentic or non-authentic way. Perhaps the easiest way to explain *authenticity* is by discussing its opposite: *pretending*. Being *authentic* simply means not pretending to be anyone else but yourself or being anything else but what you are – not pretending to be knowledgeable about something you do not really know, not acting friendly and accommodating if you really are upset and angry and oppose the issue being proposed, and not acting as if you are informed and certain if you really have doubts about an issue. Example 4 presents a situation with students pretending – and the supervisor's response to this.

Example 4 [Pretending]

At a meeting, I felt a sudden déjà vu from the previous supervision meeting with the same group. Again, they presented a list of all the activities and results they had done and their plans for how to proceed. They took turns presenting and appeared nervous. They had no discussion points or any general questions for me (the supervisor)—just a few more or less formal questions. It felt as if the group was only seeking approval for what they had done. I agreed that their project was on a promising path, and I suggested we should discuss why they had chosen this format for the meeting. It turned out that the group was unsure how to utilize a supervision meeting and that they approached me as a judgmental authority of their project work and, therefore, felt the need to justify/argue for their progression in search of the supervisor's approval.

The students in Example 4 were conducting their initial project in the first semester of their bachelor studies. They were also facing the new situation of having meetings with a supervisor (and a professor). They were nervous about being inferior as newcomers to the university and to project work, and they chose to handle this uncomfortable situation by pretending to be in control and by focusing the meeting on listing past and future project activities. The supervisor sensed their nervousness and intervened by encouraging them to *investigate* why they approached the supervision meeting this way.

When a student becomes challenged, this is sometimes accompanied by the student *speaking faster* or continuing to *repeat an argument* in different ways. This might be an indication that the student is not using his or her ability to sense whether the counterpart is really paying attention to what he/she is trying to communicate; see Example 5.

Example 5 [Repeating Argument]

The discussion among the students became increasingly vociferous as one of the students for the third time repeated his argument for including a specific empirical study as part of the project. I interrupted the discussion: "Let's put this discussion on hold for a minute. I notice that you [the student repeating his argument] insist on including this study but even though you have asked for it several times, the others seemingly resist in including it. I believe the others have heard you, and they disagree. Can we try to investigate why it is so important for you to include it? What is at stake for you?" The student replied: "I just think that making this empirical study is imperative." I paused and then asked slowly, "Could you give a concrete example of the kind of study you would like to do?" After a while it turned out that the student did not feel theoretically strong but loved to engage in more practice-oriented tasks.

In Example 5, including a specific empirical study is apparently crucial for one of the students, but repeating the argument for doing it does not work as a "method" to solve this issue. The supervisor uses stopping to change focus and investigate what is at stake for the student (being afraid that the project does not include a task that the student feels confident making).

In our experience, it is often performance pressure and anxiety that initiate self-relational doubts about being substantially "okay." This may be accompanied by unpleasant feelings of shame and of being inadequate. Performance anxiety might be related to both cases in Examples 4 and 5 given above, and is clearly the case in the following Example 6.

Example 6 [Performance Anxiety].

At the exam start, a student visibly suffers from anxiety, with trembling voice and over-breathing. I looked into his eyes, and explained that I could see he was very nervous and that it was no problem taking some time before beginning. The immediate response was a sigh of relief and I continued: "It will help if you take a deep breath and exhale; and keep exhaling until you have no air left." He accepted the proposal and I supported the student by repeating with a low voice, "and exhale … exhale." After some quiet breaths the student appeared more relaxed and I asked: "How are you now?" and a little later, "Do you feel ready to start?"

In Example 6 the supervisor chose to re-focus the exam to "what is going on," by meeting the student (eye-contact) and acknowledging (mirroring) the challenge he struggled to handle: "I can see that you are in trouble and we can try to do something about this before we continue." Over-breathing is a sign of approaching a state of panic, hence the commonly known advice to "take a deep breath." Hyperventilation may be additionally relieved by exhaling without interruptions until the lungs are empty before inhaling.[4]

Meeting a challenged student through eye-contact and mirroring what is observed may help in changing focus to "what is going on." Example 7 provides an example from a supervision meeting with a student being overwhelmed by performance pressure.

Example 7 [Performance pressure]

The masters thesis student sat down and we began the supervision meeting. I noticed that she looked distracted and was appearing short of breath. I looked at her and asked slowly, "How are you doing?" With visible signs of being touched, she said, "I have not come so far as I had hoped." I gave a long, deep sigh, paused, and met her by responding, "I can see you are touched—it must be very difficult for you." We then had a conversation about performance pressure and the risk of stress as part of the masters thesis work.

In a situation such as Example 7, the supervision may include sharing knowledge or experiences on ways to cope with performance pressure (if appropriate) or referring the student to relevant institutional help facilities (if such exist). However, in many cases, just meeting and listening to the student and his/her challenge can result in an instant relief from which a constructive academic reflection and discussion may proceed.

In some cases, the student's performance pressure and anxiety may be sensed by the supervisor in an indirect way and unveiled if the supervisor chooses to investigate what is going on, as illustrated in Example 8.

Example 8 [Performance pressure and anxiety]

I was in charge of a seminar introducing and preparing graduate students for their masters thesis project. I felt frustrated because the students only reluctantly engaged in presenting discussion papers and drafts for their masters thesis research questions. I openly entrusted to them my frustrations and asked for help to clarify what was going on and why the peer-like seminar form was kind of unsuccessful. This unveiled that the students had no prior experiences with this seminar form, and some students openly admitted being afraid, because they did not prepare well enough for their presentation, while others mentioned a fear of me asking them critical questions they could not answer. An open and crucial discussion on how to proceed with the seminar could begin.

Example 8 describes a supervisor being extrovert and explicit, sharing his/her frustrations and challenges with the students. This establishes an agenda for an issue that obviously also affects the students. For the supervisor it involves two steps: (1) taking care of one's own challenges (the opposite of trying to make it disappear by repression); (2) involving the students in taking care of this challenge (inviting co-responsibility). The following section elaborates on the supervisor experiencing his/her own challenges.

EXPERIENCING CHALLENGES AS SUPERVISOR

In this section, we characterize and exemplify situations where the supervisor confronts his or her own personal challenges or experiences issues related to his/her feelings of tension and mental or emotional strain related to negative self-relations. We also exemplify ways for the supervisor to address and alleviate such situations.

In our experience, *tension* is often related to *performance pressure* and *anxiety*. One reason for this might be the supervisor's background, including a high level of education and sustained competitive career path, providing an agelong intensive training for using their intellect and their academic reflections – perhaps at the expense of not developing bodily grounded sensing capabilities. All supervisors have experienced tension and performance pressure. Anyone denying this probably suffers from deep repression. We *face* such challenges when we make disproportionate preparations prior to a meeting or when we feel uncomfortable, disturbed, nervous, or alarmed before entering a group meeting. We *become* challenged if we "pull ourselves together" and with "clenched teeth" enter the meeting room. And we *are* challenged when we are distracted from sensing the students' attitudes/feelings during the meeting or if we choose to put on a mask and pretend, for example, to be knowledgeable in cases where we are, in fact, in doubt. Example 9 describes how this might unfold.

> Example 9 [Tension and performance pressure]
>
> I had thoroughly prepared my supervision meeting with many written notes on the 30-page draft from the project group. I hardly noticed that I was tense when the meeting began, but I did notice I got nervous when I started my feedback—and lost my perspective and outline of general vs. more detailed comments. I smiled to the students, disguised my uncertainty, and announced, "well, I will just give you my comments one by one as they appear in my printed draft." Then, I concentrated on giving all my comments. Half an hour later the last comment was given. The students expressed their gratitude and did not have any other immediate questions. When leaving the meeting, I noticed that my voice felt hoarse and overstrained.

The supervisor in Example 9 suppresses the feeling of performance pressure by "going up in the head" (the opposite of grounding), withholding the free breathing through different patterns of muscular tension in the pelvic and stomach region (squeezing the solar plexus and pelvic area), resulting in an exhausted voice. It is very difficult, perhaps impossible, to alleviate being challenged by tension without working on being grounded. Example 10 describes how a supervisor relieves tension by using a simple grounding exercise.

> Example 10 [Tension and performance anxiety]
>
> Before meeting the student group, I felt increasingly tense—almost as if I was about to enter a large auditorium scene to give a lecture or present a conference paper. I locked the door to my office and used five minutes in private to perform the basic grounding exercise standing on slightly bent legs with the upper part of my body hanging downwards and paying attention to my breathing (see Figure 1). After this exercise, the tense, almost panic-like mood was replaced with a sigh of relief, and I was ready to meet the students.

Symptoms of tension and being personally challenged by performance pressure or anxiety come in many guises and include situations where the supervisor becomes obsessed with giving comments to the group and thereby not sensing responses from the students (becoming absorbed in one's own performance); sidestepping a complex issue or question from the students (disguising one's own feeling of not being knowledgeable or good enough); defending one's own comments and sternly repudiating critical counter-arguments (error-admitting phobia); taking responsibility for the student group and their project (confusing one's own and students' responsibility); feeling nervous "on behalf of" the students, for example, before an oral group exam (suspecting that one was not good enough as a supervisor); or feeling strained, impotent, or fearful when facing a vociferous dispute or an open conflict between the students (nervousness and being on the defensive).

Responsibility confusion is, in our experience, a common symptom often experienced by younger supervisors, such as PhD-students, and it may be a challenge that could take many years to overcome. Example 11 illustrates this confusion and a proper response if the supervisor later acknowledges he/she made a mistake.

Example 11 [Responsibility confused]

When I read my student's project presentation for the mid-term evaluation,[5] I was shocked and disappointed. Why hadn't they come any further? Why had they not incorporated the comments I gave them at the previous meeting? When the mid-term evaluation began, I felt angry at them but pulled myself together and just asked them in a polite way what happened to my earlier comments? When asking, I realized that my voice reminded me of a whispering snake.

After the mid-term evaluation, I realized that I had been caught up in my own responsibility confusion, being too critical towards the students' work, acting aggressively and disappointed, and without paying attention to the positive results they also had contributed. I sat down at my computer and carefully wrote an email to the group where I apologized and explained how and why I had acted as I did.

The relation of responsibility confusion and performance pressure triggering negative self-relations may be outlined as: If "the students do not perform," then "I am responsible because I do not perform as supervisor." This may trigger a feeling of *being* wrong. The fear of being wrong is established during childhood (Juul, 2011) and early relationships with parents (Storm Jensen, 2002). However, if we realize that we became confused, we can choose to take adequate responsibility for our actions.

Many supervisors have trouble recognizing if they have made a mistake. Just like performance pressure, we have experienced this as a fairly common characteristic of a highly academic lifestyle. We refer to it as *error-admitting phobia*, that is, the fear of having made a mistake and admitting it, which typically triggers the feeling of being wrong. This may well be met with a habitual solution strategy of error-denial, that is, not wanting to acknowledge faults and flaws, as illustrated by Example 12.

Example 12 [Error-admitting phobia]

At the preparatory meeting before the project group exam, the external examiner[6] raised a substantial critique of the students' choice of methods. I hardly noticed that I got very tense. I started to defend the students' choices, remarked how early they were in their university program, and listed several problematic issues they had struggled with. In my attempt to cope with my feelings of being ashamed, I might have also told a little white lie by saying that I actually did refer to a methodological weakness during my supervision—but I cannot remember if I did. During the exam, it surprised me how well the external examiner presented the critique and that the students constructively accepted it and discussed its implications for their project work.

In Example 12, the negative self-relations resulting in error-admitting phobia were solely experienced by the supervisor. When we feel we are wrong and become anxious about this, we may either turn this inward and start to criticize ourselves ("hammering ourselves on the head") or outward to our opponents *playing the victim* ("It is *your* fault that *I* feel wrong") (Storm Jensen, 1998). Playing the victim represents the opposite of taking responsibility for one's own behavior by projecting the responsibility for the things that have gone wrong onto one's counterpart or blaming him or her for unfair or inappropriate behavior towards you. Example 13 describes a situation where the supervisor receives an email, triggering the fear of being wrong, followed by error-denial and playing the victim, both of which are quite unsuccessful strategies that are attempts to dull the immediate unpleasant symptoms. After a while, the supervisor becomes ready to re-assess the email without being challenged.

Example 13 [Error-admitting phobia and playing the victim]

I was busy and stressed during the start of the semester and responsible for allocating the supervisors to all project groups formed among 120 students. Shortly after completing this difficult task, I got an email from a student: "I understand that you have allocated NN to supervise our group and we would like to stress that we need a supervisor" … I snapped for breath, stopped reading, and quickly closed the email. For a split second, I got this creeping anxious feeling. Had I made a mistake? Did I have to remake the large allocation puzzle? This feeling immediately transferred into anger towards the students. How did they dare question my allocation! I was just about to write an angry reply (letting them understand who was in charge here) when something made me hesitate and make the sound choice of waiting for my immediate mood to dampen. The day after, I carefully read the email and realized that it was not at all an attack on me but a relevant request for contacting a supervisor with a specific research interest. Then I could write a proper reply without being challenged by feeling wrong.

If we feel attacked and we start defending ourselves (either openly or as a silent conversation in our heads), this often involves error-admitting phobia and playing the victim. As indicated in Example 13, it is introduced by a feeling of anxiety for having made a mistake that makes one wrong. This feeling of anxiety (maybe just briefly experienced or unnoticed by an immediate oppression) may transcend into a protest (anger), projecting the sense of guilt on to a counterpart, who, in this way, is made guilty in one's own challenging situation. It represents clear indications of confusing self-confidence with self-esteem: the confusion of feeling wrong (when nobody, in fact, is) because of what has been done, versus maintaining the belief of being a good person even though regrettable mistakes have been made (which we all do frequently). Posborg expresses the Sensethic focus on *distinguishing between being and doing* like this: "[Do] not mistake *doing* something wrong with *being* wrong. It is, as we all know, human to fail—and realizing this is genuine humanity. Making a mistake is not a property of being human, but a human action" (Posborg, 2009a, p. 155, translated from Danish).

If a supervisor only occasionally experiences his/her own challenges, he/she can choose to either ignore, forget, or suppress it – or he/she can choose to be open toward his/her own uncertainties, take responsibility for inappropriate actions made during the meeting, and explain or apologize for mistakes and shortcomings. Admitting a mistake (as illustrated in Examples 11 and 13) might well result in feelings that stem from hostility towards yourself (accusing yourself for being wrong) or towards others (playing the victim) into a relieving compassion, which would be an appropriate feeling toward yourself. However, if one often (or on a regular basis) experiences personal challenges, and this is difficult to deal with, it can be considered as an automated habit of negative self-relation that is worth noticing and reflecting upon – as described in Example 14.

Example 14 [Sustained over-responsibility]
One evening, I confided to an old friend that I always had a bad conscience because I did not spend more time working on my research papers. I blamed all the preparations I had to do for my teaching and supervision and that I always felt so indisposed and tired after preparing, that I had no energy left for my research. She asked me why I always prioritized my teaching: "It's like you eat up all the potatoes first and then you have no appetite left for the dessert." I started to protest: "You don't know how it is—I have to prepare all this before …." and then I suddenly became silent. Why did I behave like this? Why did I always make my "duties" first and lose my appetite for any "dessert"? I had no answer to this.

Indicators of this kind, that is, that of often experiencing tension and personal challenges as characterized above are, unfortunately, often ignored, even though they may have serious consequences for health and well-being. They include, for example, if you experience that you usually criticize the students' working effort; if you often are disappointed by their work or even angry at them (thinking "why do they not …"); if you are over-responsible, and tend to exaggerate your preparation before group meetings and when reviewing student drafts. Emotional symptoms include self-reproach, a bad conscience, and low job satisfaction. These symptoms may well develop into bodily reactions, such as poor sleep or lack of sleep, and chronic fatigue, all of which might indicate *stress symptoms*; see Example 15.

Example 15 [Experiencing stress symptoms]
After a hard day's work, I was really tired and went to bed. I almost fell asleep and maybe I did sleep for some time when I suddenly woke up. I had dreamt I was under accusation for something and that I struggled to defend myself, carefully arguing for my case. I felt drowsy and wanted to get back to sleep but what might have started as a surreal dream evolved into a series of arguments, explanations, and concerns for my upcoming meetings and activities. Even though I was exhausted, I became more and more awake and realized that I would have a hard time getting back to sleep. Then I got frustrated, upset, and angry at myself. Why can't I just go back to sleep? The time was 2 a.m., and I was facing another day of being exhausted.

Indicators of stress symptoms should not be accepted or ignored, as illustrated in Example 16. Rather, they should be used as decisive occasions for actively addressing the personal challenges. One way of doing this is through collegial supervision (Andersen & Bager, 2015). Consistent challenges might also be addressed through other forms of activity: physical grounding exercises, individual supervision, supervision workshops, or therapy. These may last for longer or shorter periods of time (one or a few sessions, sporadic courses or workshops up to a few days length, or year-long regular training programs or courses, including individual or group-based therapy).

> Example 16 [Ignoring stress symptoms]
>
> Four weeks of summer holiday. What bliss. It did take me a week or two to really enjoy it and relax from work and thinking about work, but then I enjoyed it to the fullest! The last days of my holiday, I started to feel restless and during the night before my first day back at work, I woke up fatigued and worried. I knew from experience that this had happened during earlier holidays, and that I just needed to pull myself together and get back to work. After some days, I would accommodate, get back into the routines, and stop feeling so discouraged that the holidays were over.

CONCLUSION

Supervising project groups principally comprises supervision on the academic subjects involved in the student's project work. The context of supervising project groups is constituted by processes of communicative interactions, collaboration, and social dynamics involving contact among all participants. As demonstrated in our examples, this often involves challenges due to the students – or the supervisor – experiencing personal issues that interfere with the aim of maintaining a constructive focus on academic reflections. This is why we suggest an academic *and* personal approach to supervision. Our point is to acknowledge that we regularly face personal issues that compromise the quality of the contact relationship. Our aim is to exemplify, clarify, and characterize problematic situations, as well as to understand, conceptualize, and provide some help regarding how to act upon these situations.

Indicators of emerging and disturbing personal issues include speaking faster or continuing to repeat an argument in different ways (as an unsuccessful attempt to communicate), longer or frequent periods of silence (as a result of anxiety, e.g., towards the supervisor as an authority), a student being withdrawn or showing signs of sadness (feeling inadequate and "wrong"), students dropping passive aggressive hints towards each other (manipulating), or blaming each other (playing the man instead of the ball). The existence of such group dynamics is a widespread phenomenon. In some cases, the project group chooses to hide it from the supervisor. In other cases, the supervisor might observe or sense such dynamics during a meeting. This allows the supervisor to choose to either take responsibility and intervene, or to resign and leave this challenge up to the students alone. If resignation is chosen, this may be accompanied by a feeling of discomfort and being powerless towards the group dynamic. Choosing to intervene may change the focus from "what we try to do now" to "what is going on now," with the aim of establishing an agenda of investigating what is at stake – right then and there in the meeting. The goal of this intervention is to re-establish the students' engagement in becoming authentic, credible, attentive, and present. Pursuing and changing focus requires that the supervisor observes and recognizes the students' challenges and is willing to intervene. The supervisor's senses play an important part; his/her body can sense when the contact quality is compromised before it is understood with the mind. For example, the supervisor might sense that something seems "wrong," when facing a (perhaps uncomfortable) situation that does not align well with the intended meeting taking place. We have exemplified and proposed a number of concepts to support investigations and reflections on "what is going on now," including tension, being distracted, disappearing, pretending, authenticity, manipulating, repeating the argument, responsibility confusion, error-admitting phobia, playing the victim, performance pressure and anxiety, and distinguishing between being and doing.

Being able to pay attention to body signals (i.e., sensing and feeling) is the prerequisite for investigating personal challenges with the mind – to reflect on and understand them and take them seriously by reacting appropriately (Storm Jensen, 1998, 2002, 2008). This is the case both when meeting students being challenged and when the supervisor experiences his/her own challenges.

Our body-oriented psychotherapeutic research and the Sensethic Approach identifies negative self-relations as a key contributor to causing problematic human contact (Storm Jensen, 1998, 2002, 2008). For the supervisor this is often manifested as a challenge related to performance pressure and the underlying performance anxiety. This anxiety is rooted in—and driven by—a confusion between being and doing: I observe something (for example a student looking bored; losing overview during my presentation; meeting a counter argument that questions my claim or case; etc.). I interpret the observation and makes it my responsibility to "solve" it. If I do not solve it, I fail and I am "wrong*." Then* it gets really dangerous, as I am questioning not only my actions (doing), but also if I am good enough (as a human being). Negative self-relations might result in endless speculations, over-responsibility, and work, because now my self-esteem is at stake! In addition, this may manifest reaction patterns as error-admitting phobia and playing the victim to avoid taking 100% responsibility for performing a wrong action and hereby protecting against the perception of being wrong. The confusion of doing and being points to where there is a choice and where there is not a choice. If one "can sense, that one is unrestful and anxious, then these are the feelings one has: They are an expression of one's existence [here and now] that must be accepted. On the other hand, one may choose how to act [doing], that is, how one responds to oneself and one's feelings" (Posborg, 2009a

p. 151, translated from Danish). Taking responsibility for one's own mistakes (doing) without compromising one's own being (that is, being confident that "I am still a good person even though I made a mistake, and I can take responsibility and take action to correct my wrongdoings") is to acknowledge the premise that our basic intentions are always good, but also that we may fail in trying to act according to these intentions.

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[1] According to the Danish Ministerial Order on the PhD Program, the PhD student may be charged with up to 840 hours of teaching obligations. At Roskilde University, a majority of this teaching is typically allocated to supervising project groups.

[2] Abductive reasoning refers to a process of suggesting and stating hypotheses explaining problems, as well as suggesting possible ways to solve them. This type of reasoning is especially relevant during design-oriented project work; see, for example, Simonsen and Friberg (2014).

[3] In Danish: "*Sensetik"* is a name that includes the duplicate meaning of being a general term for studies based on sensations (and sense), as well as an indication of the finding that ethics, values in human relations, are based on bodily, emotional sensations (sensetik.dk).

[4] Over-breathing using the upper part of the lungs might feel like one is missing oxygen. Physiologically, it is rather a sign of one missing carbon dioxide. This can be relieved by exhaling and emptying the lungs and then pausing to inhale until one needs air. Panic-like hyperventilation may stimulate anxiety and protest anger.

[5] Mid-term evaluation at Roskilde University is done when the project groups are approximately half-way through the project. The evaluation is conducted as a peer-review where two project groups and their supervisors meet and comment on each other's project and project status.

[6] Many exams in Denmark must be conducted in the presence of an external examiner appointed by the Ministry of Higher Education and Science. The role of the external examiner is to ensure that the examination takes place in accordance with set goals and requirements and that the student receives a fair and impartial assessment and grade.

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Variations in Project-Based Course Design

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ABSTRACT

Project-based learning (PjBL) is seeing increasing scholarly interest and pedagogical use in higher education, but instances of PjBL do not necessarily seek the same educational outcomes. Using the grounded theory method, the authors plot five courses in a PjBL program on a matrix of course design characteristics ranging from Fixed to Flexible and Individualistic to Cooperative. They describe four major variations of PjBL based on this matrix. Recognizing that PjBL courses vary in their use of student choice and student collaboration, the authors make recommendations for assessment researchers and for teachers wishing to develop new strategies that fit their institutional and disciplinary contexts.

Keywords: Project-Based Learning, Collaboration, Student Choice, Teaching Styles

INTRODUCTION

As project-based and other student-centered learning strategies gain increasing use in higher education, there is a need to recognize variations across institutional and disciplinary contexts. At present, the single term "project-based learning" (PjBL) encompasses a wide variety of practices (Helle, Tynjälä, & Olkinuora, 2006), definitions (Thomas, 2000; Kokotsaki et al, 2009; Tamim & Grant, 2013), and design principles (Condliffe, 2017). Some researchers have addressed this variety by trying to sort "high-quality" or "gold-standard" project-based learning from lower quality experiences (Larmer et al, 2015; Buck Institute, n.d.; Mergendoller, n.d.). We wish to introduce a vocabulary that recognizes distinctions between types of PjBL that may be better adapted

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to different teaching styles, institutional contexts, disciplines, and other factors. In this paper, we propose a schema for discussing project-based learning pedagogies as a spectrum of methods, with emphasis on two characteristics in particular: the degree of teacher or learner decision-making about the course, and the degree of individual or collaborative work required by the project. By plotting variations on a *course design matrix*, we hope to add nuance to future discussions; to allow teachers and administrators to talk about PjBL with a common vocabulary that celebrates the unique aspirations of every course; and to allow researchers to assess this pedagogy's diverse, not uniform, outcomes and merits.

LITERATURE REVIEW

Project-based learning has attracted an increasing amount of scholarly attention and enthusiasm in recent years, with applications ranging from elementary to college levels to professional training. According to a review of literature by Kokotsaki et al. (2016), most studies focus on the way PjBL differs from traditional learning, on problems with implementation (see also Lee et al, 2014; Tamim & Grant, 2013), or on impacts (see also Guo et al, 2020). While researchers often draw data from a single setting (such as a program, class, or school), some seek to offer comprehensive principles and best practices to apply across many educational contexts (Larmer et al, 2015; Kokotsaki et al, 2016; High Quality Project Based Learning, n.d.). Condliffe et al. (2017) provide suggestions for future research.

There is not yet clear consensus in the PjBL scholarship about the degree to which two characteristics in particular are necessary, optional, or incidental to methods of project-based instruction. Those characteristics are *student collaboration* and *student initiation* of projects. A literature review conducted in 2017 found "little consensus among developers of P[j]BL design principles . . . about . . . the roles of student choice and collaborative learning" in PjBL, among other variable factors (Condliffe, et al., 2017). To demonstrate this point, in a much-cited early review of literature, Thomas (2000) identified five criteria for PjBL: projects are "central to the curriculum" (p. 3); students struggle with major concepts to solve problems; courses involve the students in constructivist investigation; projects are "*student-driven*"; and outcomes are "realistic," (p. 4) or embedded in real-world problems, audiences, or partnerships (emphasis added). In a more recent literature review, Kokotsaki et al. (2016) found that in both project-based and problem-based learning "participants . . . achieve *a shared goal through collaboration*" (p. 268, emphasis added). As these two sources indicate, researchers tend to agree that a "project" must be central to project-based learning; however, there is no consensus on the degree to which projects must be "student-driven" or "collaborative."

The lack of consensus about the necessity of student collaboration and student initiation of projects reflects a more significant imprecision about the definition of PjBL itself. Historically, "project methods" in higher education have involved "the solution of a problem; often, though not necessarily, set by the student himself" leading "commonly" to "an end product" such as a thesis, report, design plan, or computer program (Adderley 1975, p. 1; cited in Helle, Tynjälä, & Olkinuora, 2006, p. 288; see also Blumenfeld et al., 1991). Blurring of definitions between problem-based and project-based learning remains common (Helle, Tynjälä, & Olkinuora, 2006; Wurdinger, Haar, Hugg, & Bezon, 2007; English & Kitsantas, 2013), though some scholars find it useful to distinguish between them (Wheeler, 2008; Wurdinger & Rudolph, 2009). Whether or not a "project" begins with a "problem" (or a "problem" results in a "project") is, in our view, not always a consequential point for instructors designing a course. As Helle, Tynjälä, & Olkinuora (2006) observe, "project-based learning in practice can assume a variety of forms depending upon the pedagogical, political or ethical reasons for its adoption" (pp. 288-289). This point applies to student initiation and collaboration, as well as other characteristics of PjBL.

The scholars associated with the Buck Institute for Education (pblworks.org) and The High Quality Project Based Learning Framework (hqpbl.org) seem to provide a resolution to ambiguity by focusing on best practices rather than definitions. The book *Setting the Standard for Project Based Learning* (Larmer et al., 2015) proposes a "gold standard" for PjBL that includes "student voice and choice"--along with a challenging problem or question, sustained inquiry, authenticity, reflection, critique and revision, and a public product (p. 34; see also https://www.pblworks.org/what-is-pbl/gold-standard-project-design). Coauthor Mergendoller adds "collaboration" as an element of high-quality PjBL in an article posted online in 2021 (Mergendoller, n.d.; Hqpbl.org, n.d.). The concept of "high-quality PjBL" implies that teachers are incorporating "projects" into learning activities without a consistent "quality" of outcomes. While more study would be helpful to validate this implication, the course design matrix we propose below recognizes that course attributes such as student voice and collaboration exist in a range of variations, and the matrix encourages teachers to design course projects best suited to their discipline, institutional context, and personal strengths.

METHODOLOGY

Grounded Theory and Study Evolution

As co-teachers in a program of problem- and project-based courses, in 2019-20 we conducted a study that revealed to us the need for a more nuanced schema to recognize variety in project-based learning experiences across disciplines and other factors. Because we teach a humanities course in a program weighted with STEM courses, we were initially curious about the way students and faculty perceived the "teamwork" and "leadership" opportunities in project-based courses across disciplines. When our study began, we expected STEM and humanities courses to produce different understandings of these "soft skills" associated with project-based learning. Using the grounded theory method of drawing theory out of data, our research question shifted from the beginning of our project to the analytic phase. We began our study with the following question in mind: How do students and faculty understand and practice "teamwork" and "leadership" in a sample of courses representing the diverse disciplines of a broad project-based learning program? Not surprisingly, we found close resemblances between some student and faculty ideas in the same course but very different ideas about what these key words meant between one course and another. However, disciplinary boundaries did not explain the results as we expected. As we reviewed the data, a new question emerged: With disciplinary boundaries fading, how can we account for the variety of project-based course designs that lead students and faculty to such different experiences of PjBL?

Context

We conducted our study at an urban state university in the U.S. Intermountain West. All courses were offered within a program of interdisciplinary electives called Vertically Integrated Projects (VIPs). In a VIP, students of any class year and major work alongside faculty on an authentic research or service project leading to "real-world" outcomes such as creation of devices, materials, programs, or apps; publications; or other accomplishments. Students have the option to enroll for up to six semesters, growing their expertise on a single project. Projects are "vertically integrated" because they channel the work of every academic rank (first-year student to faculty) into addressing a single challenge, community need, or problem. (For more about the VIP course model, which originated at Georgia Tech University, see http://vip-consortium.org/content/vip-consortium).

From a total of 23 VIPs offered on this campus at the time of our study, we examined 5 courses representing a range of disciplines, from engineering to social sciences to literacy education. One of the five courses was our own. All courses had a different history. One was being offered for the first time during our study. Three courses had been offered for one year prior to our study. One course had been offered for more than two years. All but one were team-taught by two or three faculty "coaches" (so called in the program's course descriptions). At the time of our study, there were 4 to 8 students, including undergraduates and graduates, registered in each class.

Data Collection

Over a two-semester period in 2019-20, we collected syllabi from 5 courses, conducted interviews with 8 faculty coaches, and examined 30 student reflections. The interviews were semi-structured and lasted for approximately 30 minutes. During the first semester of the study, we interviewed faculty twice, around midterm and during the final weeks of class. In the second semester, we interviewed faculty once near the end of the semester. One of us took detailed notes while the other led and audio-recorded interviews. Both of us asked follow-up questions when needed. Faculty interview questions and student reflection questions centered on perceptions of teamwork and leadership in the VIP. (See also Penry & Son, in-progress).

Data Analysis

From a total pool of 30 student reflection papers, we read 10 together to establish the categories of our analysis and to assign them color codes. We then divided the remaining papers and used our categories to color code the rest of the data. Our four initial categories, General VIP, Humanities VIP, Leadership, and Teamwork, reflected our hypothesis that we might see a difference in leadership and teamwork concepts and practices as courses represented more or less of STEM or Humanities influence. We used the same four coding categories for the faculty interview data. We read the detailed notes of the interviews and color coded them. If we needed more information or contexts of certain words or phrases, we went back to the interview audio files and listened to them to understand and capture ideas or exact quotations. We also read the course syllabi and color coded them using the 4 categories. This completed the first round of our data analysis.

Between the first and second round of analysis, we noticed patterns of data that did not fit our original hypothesis or coding but which yielded interesting information. For example, we observed different ideas of teamwork and leadership between courses, as expected, but the distinction of STEM or humanities course seemed insufficient to explain the data. Thus, in the second round of analysis, we used the constant comparative method to identify and refine emerging themes, ultimately changing our research question. Specifically, we now wondered: How can we account for the variety of project-based course designs that lead students and faculty to such different experiences of PjBL? Using the constant comparative method, a hallmark of grounded theory (Schwandt, 1997; Glaser & Strauss, 1967), we continuously compared emerging themes with data to modify, extend, and confirm categories or concepts. As opposed to the traditional scientific method, which begins with a hypothesis, grounded theory is an inductive method that begins with data and derives theories and interpretive themes from its systematic, recursive review. “Grounded theory is a way of . . . theorizing from data, so that the end result is a theory that a scientist produces from data collected” (Morse et al., 2009, p. 18).

In keeping with the demands of this method, we expanded our review of scholarly literature during and after analysis of our study results, as our understanding of our findings changed.

At one point in our constant comparative analysis of data, we saw that we could organize certain data in a 2 x 2 matrix. We debated the naming of the x and y spectrums at multiple points, recursively testing new x and y terms against the data until we were both satisfied that our analytic categories reflected data from syllabi, interviews, and student reflections. We consistently triangulated the data from all three of these data sets and found that similar patterns and themes emerged from them. That matrix became the basis of the present essay.

After coming to agreement on the terms of the 2 x 2 matrix that best represented our data, we named one axis the "course structure spectrum," with endpoints called "Fixed" and "Flexible," and the other the "interpersonal work style spectrum," with endpoints called "Individualistic" and "Cooperative." These terms will be discussed further in the next section. We reviewed and re-sorted our data to elaborate on the meaning of these points and their resulting quadrants, pasting quotations into a new section of our notes.

FINDINGS

The Course Design Matrix

The two key variables that we identified helped us to describe the variations in project-based courses across the multiple disciplines we were examining, without making direct correlations between disciplines and PjBL characteristics. Each variable represents a spectrum of possible course design choices. On the *course structure spectrum*, classes range from Fixed to Flexible, describing the relative roles of faculty and students in making decisions about such matters as goals, assignments, tasks, timetables, and assessment criteria. When faculty make all or most of these choices, we consider the course more "Fixed"; when students make most or many of these choices, we consider the course more "Flexible." On the *interpersonal work style spectrum*, classes range from Individualistic to Cooperative, describing the way that individual members of a course conduct their work in relation to other members of the course. In courses at the "Individualistic" end of this spectrum, students have individual goals to meet, and they work independently to reach those goals. In courses at the "Cooperative" end of the work style spectrum, students work with each other to achieve common goals. Using the interpersonal work style and course structure spectrums as the x- and y-axis of a 2 x 2 matrix (see Figure 1), we plotted the courses in our study in four quadrants, which represent four ways of approaching the organization of PjBL courses or assignments (See Figure 2).

Fixed *Quadrant 1 (Q1)* **Individualistic**	**Course Structure** *Quadrant 2 (Q2)* **Cooperative**
Work Style *Quadrant 3 (Q3)* **Flexible**	**Work Style** *Quadrant 4 (Q4)* **Course Structure**

Figure 1. Course design matrix for project-based pedagogies.

Our course design matrix bears a notable resemblance to Mascolo's (2009) foursquare matrix of teaching and learning modes. In the extended review of literature that followed our data analysis, we found that the two spectrums that helped us organize PjBL course variations were affirmed in Mascolo's schema for complicating the binary of "student-centered" and "teacher-centered" pedagogies. The variable that we call the course structure spectrum resembles Mascolo's "degree of teacher direction," ranging from Directed to Non-Directed, and what we called the interpersonal work style spectrum, Mascolo refers to as "individualized versus group learning" (p. 22), ranging from Individual to Social. Mascolo classifies many teaching and learning modes, ranging from "group drill" and "chant" (Directed-Social mode) to independent learning (Non-directed-Individual mode). The findings of our PjBL study lead us to differ with Mascolo in the relation between "inquiry learning" and our similar matrices. Whereas Mascolo plots "[p]roblem-based or inquiry learning" (his closest pedagogical mode to PjBL) on the Social end of his matrix (in it, "groups of students collaborate in an attempt to solve particular problems"), we find that PjBL can happen in all four quadrants of the course design matrix (Mascolo, 2009, p. 16). Nonetheless, we share with Mascolo the finding that teaching strategies are implemented on a spectrum, and we find the concept of a teaching spectrum essential to our understanding of variations in PjBL courses.

Quadrants

Thus far, much of PjBL scholarship creates the impression that all PjBL, by definition, belongs to quadrant 4, the Flexible-Cooperative course type. However, the five PjBL courses in our study represent three different quadrants (#2, #3, #4). These courses varied not only by exhibiting attributes of different quadrants but also by expressing differences *within* quadrants. In no two courses was the combination of course structure (the Fixed/Flexible attribute) and interpersonal work style (the Individualistic/Cooperative attribute) exactly alike. (See Figure 2.)

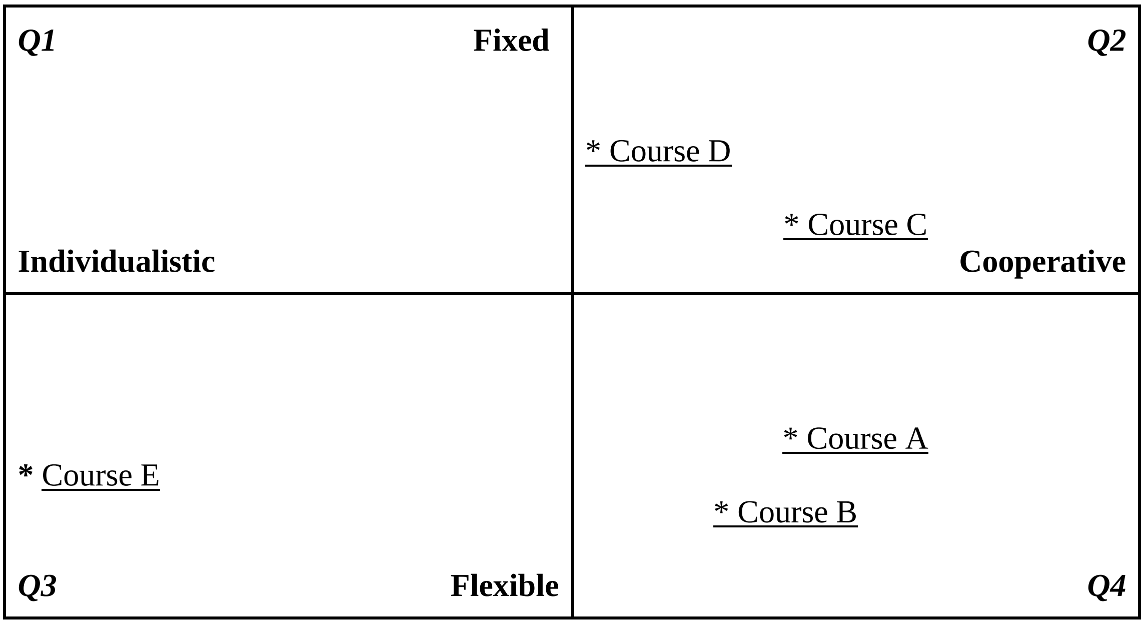

Figure 2. Courses in our study plotted on the course design matrix.

Consistent with the PjBL literature that associates Cooperative and Flexible course designs with PjBL, the courses in our study tended toward these two characteristics, with four courses (80%) in quadrants 2 and 4, the Cooperatives; 3 courses (60%) in quadrants 3 and 4, the Flexibles; and no courses in quadrant 1, Fixed-Individualistic. More specifically, two courses from our study exhibited attributes of quadrant 2 (Fixed-Cooperative), with one closer than the other to quadrant 1; one course exhibited strong attributes of quadrant 3 (Flexible-Individualistic); and two courses exhibited strong attributes of quadrant 4 (Flexible-Cooperative). Even though Cooperative and Flexible characteristics were prevalent, they were not *definitive* of project-based learning shown in the variations of PjBL courses in our study. In this section, we share qualitative data from course syllabi, faculty interviews, and student reflections to elaborate on the characteristics of quadrants 2, 3, and 4.

Despite the importance of Cooperative and Flexible characteristics in our sample, only 2 courses in our study represented quadrant 4, or a combination of both traits. One syllabus (Course A) called for students to write a "course plan," in which the student would lay out a plan for leadership or support of one or more "missions." If a mission on the syllabus did not win the support of any students, it was dropped from the semester. In one instance, faculty admitted to having a favorite mission for the class one semester, which no students chose on their course plans. Despite faculty attachment to it, the mission was dropped from that term because student interests lay elsewhere. This illustration suggests a strongly Flexible course in our schema. This course also exhibited multiple Cooperative attributes. For example, students who expressed interest in the same mission became a team for the semester. Student teams drafted plans of action, timetables, and final goals for their chosen missions under faculty guidance. Students worked together to accomplish tasks and communicated with teammates outside of class time by texting each other and calling additional meetings. Class time was spent with teams briefing each other on their actions since the last meeting and calling for support. A key role for faculty in this class was "helping students see that it was ok to change plans" and facilitating student revision of timetables, outcomes, or both.

Faculty in the other quadrant 4 class (Course B) described their method as "find[ing] a project the students are interested in working on" and "facilitat[ing] community contacts" and "the resources they needed." The role for faculty was to provide a "safety net" for student ventures. In this class, faculty helped students connect with real-world community partners on issues meaningful to them, but when partner needs shifted or projects ran into snags that could not be addressed in the scope of a one-semester class, students and faculty together went back to the drawing board to find a new project. When we first interviewed faculty for this course around the midterm of their inaugural semester, teams were reorganizing and revising plans after some initial setbacks. The most important quality of the class at that point, as described by one co-teacher, was "that everyone seems quite relaxed" with extended uncertainty. Or rather, almost everyone. This person corrected: "It's most difficult for ----, who's a do-er." By the end of the semester, faculty reported that students were able to start and accomplish a project; however, at the time of our first interview, this group was experiencing the uncertainty commonly attributed to *all* PjBL but especially likely to appear in quadrant 4. (See Lee et al., 2014, n.p., on challenges of PjBL for faculty, such as the "leap of faith" necessary when an instructor gives up some classroom control.) As the most Flexible-Cooperative course in our sample, Course B also took the most time for students to find their projects and produce results. Everyone in class--teachers as well as students--had to be able to tolerate uncertainty and ambiguity in this course type.

As important to our study as quadrant 4 was quadrant 2, where another two participating courses expressed Fixed-Cooperative characteristics. In both courses, students performed tasks and delivered outcomes substantially envisioned in advance by their instructors--a Fixed attribute. Compared to the three more Flexible courses in our study--in which faculty members did not know in advance exactly what sort of work the students would perform or what tools they would need to perform it--in these courses, faculty provided more guidance to students about what to accomplish and how to get there.

The Q2 course with a combination of Fixed, Flexible, and Cooperative traits (Course C) had a well-articulated goal using a technology funded by faculty in advance of the course.

To meet project objectives, all students needed a certain degree of preparation in common research techniques and technical skills. The need for cooperation was spelled out in three different course learning outcomes on the syllabus: Academically, students were expected to "work as a community of researchers." Personally, they were asked to "practice and reflect on effective teamwork." Civically, they reflected on "the tension between unity and difference" and learned to "honor difference, find commonality." Thus far, this course was Fixed and Cooperative. However, when challenges arose within this course, faculty asked students to brainstorm and execute solutions. According to student reflections, this Flexible approach to problem-solving helped at least one student learn more about another trait, Cooperation. As the student explained, "I've learned that when things aren't going the way you planned, having a team with similar goals made finding the next step way easier. Constantly, in the project and real-life, plans change and things must be redirected, and the best way for that to happen is when there's a pool of minds with similar goals but different perspectives." In this course, even though faculty had a clear plan for outcomes, technologies, and methods, the Flexible approach to problem-solving suggested a possible relationship between the two spectrums, with a Flexible course strategy supporting student learning at the Cooperative end of the work-style spectrum.

The Q2 course closest to quadrant 1 (Course D) was centered similarly on a faculty vision for a particular technology--in this case its development rather than its use to collect data--designed to assist a third-party community partner. All students worked to meet the same outcome, predetermined by faculty as the *raison d'etre* of the course. The syllabus provided a specific list of "deliverables" and a detailed plan for course assessment, which included a final report from each student with a predefined length, structure, and annotation style. As the faculty explained in their interview, they "found the students worked better when given more structure." This was the only course in our study with an assigned text. These characteristics made Course D the most Fixed of course designs in our sample, according to our model. However, this course also had some Flexible attributes. Students carried the responsibility for figuring out how to engineer and market their product, and their regular reflections on *themselves* and their personal growth constituted one of the course's objects of study. On the x-axis in our matrix, this class combined Cooperative and Individualistic traits almost evenly, with a slight nod toward the Cooperative side of the interpersonal work style spectrum. All students belonged to either an "engineering" or a "marketing" team; the teams communicated with each other outside of class; and class time was devoted to mutual briefings, as in other Cooperative courses. However, when asked to comment on what they learned about teamwork at the end of the semester, multiple students affirmed the value of "individual" and "self" concepts. As one student put it, "[I]t's been interesting to watch the interplay between the two different sides of the VIP . . . as far as how they interact and build off of each other's needs while also remaining self contained." Another student reflected, "In big teams (such as a nation or company) still there is much power in the individual."

The final course in our study combined Flexible and Individual attributes (Q3) in a way that made it unique both in our sample and in PjBL scholarship. In Course E, students "obtained expertise in emerging technologies" by developing a business model or designing an object using the "innovative tools and emerging technology" in a campus space designated for production of "videos, podcasts, code, apps, tools, big ideas, prototypes, business ideas, inventions, and more." In this highly Flexible and Individual course, students designed their own individual projects, including goals, timetables, and deliverables. They had a course meeting place but were not required to attend at the same time as long as they continued to make weekly progress on their activity. The syllabus referred to students as a "team," and the instructor noted that students gave feedback and encouragement to each other when they met in the common space, but they did not work together to design the same object or meet the same goal. Each student ended the course with a separate (Individual) final project and presentation. A common template for this presentation provided a rare Fixed attribute for this course, but Flexibility was evident in the wide variety of student projects and outcomes, ranging from creation of a physical object to creation of a curriculum. All final presentations included a summary of the individual project, original semester goals, achievements, and future goals. There was no indication on the syllabus or in faculty interviews that students might collaborate on their final presentations or work toward a common goal.

Our study did not yield any courses in quadrant 1, but we believe it is worth elaborating briefly on what a Q1 course might look like. We both have encountered and taught Q1 projects, and we expect future studies to reveal that this pedagogy is already pervasive at all levels of education. In this quadrant, teachers plan projects that students complete individually. Because every quadrant represents a spectrum of course criteria, students might have a choice of this or that project, and they might complete some portions of the project together and some portions individually. Teachers might assign students to a project, or students could select one from choices created by the teacher. Teachers are likely to create assessment criteria and timetables. Allowing for these variations, what separates quadrant 1 from other quadrants is that students chiefly accomplish outcomes on their own that have been envisioned and planned by a teacher in advance.

DISCUSSION AND IMPLICATIONS

While our findings did somewhat affirm our initial hypothesis – that students and faculty in STEM and humanities courses had different ideas and practices of teamwork and leadership – the grounded theory method allowed us to draw conclusions that seemed more helpful to teachers and administrators of PjBL. By creating the course design matrix, we answered our revised question, *How can we account for the variety of project-based course designs that lead students and faculty to such different experiences of PjBL?* The flexibility of the matrix, with application to any discipline or institutional context, allows PjBL research and practice to use a common vocabulary while recognizing diversity. The course design matrix introduces the possibility of greater nuance in PjBL assessment and raises questions about how to scaffold both teacher and student learning from familiar methods (usually more Fixed and Individual) to less familiar ones.

We learned from our study of project-based courses that no single set of attributes for PjBL encompasses the variety of activity that we observe across disciplines, instructor styles, and course goals. Nor is it useful to correlate one discipline with one PjBL style. We find it most helpful to think of PjBL not as a single teaching strategy but as a *variety of strategies* that put a "project"--a definable outcome produced at the end of a complex process--and its reflecting learner at the center of a lesson or course.

Most courses in our study exhibited characteristics from the Cooperative and Flexible ends of the course design matrix, which is consistent with the scholarly literature in which the terms "student-driven," "student voice and choice" (Larmer, 2010, p. 34), and "collaborative" appear frequently as defining PjBL traits. However, the diversity of course attributes in our study leads us to conclude that PjBL does not necessarily have to exhibit any *particular* attributes or combination of attributes in the course design matrix.

This finding may be most significant for researchers creating instruments to assess the efficacy and outcomes of PjBL. Success stories for this pedagogy tend to describe Flexible-Cooperative (Q4) pedagogies (see, for example, Thomas, Enloe, & Newell, 2005; Vander Ark & Dobyns, 2018), and researchers have been encouraged by the success of Q4 course types (hqpbl.org). However, Condliffe (2017) and others remind us that the assessment of PjBL is still a work in progress. Before we can be certain that Flexible-Cooperative (Q4) PjBL has the most educational value, it will be necessary to consider also the outcomes for Q1-Q3 varieties of PjBL in teaching environments where they are adopted. For example, studying project-based classes with a high level of student choice and collaboration (Q4) will not necessarily provide insight into the learning value of courses in which a faculty member carefully designs achievable projects for newcomers to a discipline who work individually (Q1) or in teams (Q2). Because we suspect they are widely used but scantily recognized as PjBL, we are particularly concerned that researchers assess Q1 courses as well as courses in the other quadrants. We need research on outcomes to find out the value of project-based curricula, regardless of whether projects are Fixed or Flexible, Individualistic or Collaborative.

The best assessments of PjBL will consider courses with a variety of attributes before drawing conclusions about PjBL generally. Not only the attributes in our course design matrix--student choice and collaboration--but other attributes commonly associated with PjBL, such as a real-world outcome or leadership, may or may not be important to any particular PjBL assignment. PjBL's overall success can be assessed based on how well the project and reflection helped students meet course learning outcomes rather than how well students acquired specific skills (e.g., collaboration, initiation, ability to apply knowledge to real-world problems). When assessors wish to know how well PjBL *does* support specific skills, it will be important to distinguish between different PjBL course designs (Q1-Q4) and course objectives.

Another implication of our findings is the benefit to teachers wishing to experiment with new teaching methods. We believe that the course design matrix invites teachers to implement project-based strategies in a way that is most complementary with their existing strengths and their institutional culture. The teacher reluctant to experience the "chaos" of a highly Flexible project may prefer a more Fixed approach; the teacher who has most success guiding students to discover their Individual strengths does not need to adopt Cooperative methods. For those who have tried PjBL, found it "messy," and are reluctant to try again, the course design matrix offers alternatives, including entirely different quadrants, so that a teacher can retain what worked about the project, then choose to provide more or less guidance (the Fixed/Flexible spectrum), or more or less of collaboration (the Individual/Cooperative spectrum), until she or he finds the way to deliver a powerful learning activity in the way best suited to the content and to her or his strengths. By considering where they are most comfortable on the course structure and interpersonal work style spectrums, faculty can minimize the risks and discomforts of PjBL while reaping at least some of the benefits of active, outcome-oriented learning combined with reflection.

The course design matrix allows us to introduce new questions to PjBL planning and assessment. Perhaps chief among them is the question (implied by the "high-quality" approach to PjBL) of whether quadrants 1-3 offer developmental value for teachers who want to move their PjBL skills to quadrant 4. As Hmelo-Silver & Barrows (2015) suggest, the "expert facilitator" possesses a "repertoire of strategies" that enable her to manage the chaos of highly Flexible course designs (p. 82). Is it possible that some of these may be developed by teachers growing their PjBL teaching strategies incrementally through quadrants? Designing PjBL in light of the course design matrix allows teachers to scale projects up or down in complexity and duration, according to available time, resources, and other conditions. This variety seems to us important for encouraging teachers not only to try project-based methods but also to keep growing as PjBL practitioners.

A final implication of this study which needs more investigation is the possibility of using the quadrants to support the scaffolding of student learning. Scaffolding in education refers to the teacher's effort to structure learning from the individual student's starting point through a series of stages that increase in difficulty and complexity. Some researchers consider scaffolding as an inherent characteristic in all PjBL (Condliffe et al, 2017). There may be potential to use the course design matrix to scaffold projects so that students move from one area of the matrix more familiar to them to an area less familiar, such as from an individual work style to a collaborative one, or vice versa. By recognizing work in every quadrant as project-based, we gain the ability to imagine various ways not only for teachers to design projects but also for students to engage with them.

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Enhancing Student's Problem-solving Skills through Project-based Learning

Ebrahim Karan and Lisa Brown *

ABSTRACT

The goal of the study is to overcome two main drawbacks of traditional science, technology, engineering, and math (STEM) pedagogical strategies using PBL - lack of student engagement and students who are not prepared for more complex problems. PBL teaching strategies practiced in an introductory class are assessed. Classroom observations and student surveys are used to determine at what level does the PBL affect students' problem-solving skills. For the first half of the semester of the course, traditional lectures were used, during the second half, students are divided into experimental (PBL strategy) and control groups. The results of the survey and student grades are analyzed to determine a statistically significant difference between pre/post-study results. From the students' perspective, there is a significant mean difference between their confidence level in solving problems before and after using PBL and the students earned higher grades compared to the students in the control group.

Keywords: Project-based learning; teaching strategies, construction management

INTRODUCTION

Solving problems is an essential skill for the future workforce in many science, technology, engineering, and math (STEM) careers. In the context of higher education, the development of problem solving skills includes a variety of teaching strategies to prepare students for solving new kinds of problems and provide opportunities for theoretical concepts to become more concrete (Netwong, 2018). STEM problems share many common pedagogical principles despite the obvious difference in their teaching strategies. For example, they present students with a real-world problem and ask them to propose a valid well-constructed solution (Jurdak, 2016). Hands-on and active

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participation have also been proposed in the literature to facilitate the problem solving learning process (Demirhan & Şahin, 2019). Developing such skills can be best achieved in using project-based learning (PBL) where students are engaged through a collaborative process of investigation over an extended period of time (Sahin, 2013). PBL represents a promising student-centered approach to overcome two main drawbacks of traditional STEM pedagogical strategies; firstly, lack of engagement in collaborative partnerships and, secondly, passive learning and compartmentalized curriculum (Pinho-Lopes & Macedo, 2014). By working with PBL, students, in groups, investigate the problem from the curriculum. Recent studies show that PBL curriculum has an overall positive impact on student attainment of professional attributes (Johnson & Ulseth, 2014).

It was noticed that students who falter in introductory STEM courses are more likely to develop learning gaps that grow as they tackle more difficult material (Alzen et al., 2018). The goal of this study is to close such gaps and build a solid foundation for more advanced work in upper level courses. This can be achieved by using PBL strategies in which instruction is delivered through small groups and students are encouraged to collaborate to master concepts. In working with undergraduate students over many years, the authors have experienced countless occasions where students are asked to work in groups to solve a problem, yet, they wait for the instructor or classmates to give them a hint to solve the problem for them. Perhaps, they have never been taught how to find the information required to problem solve. This issue is certainly not unique to the authors' experience; as other educators have noticed that many students are completely dependent on the help of a tutor for the majority of their class projects (Khouyibaba, 2015).

It is recommended to enhance students’ problem-solving particularly in introductory classes where students need to master the basics before moving on to an advanced course (Stanger-Hall, 2012). The format of PBL can be useful as a way of challenging students to answer/solve real problems in an authentic meaningful way. In the next section, we define characteristics of PBL in STEM education by reviewing recent studies. The foundation of this study is comprised by this question: How can PBL improve the students’ problem-solving skill in introductory STEM courses? To answer this question, we assess PBL teaching strategies practiced in an introductory STEM class.

A REVIEW OF PROJECT-BASED LEARNING IN STEM EDUCATION

PBL is a student-centered form of instruct which is based on six hallmarks: a driving question, the focus on learning goals, participation in educational activities, collaboration among students, the use of scaffolding technologies, and the creation of tangible artifacts (Krajcik & Shin, 2014). Like other student-centered pedagogies (e.g. problem-based learning), PBL requires students to work together through authentic questions and to find solutions to authentic problems within real-world practices (Al-Balushi & Al-Aamri, 2014) which lead to meaningful learning experiences (Al-Balushi & Al-Aamri, 2014).

A driving question (DQ) is an open-ended inquiry that guides the problem-solving approach and the project work. For the teachers, it helps to focus the inquiry and planning of the project. For the students, the DQ creates interest and a feeling of challenge and entices critical thinking (Miller & Krajcik, 2019). The DQ should be open-ended to allow numerous possible answers and get adequate answers to complex projects. At the same time, it should be provocative and challenging to encourage students to think creatively and raise the visibility of the key learning concepts (Bielik et al., 2018). Learning goals are simply the result of the instruction; what students will learn and/or be able to do as a result of the lesson. Therefore, it is necessary to use hands-on projects that successfully address significant learning goals. PBL helps teacher combine the project goals (the aim to achieve) and the learning goals (the knowledge learned in the course) (Michel et al., 2012).

Many studies demonstrate active participation in educational activities boosts students' level of understanding and improves the ability to process content, and the retention of knowledge (Baraldi, 2013; Nasmith & Steinert, 2001). Since students have to collaborate with their peers on how to solve a problem, most projects include opportunities for collaborative problem-solving activities by nature (Cukurova et al., 2016). Negotiating how to collectively solve a problem is also part of PBL (Bell, 2010). Once projects are undertaken as groups, two types of roles are defined with PBL: The individual role performs individual tasks, and group role which is composed of several individual roles and performs collaborative tasks (Yassine et al., 2013).

A number of scaffolding strategies have been presented in the literature. Examples of common scaffolds in PBL include but not limited to: using real-case projects grounded in the personal interests (Grant, 2009), modeling with think-aloud can be used to generate student questions during a project launch (Mou, 2019), projects can be broken into parts to better facilitate collaboration in small groups, hands-on activities can be used to link theory to practice (Joyce et al., 2013), and graphic organizers can be used to visually depict an idea either through writings or charts (Chasanatun & Lestari, 2017).

Last, the creation of artifacts is a distinguishing characteristic of PBL compared to other student-centered pedagogies. Students create a set of tangible project/products that address the DQ. These artifacts are shared and present their gained knowledge (Arcidiacono et al., 2016).

RESEARCH METHODOLOGY

The class that is involved in this study is a required introductory course for BSc students in Construction Management at Sam Houston State University (SHSU). The class selected for this study is Wood Frame Construction containing 26 students with 3 females (11%) and 23 males (89%). The class is a lecture/lab course with 1-houe lecture and 3-

hour lab per week. Figure 1 shows the woodworking area that allows exposure to the machines and hands-on practices typically found in industry.

Figure 1. The woodworking lab facility for the selected class.

The section selected for this study was offered in Spring 2021 with the COVID-19 pandemic entering its second year. As a response to COVID-19, the course delivery has been modified to reduce classroom density. The class is divided into two sections; each meets once a week with half of the students enrolled in the class (13 out of 26 students).

The authors' effort has focused on applying PBL methods as an alternative to "cookbook" procedures. Traditionally, students in Wood Frame Construction were supposed to perform the exact sequence of steps specified by the instructor or the textbook. From authors' observations, it could be seen that students did not learn when and how to apply these same procedures outside of the classroom. A deeper understanding of the wood working material is needed. Most students were conditioned to wait for the instructor to give them the answer and did not take collaborative inquiry seriously.

We compiled a list of recommendations and strategies for improving engagement to fulfill educational objectives. First, we used a DQ as an entry event to give students a sense of purpose and challenge. The questions are mostly focused on solving a problem (e.g., how to frame a wall or door). Second, each project would give students opportunities to communicate, collaborate, and think critically. In addition to the PBL pedagogical benefits, there are at least three more reasons that justify the use of PBL for this introductory STEM class; First, students construct their understanding by building their wood products. Second, students are able to display their learning in a continuous process throughout a woodworking project that is consistent with real-world practices. Third, student presentations make their problem-solving skill visible to others.

The first half of the semester, traditional lectures were used to introduce all students to new topics; the instructor delivered the content over the course of a few lectures, set assignments with step-by-step procedure to measure student comprehension and moved on once it is complete. During the second half of the semester, the students enrolled in the Wood Frame Construction class are divided into experimental and control groups, with those in the experimental group being taught with PBL. Those in the control group are taught with the traditional lecture/lab method. For seven consecutive weeks, the students in the experimental group are given different wood frame projects such as framing a roof or stair, installing a door, and building a fence. As an example, the students were taught how to properly layout gable and hip roofs and introduced to rise, run, pitch, and rafter length calculations. A roof plan for a sloped gable roof was used as the DQ and the students were asked to calculate the actual length of the rafters. The DQ is presented to each team one week in advance and each team is given 5-10 minutes during the class to discuss and select which role to play or topic to study.

The student could use email, text messaging, and video communications to solve the problem. Last, students were asked to conduct real inquiry as opposed to find the information in the textbook or websites. The resources are available to use but ideas should be generated and then tested. The students were asked to actively participate in the class activities and they had to collaborate with group members to find and agree on a solution. Drawings are used as scaffolding technologies and there was a tangible artifact for each project. For example, the students were provided with a roof plan drawing and delivered a framed gable roof. In another project, the students were provided with a site plan and customer's requirements of a fence and delivered an assembled fence with a footing, two posts and pickets between the posts.

A structured problem-solving technique is used for the experiential group in the study to identify, analyze, and solve problems in an organized manner. The experimental group must agree to a solution and be able to explain the solution and the strategy used to solve the problem. Figure 2 shows students working on their woodworking projects. The learning environment for the experimental group is designed based on many elements of constructionism; the instructor acts as a facilitator and guides the students through the necessary steps to complete their project. The students are assigned tasks in which they must brainstorm, investigate, and solve problems. Other elements for the experimental group guided by constructionism include presentation of rubrics which define expectations, presentation of artifacts, collaboration between the students, and using authentic real-world projects. Constructionism (Papert, 1993) is both a theory of learning and a strategy for education asserting that knowledge is not simply transmitted from teacher to student, but actively constructed in the mind of the learner.

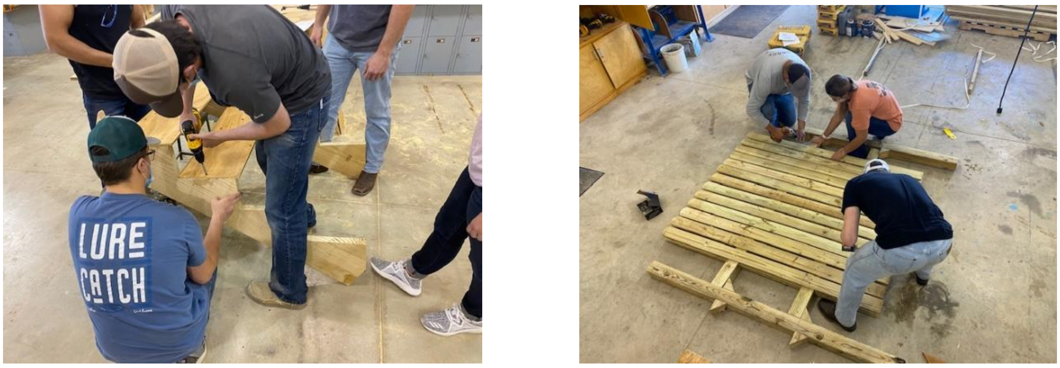

Figure 2. Examples of the woodworking projects (building stair and wood fence).

The course material has been revised to improve students' creativity and problem-solving skills through PBL techniques. Instead of providing step-by-step instruction to meet the outcome (e.g. wood planter box), the final product is identified, and students should develop creative and practical solutions (e.g. what should be used for the joints, wood glues or nail or screw connections, what are the feasible decisions based on the available tools). Once a solution is agreed upon, the team must decide how to realize that solution by building the product. Students work together in small groups and the problems are posed in a wide variety of contexts and representations.

The students were expected to present their work to the class at the end of each project. These wood products, which were representations of students' solutions resulting from the given projects, were presented as the final products to the control group. Because the projects were exactly the same for the control and experimental groups, there were opportunities for sharing ideas and getting feedback with peers. The students in both groups were given the opportunity to revise their artifact for the final project. Given the circumstances related to COVID-19, whole class presentations were not scheduled and the students did not have the opportunity to foster their intra-group communication and sharing.

DATA COLLECTION AND ANALYSIS

Data is collected for this study in two forms; through a student survey and final grades. All students in the experiential group are given a pre-survey at the beginning of the semester (when the study initially begins) which is also the same survey given at the end of the semester (conclusion of the study). The results of the survey and the students' grades are statistically analyzed to determine any statistically significant difference between pre/post-study results for the students in the experimental group. The survey used in the study is available in the appendix.

Table 1 shows the results for the pre- and post-study surveys for the experimental group. The first three questions focus on individual student's ability to solve problems. In questions 4-6, we wanted to see whether students' confidence increases while their dependence on instructors for problem solving decreases by having them present ideas and solutions. The last five questions focus on group problem-solving and the effects of various communication behaviors on the group's problem solving.

Question		**Strongly Agree**	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
	Score	**5**	**4**	**3**	**2**	**1**
1- I feel confident solving wood working problems on my own.	Pre-study	23%	46%	15%	15%	0%
	Post-study	*46%*	*38%*	*8%*	*8%*	*0%*
2- It is easy for me to find a solution to a wood working problem.	Pre-study	23%	46%	15%	15%	0%
	Post-study	*46%*	*23%*	*23%*	*8%*	*0%*
3- I use drawings or visualize the final product to find my solutions.	Pre-study	46%	38%	15%	0%	0%
	Post-study	*54%*	*46%*	*0%*	*0%*	*0%*
4- I feel comfortable explaining my solution to other group-mates.	Pre-study	31%	54%	0%	15%	0%
	Post-study	*54%*	*15%*	*23%*	*8%*	*0%*
5- Explaining my work/solution is an important part of learning about wood working	Pre-study	46%	54%	0%	0%	0%
	Post-study	*54%*	*31%*	*8%*	*8%*	*0%*
6- Problem solving is a subject that I am good at.	Pre-study	31%	54%	15%	0%	0%
	Post-study	*23%*	*69%*	*0%*	*8%*	*0%*
7- Working in groups helps me better understand woodworking.	Pre-study	85%	15%	0%	0%	0%
	Post-study	*77%*	*15%*	*8%*	*0%*	*0%*
8- I feel like I can help my group plan for a woodworking assignment.	Pre-study	46%	38%	15%	0%	0%
	Post-study	*54%*	*38%*	*8%*	*0%*	*0%*
9- If I am struggling with an assignment, it helps to have a classmate explain it to me.	Pre-study	69%	15%	15%	0%	0%
	Post-study	*54%*	*38%*	*8%*	*0%*	*0%*
10- I feel like my opinions and ideas are used in my group.	Pre-study	62%	8%	15%	15%	0%
	Post-study	*31%*	*38%*	*31%*	*0%*	*0%*
11- Working in groups could help me understand hands-on projects better.	Pre-study	69%	31%	0%	0%	0%
	Post-study	*62%*	*38%*	*0%*	*0%*	*0%*

Table 1. Survey results for the experimental group (use of PBL).

The proposed analysis is consistent with different theories, such as social constructivist theory, which emphasizes that students learn by doing especially when they work together with the teacher's guidance. The survey aims to understand whether the provided learning environments allowed students to take responsibility for their learning. Furthermore, by including mathematical statistics and data analysis the authors wanted to assess how the students (as individuals) learn differently to one another. This is also consistent with multiple intelligence theory that differentiated the intelligences of learners that are manifested in different skills and competencies.

Figure 3 demonstrates the difference between the pre- and post-study surveys. Only one data point is presented for each question. A Likert scale was used to quantify the strength/intensity of students' attitude. Each of the five responses has a numerical value to measure the attitude under investigation. The values are used to create an aggregated (or average) score for each question to measure the attitude of the experimental group. The differences in the collected Likert scale data are were considered statistically significant if the p value for a paired t-test statistic associated with the particular pair of means is smaller than 0.05. The t-test are conducted for all thirteen questions and the results are shown in Table 2.

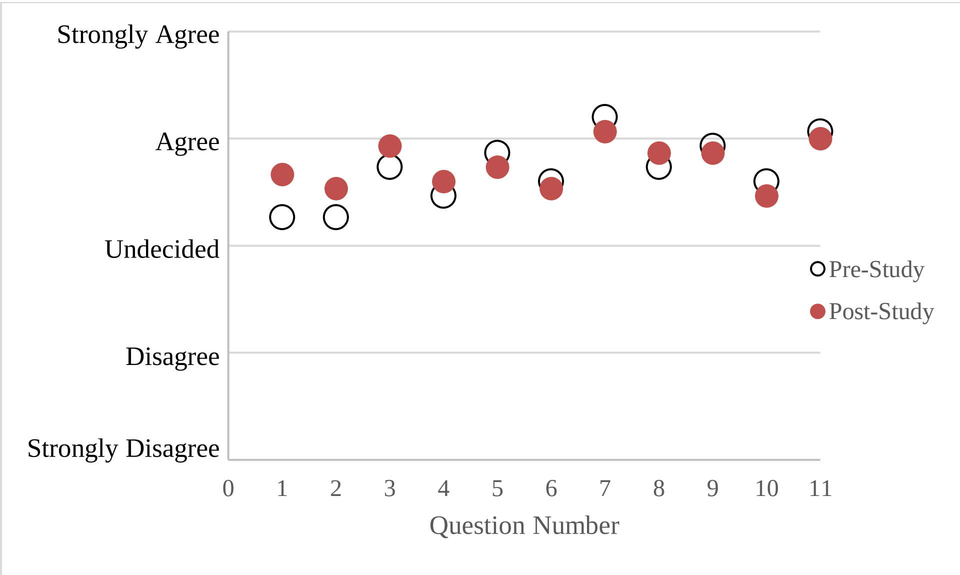

Figure 3. Survey results for the experimental group (use of PBL).

Question	Mean		Std. deviation		t	Sig. (2-tailed)
	Pre-Study	Post-Study	Pre-Study	Post-Study		
1- I feel confident solving wood working problems on my own.	3.61	4.23	1.19	0.93	-2.889	0.014*
2- It is easy for me to find a solution to a wood working problem.	3.62	4.08	1.19	1.04	-3.207	0.008*
3- I use drawings or visualize the final product to find my solutions.	4.31	4.54	0.75	0.52	-1.897	0.082**
4- I feel comfortable explaining my solution to other group-mates.	4.00	4.15	1.00	1.07	-0.805	0.436
5- Explaining my work/solution is an important part of learning about wood working	4.46	4.31	0.52	0.95	0.805	0.436
6- Problem solving is a subject that I am good at.	4.15	4.08	0.69	0.76	0.562	0.584
7- Working in groups helps me better understand woodworking.	4.85	4.69	0.38	0.63	1.477	0.165
8- I feel like I can help my group plan for a woodworking assignment.	4.31	4.46	0.75	0.66	-1.477	0.165
9- If I am struggling with an assignment, it helps to have a classmate explain it to me.	4.54	4.38	0.78	0.65	1.000	0.337
10- I feel like my opinions and ideas are used in my group.	4.15	4.08	1.21	0.86	0.433	0.673
11- Working in groups could help me understand hands-on projects better.	4.69	4.62	0.48	0.51	1.000	0.337

Table 2. Paired t-test results for the pre- and post-survey results.

* Significant at $p<0.05$

** Significant at $p<0.1$

The null hypothesis states "there is no difference in mean score of students' opinion when PBL is used". Based on the significance (2-tailed) value for the first three questions, we can conclude that there is less than 5% (or 10% for Q3) probability that there is no difference in individual student's ability to solve problems with and without using PBL. From the students' perspective, there is a significant mean difference between their confidence level in solving wood working problems when they learned through PBL compared to the traditional teaching. Furthermore, the students in the experimental group found it easier to find a solution to a wood working problem when PBL is used. Regarding the common scaffolds in PBL, the survey results show drawings and visualization of the final product are used more often to find the solutions.

Another important metric to measure the strength of PBL is the students' grades before and after using this learning method and the comparison between the grades for the students in the control and experimental groups. The control group was given similar projects but with the sequence of steps specified by the instructor or the textbook. Although students' grades are not necessarily an indicator of students' problem-solving skill, they can reflect the knowledge possessed by the students and thus show the effectiveness of PBL. We use the paired t-test to compare the students' grades before (from the beginning to the middle of the semester) and after using PBL (from the middle of the semester to the end of the semester). To exclude and understand the changes in the grades for the second half of the semester, the paired t-test is also used for the control group and the results are shown in Table 3.

Group	**Mean**		**Std. deviation**		**t**	**Sig. (2-tailed)**
	Pre-Study	**Post-Study**	**Pre-Study**	**Post-Study**		
Control (traditional learning)	0.752	0.749	0.113	0.244	0.085	0.933
Experimental (use of PBL)	0.797	0.816	0.113	0.158	-0.528	0.607

Table 3. Paired t-test results for the pre- and post- students' grade results.

Although the average difference in the students' grades for the experimental group before and after using PBL is not statistically significant ($p=0.607>0.05$), students in this group earned higher grades and could improve their grades compared to those in the control group. In addition, we use the independent samples t-test to compare the grade difference between the control and experimental group and determine whether students benefited from PBL earned grades that differ on average from those did not learn through PBL. The results for the independent samples t-test is shown in Table 4. The students who learned through the PBL performed better compared to other students in the class, but the difference was not statistically significant.

	N	**Mean**	**Std. deviation**	**F**	**Sig. (2-tailed)**
Control (traditional learning)	13	0.192	0.131	0.006	0.941
Experimental (use of PBL)	13	-0.038	0.162		

Table 4. Comparison of Students' grades for the experimental and control groups.

CONCLUSION

As a response to COVID-19, the course delivery for the selected class shall be modified to reduce classroom density. To make the most of the limited time left for face-to-face interaction, PBL was found to be an appropriate instructional approach to better engage students in the investigation of real-world problems. The purpose of the study was to understand whether PBL positively impacts students' problem-solving skills and their interests/connection to real-world problems. This quantitative study included two groups of undergraduate students. One group of students were learned through PBL for half of the semester, and the other group of students did not have the PBL learning experience. Every student in the two groups were exposed to the same curriculum throughout the duration of the study.

Data is collected for this study in two forms: through student surveys and final grades. The survey results indicate that PBL learners could benefit from this alternative learning method regarding the individual student's ability to solve problems. The survey results for the questions regarding the students' confidence, group problem-solving and the effects of various communication behaviors on the group's problem solving were not statistically significant. Regarding the students' grades, PBL learners performed better than the other group of students (2% increase compared to 0.4 decrease). Both control and experimental groups showed the same trend with respect to class participation before the beginning of the study. However, the participation rate of PBL learners in class activities was noticeably higher than that of the control group. This can be explained by the degree of active involvement of students in problem-solving as the instruction alone is not sufficient to solve the problem. The survey results and student grades were tested quantitatively in this study, but they can be further tested on more data to represent performance norms of different student-centered pedagogies.

Given that the study group may represent only a portion of the target population, it would be useful to repeat the study with a similar setting but larger student group or combining a number of introductory STEM courses in future. The investigation of communication and collaboration skills were beyond the scope of this study and the measurement of these two twenty-first-century skills can be a subject for future research. A test with open-ended questions can be used to measure students' communication skills and a peer-collaboration rubric can give students an opportunity to evaluate their team-mates.

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APPENDIX:
SURVEY USED IN THE STUDY

Please answer the following questions honestly. Your response to these questions will not affect your grade but will help me better understand different ways to teach you in the classroom! The survey will not be graded and your responses will be anonymous.

	5 Strongly Agree	**4 Agree**	**3 Undecided**	**2 Disagree**	**1 Strongly Disagree**
I feel confident solving wood working problems on my own.					
It is easy for me to find a solution to a wood working problem.					
I use drawings or visualize the final product to find my solutions.					
I feel comfortable explaining my solution to other group-mates.					
Explaining my work/solution is an important part of learning about wood working					
Problem solving is a subject that I am good at.					
Working in groups helps me better understand woodworking.					
I feel like I can help my group plan for a woodworking assignment.					
If I am struggling with an assignment, it helps to have a classmate explain it to me.					
I feel like my opinions and ideas are used in my group.					
Working in groups could help me understand hands-on projects better.					

Something I would like to change about group work is:
Something I like about group work is:

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Exploring Approaches for Blended Learning in Life Sciences

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ABSTRACT

Digital tools and platforms offer new solutions to design and conduct university teaching. This case illustrates how such digital solutions may be utilized in problem-based learning programmes within life science educations. Specifically, the case evaluated the use of live-streamed and recorded lectures, the incorporation of digital formative assessment in lectures, and the use of a digital platform to support experimental project work in a research laboratory. We find that digital solutions provide flexibility for both lecturers and students, advantageous options for collecting and sharing information, and for engaging students in their learning process. However, digital tools cannot replace all aspects of traditional in-person teaching, such as social interactions. Rather, when blended with in-person teaching, digital solutions have a large potential for supporting new forms of and approaches to both theoretical and experimental university teaching.

Keywords: Blended learning, problem-based learning, formative assessment, laboratory teaching, digitalization

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INTRODUCTION

The learning outcomes in life science education programmes, such as biology and biotechnology, contain both a theoretical and a practical element. At Aalborg University (AAU), these programmes employ authentic problem-based learning (PBL) to bridge scientifically based knowledge, obtained through courses and projects, and experimental experience, obtained through laboratory training.

The PBL-based pedagogical model at AAU allocates 50% of the curriculum to courses and the other 50% to self-directed project work (Servant-Miklos 2020; Dahl et al. 2016). The courses allow equal time for lectures and theoretical exercises, based on specific problems. This supports the projects which are designed to teach the students to solve real-life problems through a combination of research and experimental work. In this way, the PBL-based courses and projects synergize to prepare students to put theoretical knowledge into practice.

The AAU model demands a combination of teaching strategies that fit with the PBL regime (Dolmans et al. 2005). Such teaching should be interactive and engaging and stimulate constructive and contextual learning (Exley and Dennick 2009; Azer 2009). Moreover, it must embrace the practical component central to project work. In life science educations, this involves laboratory experiments, which students must plan and execute on their own initiative. However, the transition from theory to practice is challenging and necessitates intense instruction and supervision by an expert to ensure correct and safe laboratory practice during the experiments.

The COVID-19 pandemic restricted the use of existing interactive teaching formats and strategies. Urged by these challenges, we formed a working group that explored different ways to incorporate digital tools in teaching. The working group met frequently to discuss experiences, provide peer feedback, and develop new teaching ideas. At the same time, students were asked to evaluate the teaching activities via oral feedback, quizzes, or questionnaires (details on the pedagogical approach can be found in the full report). Thus, this case illustrates *to what extent digital tools provide solutions that improve both theoretical and practical PBL-based university teaching and what the outlook is for incorporating these solutions in life science education programmes.*

This was evaluated in three pedagogical experiments centered around large group classroom and laboratory teaching. In our opinion, these domains have the biggest potential and highest need for digital transformation. The three pedagogical experiments explored digital approaches for structuring lectures, for formatively assessing lectures, and for supporting laboratory teaching. Here, we present each experiment and discuss our experiences and opinions, which contribute to a future teaching paradigm based on blended learning.

LECTURE STRUCTURE

In the PBL model, lectures provide a framework of theoretical and applied knowledge that is used as a steppingstone for project work. The structure of a lecture is critical to encourage student engagement, critical thinking, and interactions in the class (Exley and Dennick 2009). The potential of digital tools for increasing student learning, perception, and engagement during lecturing was explored by a series of activities concerning the lecture structure.

Live-streaming and recording of lectures has become simple with the implementation of digital platforms such as Microsoft PowerPoint, Zoom, and Google Meet. Lecture recordings allow students to revisit the lecture to recap specific topics at their own pace. Digital platforms have also facilitated the implementation of pre-recorded lectures as student preparation for a subsequent live lecture, in which the lecturer can then focus on core topics and thereby improve the overall learning outcome (Moravec et al. 2010).

The presented case explored the potential of pre-recorded lectures to enhance student learning compared to live-streamed lectures. Further, the impact of lecture duration on student learning was investigated by comparing short 20-minutes lecture sessions with long 45-minutes sessions. Students evaluated which lecture formats (pre-recorded vs. live-streamed lecture and short vs. long lecture session) they preferred. In general, the students appreciated having lectures recorded and made available, whether being a recorded live-streamed lecture or a pre-recorded lecture. Additionally, most students found shorter, topical sessions a useful format for obtaining new knowledge, due to better subject delimitation and focus.

A good lecturer-student connection helps generate and maintain the attention and engagement of students during lectures (Steinert and Snell 1999). Under circumstances with a lack of in-person connection, such as during online or pre-recorded lectures, it is therefore critical that the lecturer reflects on alternative initiatives/strategies to engage the students.

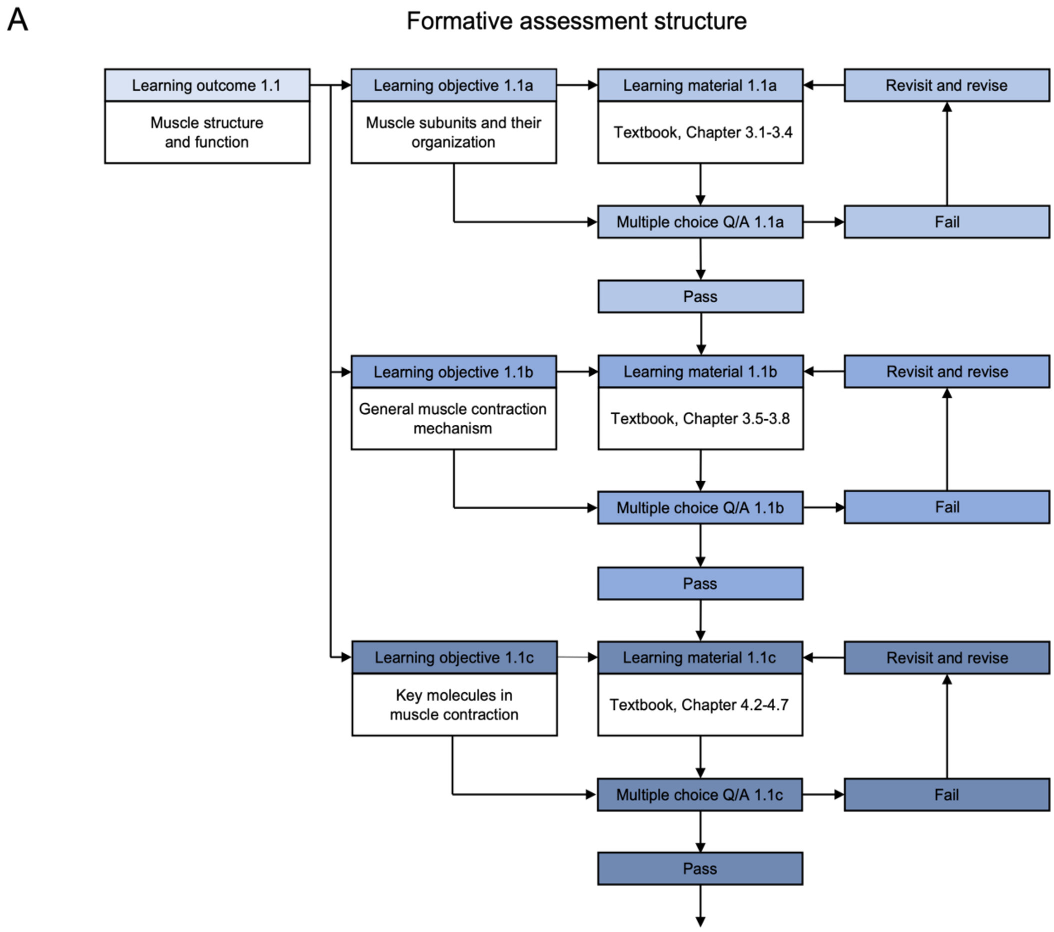
To improve student engagement during online lecturing, this case used digital support tools for interacting with the slideshow presentation and for incorporating intermittent quizzes. In the former activity, lecturers interacted with the slideshow by using a digital laser pointer and/or by writing on the slides while communicating their content. In the latter activity, students were presented with several multiple-choice questions during the lecture, using the digital student response system Socrative. Most students found both slideshow interactions and integrated quizzes useful for improving their engagement in the lecture and their understanding of the topic covered.

LECTURE ASSESSMENT

Formative assessment of student learning and teaching quality describes the process of making sure students understand the topic being taught while it is being taught. The goal of formative assessment is to actively monitor student learning through feedback for real-time adjustment and improvement (Boston 2002).

This case used Socrative to formatively assess student learning during hybrid in-person/online lectures. In preparation for each lecture, the learning outcomes were defined, and for each learning outcome, a series of learning objectives were identified (Fig. 1A). For each learning objective, several multiple-choice questions were prepared (Fig. 1B). These questions were presented to the students *via* Socrative immediately after communicating the associated lecture content and student responses were used for real-time formative assessment. If most of the students failed to correctly answer a question, the lecturer elaborated on the topic associated with the specific learning objective before moving on to the next learning objective.

Apart from real-time assessment of student learning based on individual learning objectives, the use of a digital platform allows collection and analysis of data across learning objectives and students (Fig. 1C). Upon completion of the course, the lecturer can use the accumulated results from the multiple-choice questions to pinpoint topics for which most students fail to understand one of more learning objectives. This approach allows the lecturer to refine the content and improve the learning quality of each lecture, and eventually of the entire course. The method is especially important in lectures where learning objectives are highly inter-connected in a way that understanding of the current learning objective depends on the understanding of a previous one. Over time, this approach can also be used to refine learning materials, thereby improving the course.



B

Example multiple choice question

Multiple choice Q/A 1.1b How is a muscle contraction initiated?	**Student responses**
A. Muscle contraction is stimulated by a homone signal	10%
B. Muscles sense tension in tendons and contract in response	20%
C. Muscle contration is stimulated by an electrical impulse *(Correct)*	70%

C

Student response overview

Student no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1.1a Muscle subunits	A	B	A	A	C	A	A	B	B	A
1.1b Contraction mechanism	C	C	B	C	A	C	C	B	C	C
1.1c Key molecules	B	B	C	A	C	A	B	B	C	B

Figure 1. Continuous formative assessment of lectures was done to pinpoint topics that students failed to understand. A. Flowchart illustrating the formative assessment structure of a lecture about muscle structure and function. Each learning outcome was subdivided into specific learning objectives with associated reading material. For each learning objective, a multiple-choice quiz was used to assess whether students understood the content just presented before moving on to the next topic. B. Example multiple-choice question associated with learning objective 1.1b. C. Example table of student responses to multiple-choice questions related to each learning objective. Green: correct answer. Red: incorrect answer. Examples have been adjusted from the original experiment for simplification (see the [full report]() for implemented assessment).

LABORATORY PRACTICE

The technological advancement of life sciences relies on continuous research progress, inevitably associated with laboratory experiments. This means that students enrolled in life science education programmes must acquire hands-on experience with laboratory practice. This is especially important in a PBL environment, where student projects are centered around experimental work.

However, students are often confused and overwhelmed by the many practical details and guidelines associated with good laboratory practice, which steal the attention from the scientific problem related to their project (Galloway, Malakpa, and Bretz 2016). Particularly in the initial learning phase and in early semesters, practical training is equally demanding for instructors who must be available almost constantly to support and instruct students.

Thus, this case evaluated the use of a digital platform for supporting laboratory practice. The online whiteboard and collaboration platform Miro was used to design an interactive guide on how to handle chemical waste generated during laboratory work (Fig. 2). The rationale for making the guide on chemical waste handling was that the ability to handle laboratory waste correctly is part of the practical curriculum of *all* students, thereby increasing applicability of the guide.

A decision-tree-based approach was used to transform an overall challenging workflow into a manageable series of decisions (Fig. 2A). The tree has a fixed starting point, from where it branches out, and the user must navigate through the branches by making decisions based on available information/knowledge (Fig. 2B). At every decision node in the tree, there is a link to a digital whiteboard that explains the practical procedures associated with the decision, via text, photo, and video instructions (Fig. 2C).

A group of students tested the digital waste handling guide and compared it to a written laboratory manual covering the same content. All students preferred the digital guide over the written manual and indicated that such a tool supports laboratory work and makes it easier to navigate in the laboratory by being instructive, intuitive, and simple.

The implementation of a feedback function in the digital guide itself provides the student easy access to ask clarifying questions or point out if information is lacking. In our experience, students hesitate to ask these questions if it requires a lot of time or effort. Thus, a one-click-away feedback function facilitates and improves the learning process of the students and ensures that deficiencies in the guide can be addressed and amended by the creators to continuously improve its functionality. Finally, the students thought the concept of the digital guide would be useful in relation to other topics than waste handling, such as standard operating procedures/protocols in the laboratory or handling of advanced laboratory equipment.

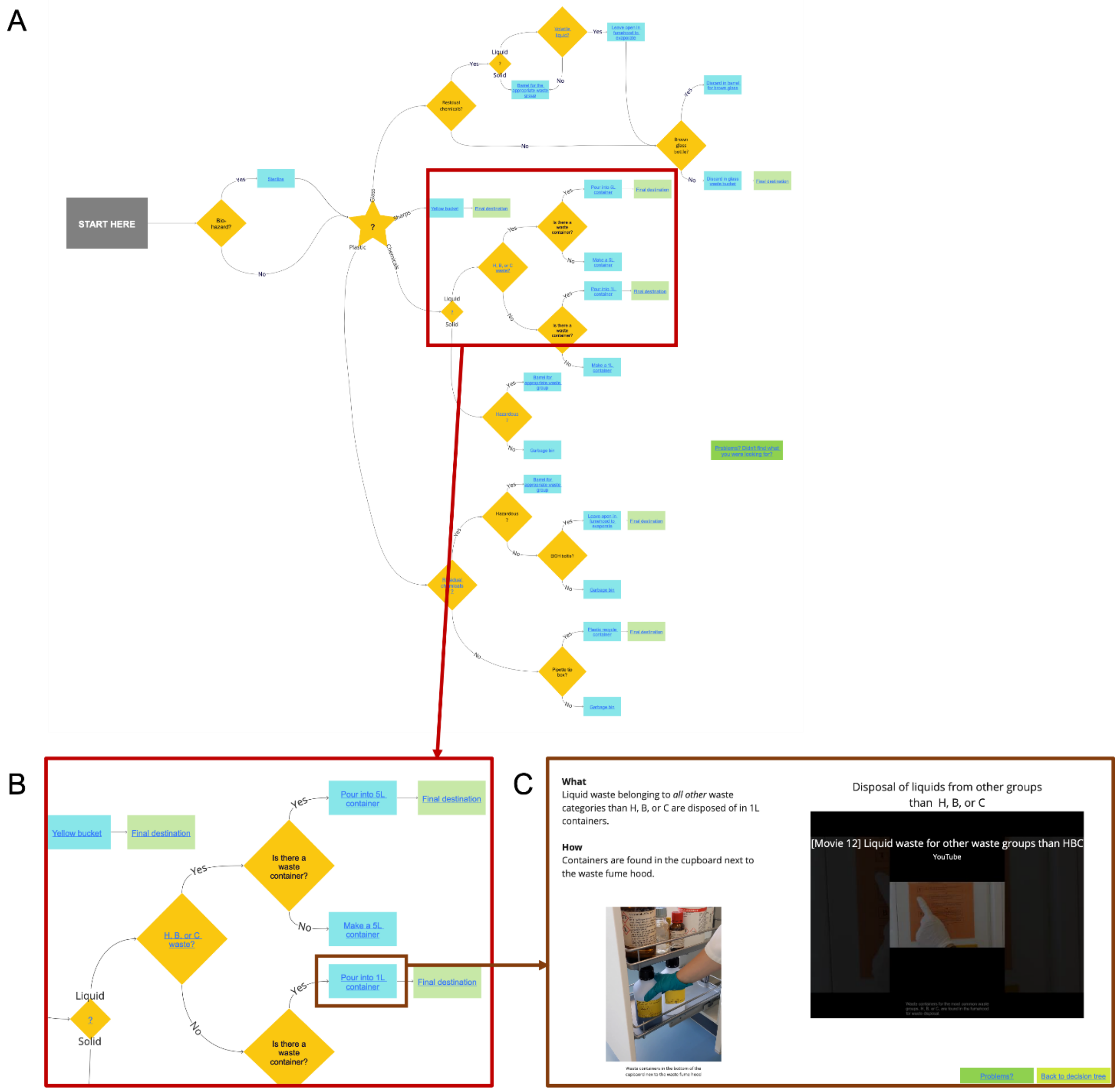


Figure 2. An interactive laboratory guide on chemical waste handling to support experimental laboratory work. A. Complete decision tree on chemical waste handling, designed in Miro. B. Subsection of the part of the decision tree that concerns chemical waste categories. C. Example of a whiteboard including text, photo, and video instructions, the latter with narration and subtitles. All information on the whiteboard was prepared for the specific laboratory used by the students.

LEARNINGS FROM EXPERIMENTS WITH DIGITAL TOOLS

Across the three pedagogical experiments presented above, we found that digital tools offer novel ways to design teaching and course curricula. We also found that digital tools offer useful, new ways to facilitate already existing activities in an organized, streamlined, and engaging fashion. However, one should carefully consider when and where these added benefits can be achieved, as they generally require a time-investment and compromise some types of student interaction. Here, we elaborate on some of our main experiences from working with digital tools in university teaching.

Variation in online lectures

All activities that tested ways of breaking up a lecture were perceived positively by students, in line with similar previous studies (Hsin and Cigas 2013; Wammes and Smilek 2017). Lecture variation was key to engage the students in their own learning process and to obtain and maintain their attention. We also found that a digital format offers several approaches to creating variation in lectures.

Most online platforms and recording/presentation software (e.g. Microsoft PowerPoint, Zoom, Google Meet) offer digital tools that allow the lecturer to animate and/or interact with a presentation. Slideshow animations are easily implemented in PowerPoint and have the potential to increase the scaffolding effect, by providing information bit by bit thereby breaking up the learning into chunks and reducing information overflow. Another important tool in presentation software is the digital pen. This allows the lecturer to use the slideshow presentation as a whiteboard, which naturally reduces the pace of presentation, thereby allowing more time for the students to absorb the presented content and acquire the associated knowledge. Both approaches have the added benefit of guiding the students' awareness to specific areas of the presentation to enhance their focus and attention. The interaction with a presentation is especially important when using pre-recorded lectures in which the lecturer cannot engage the students in real-time.

Digital tools also provide solutions for implementing student response systems as an element of variation in real-time lectures (online or in person). This kind of lecture variation makes the students actively participate in and reflect on their own learning process. In addition to engaging and activating the students, the implementation of quizzes, questions, or group discussions throughout the lecture facilitates the assessment of student learning and teaching quality. Online platforms such as Padlet, Socrative, and Kahoot! are easily accessible and allow the lecturer to follow student responses in the form of quiz answers or discussions in real-time. They can serve as a fun and entertaining break of rhythm and tracking of responses may motivate competitive students even further.

Flow of information

Since digital tools provide a unique opportunity to collect, share, and re-use information (Ahshan 2021), our experiments revealed many benefits from incorporating these tools in teaching activities. Not only will most digital platforms save information for later use or analysis, but they remain accessible and can be continuously updated to refine teaching material, notes, or instructions.

Lecture recordings or instruction videos can be uploaded to an intranet platform, such as Moodle or Blackboard, or to open access platforms on the internet such as YouTube. Some digital platforms offer to store information privately or publicly, thereby enabling the lecturer to selectively make information available to specific students at a specific time. An important point to note is that if lecture recordings are given as curriculum in preparation for a subsequent in-person lecture, they should replace a corresponding part of the reading material. Otherwise, the curriculum becomes too comprehensive as the students need to spend more time for course preparation than the time allocated. One may argue whether it is worthwhile to make topical videos in-house, as many high-quality teaching videos are available online, e.g., by Cousera or edX. We do, however, find that videos tailored for a specific course curriculum, exam exercises, or for practical work in in-house laboratory facilities do add value for the students. Moreover, the learning process of some students may benefit from the comfort of knowing their teacher rather than being faced with a stranger on the internet from an on-demand course.

Collection of information from students can be achieved with online digital platforms, such as Socrative. The collected data can subsequently be analyzed in detail, thereby allowing the lecturer to identify knowledge gaps. This contrasts an oral feedback approach which can only function to give a snapshot of the students' learning process. An added benefit of implementing an online digital response system compared to asking for plenary feedback is the possibility to anonymize participants, thereby removing the social barrier and ultimately increasing the amount of applicable feedback.

We also found that laboratory teaching can benefit from incorporating digital tools. Platforms like Miro and Padlet provide means to share, organize and streamline information, and can be designed for a specific purpose. They can thus contain a level of information that better resembles the nature of practical work, i.e., in the form of instruction videos, flowcharts, and notes. They also provide design options that can ease the learning process of students through a stepwise process. For example, the decision tree-based design of the digital guide presented in this case allows the condensation of comprehensive information to keep focus on necessary knowledge and off distractions. Moreover, the information can be used by the instructor again and again in future semesters with no or little requirement for revision.

Finally, digital tools including Miro, Padlet, Microsoft Teams, Google Docs, OneNote, and Overleaf facilitate group work as they provide an easy solution for students to share information and interact with a task together from different computers. These platforms have much of the same flexibility as drawing on a piece of paper or a whiteboard has and can readily be used for brainstorm-type exercises. Importantly, these platforms save the content and can be used to “immortalize” notes or to share them with other students or teachers.

Meeting students in the digital space

The use of digital platforms in teaching creates a hub and meeting point for lecturers and students, which can be accessed at the convenience of all. This increases the flexibility for lecturers and students – online lectures, documents, and other resources can be accessed anywhere and from any device and gives students the possibility to work from home. In PBL projects, digital platforms provide valuable tools for students to share, discuss, and organize information with each other or with their instructor, who is just “one click away”.

On the other hand, as digital platforms constitute an extra link between the lecturer and the student, they may also increase the perceived distance. It is our experience that online lectures impair the lecturer’s sense of student attention and interest. Teaching through a digital platform decreased our ability to evaluate if the students were interested in the topic, understood the content, or paid attention. We also found that the students were reluctant to ask questions or participate in plenary tasks. These obstacles were enhanced by the option to turn off cameras, which most students did. With cameras off, the lecturer cannot know whether students are even present. These challenges are particularly problematic during exercises, discussions, and question time. We speculate whether the option to turn off the camera decreased the students’ attention on the lecture, as they could be distracted by other activities without disturbing the other participants.

The increased student-lecturer distance created by implementing digital teaching platforms may be a hindrance especially for early semester students. Both in responses from students and in our own experience, students in early semesters are more dependent on scheduled lectures, face-to-face interactions with the lecturer, and a social network with other students for an optimal learning process. In contrast, students in later semesters are more experienced in study techniques and in managing their tasks and time and are independent enough for online self-studies. It is therefore important to consider, at which stage in an education programme it is appropriate to replace in-person lecturing with online elements, and when it is better to use these elements as a complement. Ultimately, this points towards blended learning as the optimal method of teaching rather than methods that exclusively use in-person or online teaching elements. The ratio between the elements, however, should be carefully considered and adjusted based on the academic level of the students and on the curriculum.

Regardless of whether digital tools are used to supplement or replace in-person teaching or teaching material, one should keep in mind that it is a time-consuming task to implement these. The time investment however often pays off if the prepared material can be reused with no or minor revisions. This applies to both lectures and laboratory teaching. The digital guide used to support laboratory practice has the potential to save valuable instructor time by removing the need for instructing students in real-time and by avoiding tedious repetition of the same instructions as new students enter the laboratory each semester. Together, this can transform laboratory teaching into blended learning.

CONCLUSIONS

Digital tools offer new and alternative means to conduct PBL-based university teaching. We found that these tools should be used as supplements rather than replacements for in-person teaching, as in-person interactions between students and teachers are important. Digital tools offer ways to share information, including recorded lectures, notes, information charts, and guides. This has a large potential in PBL-based projects, where students can organize and share information with each other or their instructor. The opportunity to access and revisit learning material throughout the course and during exam preparations was popular among students. Moreover, digital tools allow information logging and saving for reusing, evaluating, and revising the curriculum in the following years. Streamed lectures are challenged by the lack of lecturer-student interaction. Therefore, it is particularly important to create variation to the speed, dynamics, and focus. We found that this could be achieved by breaking down the lecture into shorter sessions, and by using slideshow animations, digital pens, and quizzes. Taking these aspects into account, several of the investigated digital tools may be valuable additions in a teaching design for blended learning.

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360 VR PBL: A New Format of Digital Cases in Clinical Medicine

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ABSTRACT

In this paper, we present and discuss an explorative study on the use of a social 360° virtual reality (360VR) for supporting case-based Problem Based Learning (case-PBL) in clinical medical education. In the context of case-PBL, we argue that our social 360VR learning space extends the design and application of cases in medical education by including elements from project-PBL. Three groups tested the learning design as a part of the clinical exercises in their 5. Semester bachelor course. After the social 360VR activity, the students performed a physical examination of the collateral and cruciate ligaments of the knee like the one in the training material. Our preliminary findings indicate that the students immersed in social 360VR collaboratively establish a mutual understanding of how to perform the examination through identifying problems related to the examination and by taking responsibility for their own and the other group members learning.

Keywords: Problem Based Learning, Social Virtual Reality, Social 360VR, Medical Education, Digital Learning, Covid-19

INTRODUCTION

Case-Problem Based Learning (case-PBL) is traditionally characterized by well-defined problems and teacher-led learning designs (Servant, 2016; Stentoft, 2019). In contrast,

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project-PBL is organized around “open-ended and student-centered projects running over extensive periods of time” giving the students a higher degree of responsibility for their learning processes (Stentoft, 2019, p. 960). As argued by Stentoft (2019), case-PBL and project-PBL should be viewed as complementary in medical education not as mutually exclusive. In this paper, we introduce and explore how social 360VR can be used as a digital platform for case-PBL in medical education. Virtual Reality (VR) is not a new medium for learning in medical education, but it is generally used for training of specific skills (Matzke et al., 2017) and less on elements associated with project-PBL (e.g. responsibility for own learning, team-based learning, self-directed learning, identification of problems, etc.). Our aim is to explore how a 360° video of medical students examining the collateral and cruciate ligaments of a knee (training video) can be used as a case for other medical students in social 360VR, who will have to perform the same type of examination on a person as in the training video. This case-design is open-ended without designed “problem triggers” (Stentoft, 2019) and the students in social 360VR will have to negotiate how to perform the knee examination. Further, the students will perform the examination in pairs to stimulate reflective dialogues between the students.

Our work with 360VR PBL is a consequence of the Covid-19 pandemic, where teachers had to experiment with new digital formats of PBL (Lyngdorf et al., 2021). In their research, Lyngdorf et al. (2021) found that elements of active learning had been under pressure as the existing digital tools did not support interaction and feedback in very advanced and sophisticated ways. While theory and facts are easier to present in online lectures, it is more difficult to integrate practice-based elements in online teaching formats (Dodds, 2021). Gaur et al. (2020) argued that medical educators should develop innovative solutions to foster students’ experience of the “immersive nature of medical education” (p. 1995). In the context of medical education this includes getting access to real patients, seeing and experiencing how an examination or operation is performed – not just how to perform a specific skill.

In this paper, we explore how 360° video can be used in clinical exercises in Higher Education (HE) medical education as an extension of case-PBL (Stentoft, 2019). With social 360VR teachers and students are no longer confined to viewing a video on a flat screen, instead the 360° video is projected in a Head Mounted Display (HMD) (McIlvenny, 2020a) providing a more immersive social experience. With social 360°VR new opportunities for bringing authentic cases into PBL arise and new formats for collaboration is emerging (Davidsen & McIlvenny, 2022). We consider our work as an innovative extension of how PBL cases are usually used in clinical medicine (Barrows, 1996; Stentoft, 2019) and an addition to the longstanding commitment for using technologies in medical education (Helle & Säljö, 2012). The preliminary findings indicate that the students see 360VR PBL as a great supplement to the ordinary clinical exercises and that they actively use what they learn in social 360VR in later clinical examinations.

VIRTUAL REALITY IN MEDICAL EDUCATION

There is a growing body of research on 360VR (Pirker & Dengel, 2021), however, the dominant type of VR in education is still the use of computer-generated 3D worlds (Bailenson, 2018; Radianti et al., 2020). The argument for using computer-generated VR is that students can practice new skills in a simulated environment that enables corrections, repetition, non-dangerous failure and interaction with expensive laboratory facilities or far-away environments (Jensen & Konradsen, 2018). The use of VR-simulated surgical training enables individual students to learn surgical skills in a risk-free environment and increases their technical competencies. It also improves the individual students' performance and decreases operating time in, for example, laparoscopic procedures (Frederiksen et al., 2020). Further, the students can develop their skillset at their own pace, which would not be possible with a real patient. Research has also shown that the use of simulated training helps the students develop their non-technical competencies, including communication skills and teamwork (Lungu et al., 2021).

Different studies have investigated the differences between using 360VR videos and 2D videos in medical education with individual students. One of the positive outcomes in 360VR is a higher level of involvement while watching the video and it is also suggested that the use of 360VR prepare the students for dealing with real-life situations (Arents et al., 2021). According to Pirker & Dengel (2021) the use of 360VR has potential in educational activities focusing on factual learning, but also in relation to a change of attitudes, emotional value, increasing interest, and engagement. They only found some studies reporting major disadvantages and challenges with the use of 360VR videos, such as increased cognitive load, problems with integrating the immersive media in the every-day teaching sequence and negative learning affects due to the low embodiment in 360VR videos (Pirker & Dengel, 2021). Pirker and Dengel (2021) also noted that 360VR could "prove to be a game-changer for the future of distant learning" (p. 86), which we are exploring in this paper in relation to case-based PBL.

DESIGNING A PBL CASE IN SOCIAL 360VR

With the case-PBL learning design, we aim to support collaboration between the students and a higher degree of responsibility for their learning in social 360VR. Instead of exposing individual students to the training video, we have used a social 360VR platform called CAVA360VR developed by the BigSoftVideo group at Aalborg University

(Davidsen & McIlvenny, 2022; McIlvenny, 2020b). In CAVA360VR (picture C in Figure 1) students can play and annotate a 360° video together with other students distributed between different locations. In CAVA360VR each participant in represented with an avatar head following the movement of the head and a pair of hands synced with the movement of the controllers. At the moment the CAVA360VR supports up to 20 users working together at the same time and it is also possible to participate using a windows computer without a HMD. In addition, to the technological platform used in the case design, we have also used a training video with students being tasked to examine a knee for the first time (see Figure 1 picture A). In the training video, we witness some failures and uncertainties about how to perform the examination, which we believe can promote learning for other students working with the data in social 360VR (Tawfik et al., 2015). In a way, the training video is showing how two students are identifying problems and learning goals in relation to a knee examination. They address the problems they face together, which is then acting as the learning design for the student groups in social 360VR.

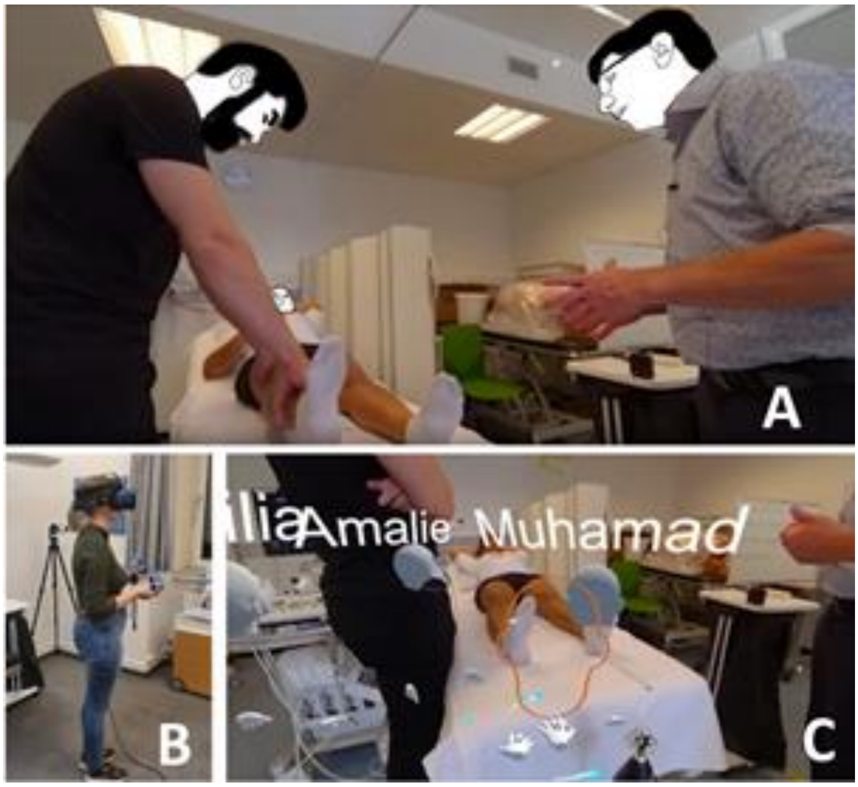

Figure 1. (A) Picture from the original 360° video. (B) The technical setup outside of the CAVA360VR space. (C) The technical setup inside the CAVA360VR space.

The basis for the PBL activity in 360VR is a 17-minute-long non-scripted video showing a professor and two students. The 17 minutes is from a longer session on 100 minutes, but we decided to focus on this part to limit the time in social 360VR. In the training video, one of the students is performing a physical examination of the collateral and cruciate ligaments of the other student's knee and the professor is providing feedback and stimulating questions during their examination. In Figure 2, we have visualized the elements and process of the case-design.

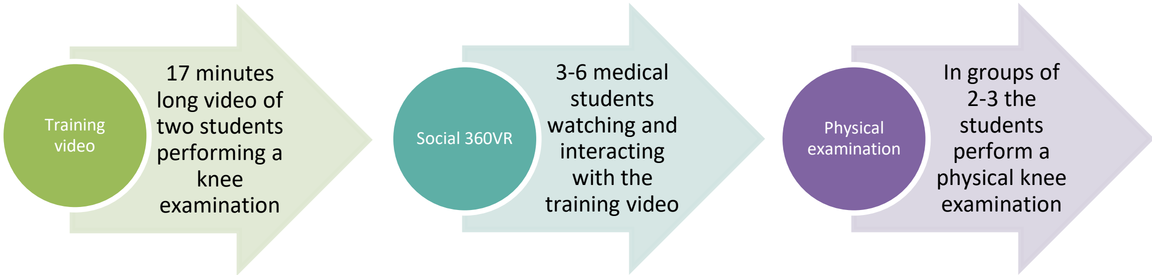

Figure 2. Visualization of the case-PBL design.

In our instruction to the students participating in the social 360VR tests, we explained that each of the students should wear a headset in separate rooms watching the 360° training video together immersed inside CAVA360VR and use the tools to collaboratively learn how to conduct the examinations (see Figure 1 picture B and C). They did not receive any direct instruction on how to annotate inside VR – they had to figure that out for themselves. We also informed them that after they finished being in social 360VR they should be able to perform the same examination on a human subject as in the training video. We did this in order to identify the level of transfer from social 360VR to situated practice (Dohn et al., 2020), which we will analyze in detail in another paper. This also meant that the students were not only tasked with retaining the knowledge provided in the training video, but also had to transfer the knowledge to physical examinations performed in dyads, meaning that the students had a shared responsibility for learning how to perform the examination. Table 1 is providing an overview of the three tests – the duration of the social 360VR activity (we are not evaluating effectiveness in terms of time spend in 360VR), a short description of the conditions and the time spend on the physical examination afterwards and the student's prior knowledge and experience in clinical examinations.

	Time spent in immersive 360°VR	**Conditions in 360VR**	**Time spent on the physical examination**	**Prior knowledge and experience in clinical examination**
Group 1 (3 students)				
Student A	40 min. 17 sec.	Unscripted 17-minute video clip in social 360VR	5 min. 45 sec.	No prior knowledge No experience with clinical examinations of the knee
Student B				
Student C				
Group 2 (6 students)				
Student D	36 min. 28 sec.	Unscripted 17-minute video clip in social 360VR	4 min. 54 sec.	Prior knowledge No experience with physical examinations of the knee
Student E				
Student F			4 min. 30 sec.	
Student G				
Student H			3 min. 42 sec.	
Student I				
Group 3 (5 students)				
Student J	49 min. 28 sec.	1 student seeing reflection prompts while playing the training video – no other students were able to see the prompts.	16 min. 21 sec.	Prior knowledge No experience with physical examinations of the knee
Student K				
Student L				
Student M			7 min. 17 sec.	
Student N				

Table 1. Overview of the three tests.

The tests were conducted in the end of 2021 and follow the GDPR regulations provided by the university – and the data is stored in servers provided by the university. Informed consent was obtained from all students who participated in the tests. The sessions in social 360VR were recorded with video cameras and a screen capture tool. This dual setup allows us to see both what the participants do inside 360VR and how they use the controllers in the physical space. The knee examinations were also recorded. This data has been watched and an initial logging of the material was performed (Davidsen & Kjær, 2018) using DOTE (McIlvenny, Davidsen, et al., 2022).

PRELIMINARY FINDINGS

In this case description, we focus on how the students in social 360VR organize their learning activity and how they use the tools in CAVA360VR to negotiate their understanding of the problems that are affiliated with the examination of the collateral and the cruciate ligaments of the knee. There were no problem triggers embedded in the case-PBL, and we are interested in finding out whether the students can learn how to perform the various tests.

Inside 360VR, the students used the various tools provided by the software to identify and define the problems occurring in the video and to structure their learning in the 360VR environment. The students frequently used the laser point to mark specific objects as relevant for each other (see Figure 3). The students also used the drawing tool to highlight and "freeze" these markings, for example drawing an arrow to indicate the motion in which the student pulled the knee. The drawing tool was also used for taking notes in 360VR (this proved troublesome for some due to the smoothing feature of the draw tool). A second strategy was to rewind the video which allowed the students to repeat sections of the video to further enhance their understanding of the procedures of the various tests.

Figure 3. Screenshots of (A) students pointing and (B, D) drawing using CAVA360°VR and (C) writing.

Another strategy the students used was to pause the video inside 360VR. The video would then be paused for all the students, which meant that all were "frozen" in the same moment of the video. During these pauses the students either summarized the knowledge they just heard or helped each other to understand what was going on in the training video.

While watching the training video, the students also began answering the professors' questions. By doing so they engaged with the dialog between the professor and students in training video. Some of the students mentioned in the subsequent feedback session that they had a feeling of standing physically in the room in the training video, which this shift in roles can be an example of.

In test 3, one of the students had several prompts appearing in front of her in 360VR (see Figure 4). These prompts guided the students to reflect on and discuss the information given to them in the training video. The students afterwards explained that it had a positive effect on them and helped them to understand what was going on in the training video. Only one of the students was prompted with the questions and the four other students were dependent on the fifth student to communicate the questions and the fifth had another responsibility in session compared to the others.

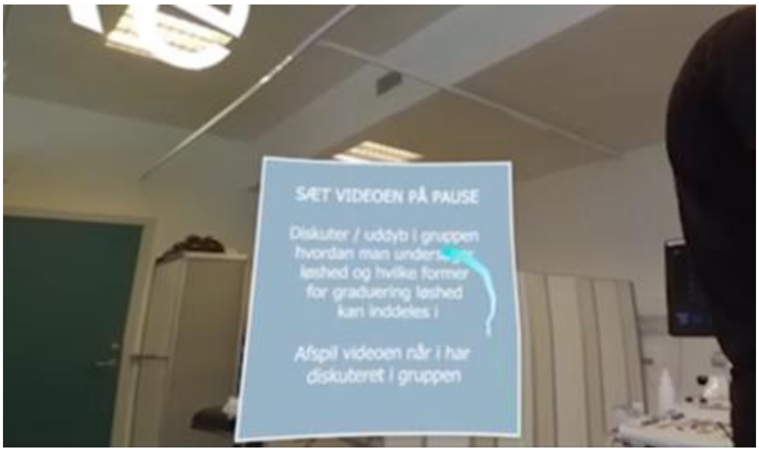

Figure 4. Scripted question.

Our preliminary findings also indicate that for the students to be able to perform the clinical test they are dependent on the use of different strategies for learning about the examination. Above we described their use of the technology to support their learning, but we also see how important the use of other skills and competencies related to communication, collaboration and problem-solving are for establishing a shared understanding. For example, we see that the design of the avatar only gives the students few nonverbal cues such as head and hand/controller movement. They then have a sort of handicap that forces them to rely on other resources – such as verbal communication. They must rely on their communicative ability of using words to visualize and describe their understandings. Their communicative abilities thereby play a fundamental role in situations where the technology or nonverbal cues from the avatar is not enough.

In our data we also see that when there is missing information in the training video, e.g., how a test is performed, the students who had prior training in the clinical examinations were able to use that knowledge when they performed the test, whereas the students without the prior training had to improvise on how to perform the test. At the same time the missing information, (e.g. when a certain medical term was used) allowed the students to build on each other's knowledge showing the importance of the collaborative learning space. It became a strength for the students to work together as a group because otherwise they might not be able to reach the correct understanding.

The ability to work together and analyze the training video inside the social 360VR using different learning strategies enabled the students to perform the two clinical tests (test of the medial and lateral collateral ligament and the anterior cruciate ligament) afterwards (see Figure 5). Our preliminary findings show that all of the students who perform one or more of the tests are able to do it despite they never tried it before and only seen it be done (the students' performances have been assessed by a doctor with expertise in clinical examinations). In the physical examination not all the students performed all the tests, and one student did not perform any of them. But they still participated in the examination by guiding and helping the other student(s).

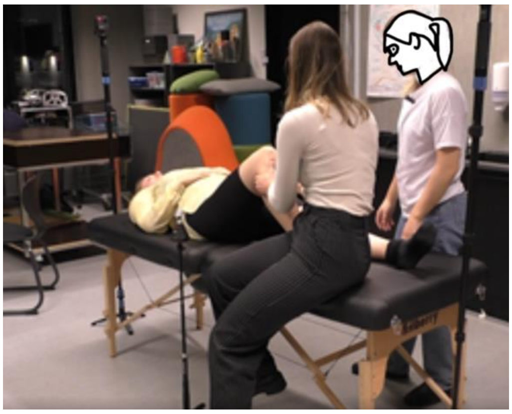

Figure 5. Examination of a knee.

The design of the case-PBL that we present here thereby construct a learning space where the students not only learn to take responsibility of their own learning but also are encouraged to take part in the responsibility of the group and ensure that the other student(s) also reaches a positive learning outcome. It is also a design that enables the students to train other skills and competencies related to communication, collaboration and problem-solving – competencies that creates the fundament of becoming a competent doctor.

DISCUSSION AND FUTURE WORK

With our explorative study on using social 360VR as a platform and learning design for case-PBL in medical education, we bring a fresh perspective on the longstanding commitment to supporting and facilitating ”students’ mutual learning, sense-making and collaborative engagement” (Bertel et al., 2021) with digital tools in PBL. Instead of designing specific problem triggers, we gave the student’s a higher level of responsibility to figure out how to perform the different examinations. The explorative study shows that social 360VR can offer a more advanced and sophisticated platform supporting students PBL practices, not just an individual student’s repetition of a task. In addition, the explorative study also indicates that students can learn from watching other students’ failures and mistakes (training video), which is also prompting mutual learning and sense-making for the students. Based on our explorative study, we envision that social 360VR could support case-PBL practices for students and teachers in novel ways. The next step for us is to work with implementing social 360VR as design and environment supporting digital PBL cases in medical education.

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Improving Employability for Students through Co-Creation and External Collaboration: Experiences and Outcomes

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ABSTRACT

This paper presents how a ninth semester teaching programme created employability skills among students. During the semester, students were expected to collaborate with a company or an organization to solve a task set by the external partner. The students used their academic and analytical skills and competences as a part of working with the 'product' (pitch and report), which they also delivered to the external partners. The students thus gradually became aware of the competences they used. The collaboration with companies and organizations formed part of and was integrated into the courses taught during the semester. The theories, concepts and themes presented in the instruction during the first part of the semester could be used by students in their collaboration with the external partner, both practically and theoretically. Students worked with external partners for six weeks during the second half of the semester.

Keywords: Co-creation, employability, external partners, interdisciplinarity, PBL

INTRODUCTION

In this paper, we examine how employability skills and real-world tasks mutually inform each other in our ninth semester programme called 'Mobility'. We applied problem-based learning (PBL), which is used at Aalborg University, as the main teaching model. Employability skills are inherent in PBL, we argue, because students are in charge of their own learning (Clausen & Andersson; 2019). This semester was offered to students, who,

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for various reasons, were not able to pursue an internship. In the fall of 2018, we introduced new and different teaching initiatives and exam forms during the ninth semester of the master's programme 'Global Refugee Studies' (GRS) at Aalborg University. The semester consisted primarily of Tourism and GRS master's students. We called this programme the 'Mobility' semester to include the themes, cases, concepts and theories reaching across the disciplines of tourism studies and refugee and forced migration studies. The courses are taught in English, and the majority of students who participate are international students. This creates an intercultural and interdisciplinary learning space. The students come from a variety of different bachelor's programmes, but they have followed both the seventh and eighth semesters at Aalborg University during their respective master's programmes. The challenge in the Mobility semester is that the students are expected to co-create (Thøgersen, 2011) when working together to solve tasks using their different disciplines from the humanities and social sciences. It has been a challenge for us as educators to think across and beyond core disciplines and backgrounds and, at the same time, create a common learning-platform that students could use as basis for their collaboration. We created this common platform during the first six weeks of the semester as we are teaching courses and seminars.

In this paper, we discuss a pedagogic challenge: Is it possible to co-create an active and creative learning process in a collaboration between students, lecturers and external partners, in which the students take an active role and the students' academic competences are visible both for the students themselves and for collaborating partners? The partners in our case were a non-governmental organization (NGO), a start-up company and a municipality. During the semester, we chose to highlight what competences students at a master's programme possess during in-class discussions. More specifically, we let students work in groups on tasks and examples from 'real life problems' during the courses. Students thus became aware of their own academic and analytical competences, which they used in the collaboration with stakeholders outside the university. In this way the student becomes aware that he or she brings knowledge and skills to the collaboration with the company or organization. Consequently, the learning process is not only about how a company works, but it is acknowledged that students bring their own knowledge to the collaboration as well. This learning process supports students' employability, because the student gains greater awareness of the competences they bring forth themselves.

METHODS

This paper presents how we designed, executed and reflected on a semester and its learning processes. We taught the semester ourselves. We have chosen to present the programme using our own experiences and building on data from interviews with students during and after the semester. The framework for the semester is PBL (Kolmos

& Holgaard, 2007; Kolmos, Krogh, & Fink, 2004). We worked with a small start-up company for one week at the beginning of the semester to give the students skills to work with an external partner during a longer process of collaboration later on (see model 1). The teaching and learning process during the described semester was dependent on our prospects of adapting to the expectations of the students and the external partner(s). We used situational supervision (Kolmos & Holgaard, 2007), because the class was quite small (17 students) and we were able to collaborate closely with students. This entailed that we continuously evaluate, interview students and collaborate with them to develop our teaching and research.

THE MOBILITY SEMESTER

It has come to our attention that our students have good skills in building arguments and analysing when writing longer papers, but they lack competences in communicating their skills in forms other than written reports. We therefore included seminars facilitated by the Incubators unit[1] at Aalborg University on graphic presentation and how to pitch an idea in three minutes. We also included this idea in a new form of exam, in which students had to pitch a task/idea in collaboration with their external partner as part of the exam. In addition to the pitch, there was a more academic component of the exam, in which students presented theories and concepts relevant to their task. This was discussed with internal and external examiners at the exam. The requirements for the exam were that theories and concepts were chosen closely connected to the pitch. Furthermore, the students were supposed to reflect on their choices during their work during the semester project and pitch in collaboration with the external partner. Students would thus become aware of their own learning process and how they could build competences, which can be used in their professional career after graduation.

We divided the semester into two parts (see table 1 below). During the first six weeks, the students were following three courses, all at the intersection of Tourism and Refugee/Migration studies. The courses were designed as four hours seminars in which we used different types of teaching. We talked over power points (recordings), especially when the topic involved the presentation of theories. We expected students to have listened to the power points before seminars, and we expected that they had read the texts. The students had a very active role during classes. Either they were supposed to work in groups with tasks, which they would then present to the class, or they were given different cases, on which the students worked during the seminars and later presented and discussed with each other in plenum.

Module 1				Module 2	
Course Seminars	Pilot project with start-up company Pitch to company after one week Students work in groups and everybody works with the same company	Course Seminars	Course exam	Project process Groups collaborate with a company of their own choice	Project exam Pitch as part of the exam
3 weeks	1 week	2 weeks		8 weeks	1 week (January)
	Interviews with students after pilot week			Supervision	Interviews with students after exam

Table 1. Semester overview.

We used cases and/or examples during class to engage students and to enhance critical thinking. We also gave short (maximum 20 minutes) lectures. These lectures aimed to create tools to involve students, for example by posing questions in the last part of the lecture with ideas for the students to work with in groups. The use of recorded power points allowed students to come prepared for class, be active and contribute with their perspectives on topic and theory. They were able to use the concepts they had prepared for in discussing the cases presented during the classes/seminars to create new knowledge and learn from the in-class discussions. Simultaneously, we created a learning space outside the walls of the university in collaboration with the external partners.

To prepare students to work with external partners for a longer period of time, we chose to use one week of the course period (see table 1) to make a more structured process in which students were asked to solve a task for a start-up company. We established contact with the company before the start of the semester and collaborated with the company to create three tasks, which the students had one week to solve in groups. The students presented their tasks to the company, an external evaluator, the lecturers and each other. It ended up being a very compressed process, which was challenging for the students, because there was very little time to prepare the result. On the other hand, our calculation was that this was a valuable preparation for the longer process later in the semester, when students were supposed to initiate a collaboration with an external partner, get an assignment and deliver a result. In the interviews we conducted after the students had presented their pilot-week results, the students expressed frustration because it was difficult for them to figure out what the task was, how they were supposed to solve it and what the company expected of them. It turned out that we had not succeeded in giving the students enough information in preparation for the week and we had not coordinated with the company to agree on expectations. It was rather demanding for the organizers/teachers to involve a company in the teaching process. Once the collaboration was in process and the students were working with their tasks, however, they ended up being quite content with the results they created and their presentation to the company.

The teacher's lecture became preparation for lectures along with reading texts by flipping the teaching situation (Herreid & Schiller, 2013; Slomanson, 2014). We used 'talking power points', podcasts, videos and policy papers as preparation for physical teaching. The students were supposed to get acquainted with the material before showing up to seminars, so we did not have to spend time introducing theories and cases, but started right away interacting with students during the seminars in which the students were participating in forming the teaching situation. Students 'discovered' new links and contexts, of which they had not been aware before. We introduced the semester very thoroughly to make students aware that they would not benefit from the seminars unless they were engaged and active and came prepared having read/listened to/seen all material before the seminars started. This was probably possible because we taught a small class of 17students, and we could follow them and sense whether they were engaged in the topics. We also experienced that they saw interdisciplinarity as an advantage, coming from different master's programmes.

The students were required to work with an external partner in module 2 (see Table 1). This could be a company, at start-up, municipality or NGO. The students chose their external partner themselves. Before starting module 2, we had made arrangements with three partners: a homeless shelter, a start-up company and an NGO, to give students access to partners. They could also collaborate with a partner of their own choice. It was important that students began their collaboration with the external partners quickly, because they only had eight weeks to complete the report and solve the task set by their partners. The exam consisted of a discussion of the report and a pitch for instructors and external partners based on a solution to the set task.

COLLABORATION WITH EXTERNAL PARTNERS

Working with external partners requires extra efforts from the instructors. As an instructor, you have to create a framework for the collaboration so it becomes manageable for the students to work outside university and lecture rooms. Students are concerned about format and exams, and it is very important that they have all the information they need to create an inspiring process for the students during the rather short amount of time they have for solving tasks, preparing their pitch and writing the report. Working with external partners contributed to giving students a chance to solve tasks meaningful to them. They contributed with their academic knowledge and their experience with project management acquired during their work with other university semester projects written in groups. We have therefore tried to make it clear to students that they already had competencies that could be used for cooperation with external partners. At the same time, we were careful to brief our external partners about what they could expect from the students.

The students could use the skills acquired from the pilot week working in cooperation with an external partner, as well as knowledge they had obtained in the more theoretical parts of the semester and in the visualization seminars to reach a new level of co-creation (Thøgersen, 2011). They contributed to create new ways of developing a semester project in collaboration with the external partner and many different competences were used. We argue that this contributes to the creation of skills that can be used to create employability.

Our experience shows that students gained a better understanding of their own competencies and skills by working with an external partner. They realized that they could use their knowledge in collaboration with external partners to solve the task on which they were working. Our students cooperated with three types of partners, as mentioned earlier, and they received different tasks, such as suggestion the organization of a human resources department for a start-up, making a promotion video for an NGO and developing a strategy for coastal tourism for a municipality. During the interviews after the exam, the students pointed out that was important to them that we already had put some work into finding interesting and interested partners to work with.

EVALUATION

We have done the Mobility semester four times in the form described in this paper. We have evaluated the experiences over the years with students, both through university evaluation surveys and through interviews with students. From our qualitative interviews with students and external partners, we can see that students have achieved a different degree of engagement in the collaboration with external partners than they had before. One of the reasons for this could be that students were given the opportunity to contribute with solutions that the company needed. We acknowledge that it would have strengthened our paper had we interviewed the participating partners with whom the students collaborated, as this would have informed our arguments claiming that the students contributed with solutions. On the other hand, we saw that students' ideas and solutions were implemented by some of the organizations, such as the municipality who wanted a strategy for coastal tourism.

Another observation from our work in the Mobility semester was that our work with different teaching and learning methods, new formal collaborations with external partners and new exam forms (students are pitching their ides at the exam) created a foundation for reflections. From our qualitative material and from our encounters with students generally it appeared that they appreciated the initiatives presented at the semester. By changing the format for the exam and connecting directly to the solution of tasks for external partners, students felt a connection between academic and practical work. This is something they can bring with them when leaving university and applying for jobs or presenting ideas in different settings, and it adds to their overall employability.

CONCLUSION

Our point of departure for the work with the ninth semester Mobility programme was whether it was possible to co-create an active and creative learning process among students, instructors and external partners in which students' skills and academic competences became visible for both students and for the collaborating partners. In this paper, we have shown how students have acknowledged new insights into their own skills and competences. They 'discovered' that they have gained knowledge from their university studies that can be applied and used in settings and situations outside the university. This was done, in our case, by working in interdisciplinary groups of students from different study programmes and working with external partners from, in this case, an NGO, a municipality and a start-up company. At the same time, we were able to use our Mobility semester and the students participating in it as data for our own research. The students have, of course, given their consent to be part of our research, which is a longer study of PBL in different settings. We have used our research to implement new initiatives in our teaching in an organic process of testing, adjusting and co-creation with students, and we continue to work with developing new teaching initiatives.

The knowledge and competences that students obtain from participating in the Mobility semester can in many ways be compared to the experiences and skills students who do an internship build. In our programme, we tried to create a semester that gives students who do not (or cannot) pursue an internship the opportunity to work with an external partner. This allows Mobility students to work with an external partner in a process that has some elements of an internship, but in which we combine practical work with more theoretical classes and seminars during the first part of the semester. In our experience, this format is rather demanding of the teachers/instructors, because they have to establish a framework that covers the different parts of the semester, and they have to reach out to external partners to get them onboard in the process. It does, however, create an interesting and inspiring space for learning and teaching for both students and instructors, and once a workable structure has been built, it can be re-used in different forms in future semesters.

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[1] Incubators at AAU is a unit that helps students form their start-up company while studying at the same time.

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Facilitating Postformal Thinking Through Problem-Based Learning in the History Survey Course: An Empirically Tested PBL Model

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ABSTRACT

This case study presents a problem-based learning (PBL) model that guides general education history students to practice and acquire more advanced problem-solving skills – those found in postformal thinking systems – and to apply these thinking skills to develop and share solution alternatives both to periodized historical issues and to current problems and issues. The article also summarizes findings from three studies that tested the impact of the PBL model on students' cognitive growth, level of course engagement, and perception of content relevance. These findings include student comments on the impact their PBL experiences had on their thinking skills and the usefulness of these skills in problem solving. The article concludes by providing tips on implementing the PBL model in a college general education history course.

Keywords: problem-based learning, postformal thinking, survey history courses, history education

Effective critical thinking and effective problem solving are common general education goals among colleges and universities (Markle et al., 2013). The history survey is often a required course in general education curricula, under the assumption that, in addition to historical content knowledge, students will gain critical thinking skills, especially the ability to connect the present with the past in a way that will help them address problems and issues in the classroom and beyond. However, most history survey courses default to a "coverage" model and fail to guide students to achieve primary general education goals, with students often regarding teaching methods and learning outcomes as redundant and

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irrelevant (Calder, 2006; Mintz, 2018). The PBL model confronts history survey students with complex periodized historical issues and guides them to systematically apply postformal thinking operations as they develop and defend their solutions and compare them with the actual outcomes and consequences of the historical issue addressed, and, finally, at the end of the course, to apply these skillsets to current problems and issues that affect their lives.

THEORETICAL FRAMEWORK OF THE PBL MODEL

The PBL model is based on a cognitive apprenticeship framework (Collins & Kapur, 2014) through which the instructor scaffolds students through modeling and coaching to practice and acquire more advanced problem-solving/cognitive skills (Hmelo-Silver, Bridges, & McKeown, 2019). The steps or processes of the PBL model are based on Lev Vygotsky's (1978) concept of Zone of Proximal Development (ZPD) and are designed to guide students to practice cognitive systems that would normally be out of their reach (Lajoie, 1993) due, in part, to a dual system of cognition in a problem-solving context that is common among first-year college students and common among students and individuals in general (Evans, 2008; Keating, 2004; Witteman et. al, 2009). The first system in this dual cognition dynamic is *intuitive/emotional thinking*, which is guided by an "if-it-feels-right-it-is-right" approach that leads students to shut down inquiry and accept their intuitive conclusion (Basseches, 2005; Berger, 2008; Wynn, 2015, 2018; Wynn, Mosholder, and Larsen, 2014, 2016; Wynn, Ray, & Liu, 2019). The second is *closed-systems formal thinking*, in which students apply abstract reasoning to solve problems but do so in an absolutist way that often leads them to quickly select solutions based on what they consider to be similar problems they have encountered and "solved" in the past and to shut down further inquiry. This causes closed systems problem solvers to overlook important contextual variables, judge key aspects of the problem as irrelevant to the solution and select a "correct" answer they consider applicable to all similar problems (Wu & Chiou, 2008; Wynn, 2015, 2018; Wynn, Mosholder, & Larsen, 2014, 2016; Wynn, Ray, & Liu, 2019).

Vygotsky (1978) defined ZPD as "the distance between the actual developmental level as determined by independent problem-solving under adult guidance or in collaboration with more capable peers" (p. 89). The steps of the PBL model prompt students to inductively recognize the limitations of the common inadequate problem-solving systems described above as they are guided to practice the more adequate postformal thinking systems in problem-solving contexts. Postformal thinking involves the application of two subsystems: relativistic thinking and dialectical thinking (Scott-Janda & Karakok, 2016). Relativistic thinkers recognize that reaching an accurate understanding of the context and complexities of a problem is key to developing workable solutions. They systematically look for multiple truths, multiple perspectives, complexities, and contradictions as they work to contextualize the problem through multiple frames of reference (Chang & Chiou, 2014; Chiou, 2008; Kahlbaugh & Kramer, 1995; Kallio, 2011; Kramer, 1983; Marchand, 2002; Sinnott, 1998; Wynn, 2015, 2018). Dialectical thinkers combine relativistic considerations and recognize that contradictions within a problem are interrelated and connected. They seek to understand the rationale and reasoning that support opposing perspectives and use the knowledge and insights gained to develop resolution alternatives (Basseches, 1984, 1989; Ho, 2000; Kallio, 2011; Savina, 2000; Scott-Janda & Karakok, 2016; Wu & Chiou, 2008). They also recognize that change is constant and inevitable and will challenge any solution reached through the problem-solving process (Blouin & McKelvie, 2012; Wynn, Mosholder, & Larsen, 2014, 2016; Wynn, Ray, & Liu, 2019). The steps of the PBL model are based on postformal thinking operations and are as follows.

Step 1 – Problem Development:
The instructor introduces the issue to pique student interest and establish student "stakeholdership" and to portray the historical or current issue as multidimensional with multiple frames of reference or valid points of view.

Step 2 – Initiation of PBL Events-Argumentation and Student Inquiry:
The instructor guides students to define the issue at hand, to identify both its contextual complexities and its multiple frames of reference or perspectives, and to recognize the need for further inquiry to better understand its complex dynamics. A decision-based or argumentation structure is then used to prompt students in groups to generate arguments or solutions and to work to resolve conflicts and contradictions among competing positions. This is done primarily through simulation/debate, or other activities based on periodized historical issues (See the topical outline/PBL activities list below.) After each PBL activity through which students construct an understanding of the contextual complexities of the problem/issue at hand, students identify what they've learned about the issue and the inherent contradictory, opposing, or multiple positions and then identify and gather additional information as needed to develop solution alternatives.

Step 3 – Problem Solution and Debriefing:
Students generate solution alternatives, deliberate, and select the most appropriate one and evaluate its historical or potential consequences. Students are then guided to compare their solution with the actual outcomes and consequences of the historical issue. A concluding essay may be assigned that prompts students to accurately frame the issue, summarize opposing/multiple perspectives and inherent contradictions, reach, and support a solution alternative, and compare it to actual outcomes and consequences. This is followed by debriefing, which includes a review of the content, concepts, and skills applied during the problem-solving cycle. A metacognitive reflection questionnaire

(MRQ) is administered to guide students to recognize and reflect upon the thinking systems they used and the successes or failures of each in the problem-solving process. This helps students develop a cognitive self-awareness in a problem-solving context. (Adapted from Wynn, 2018)

PBL CONTEXT AND IMPLEMENTATION

The PBL implementation took place as part of three studies conducted at a Kennesaw State University, Kennesaw, Georgia, USA between 2013 and 2019. The pilot study (Wynn, Mosholder, & Larsen, 2014) and second study (Wynn, Mosholder, & Larsen, 2016) tested the PBL model's impact on student engagement, perceptions of content relevance, and postformal thinking gains (pre/post treatment) of students in first-year learning community (FYLC) sections and stand-alone sections of a U.S. history survey course (HIST 2112-*US Since 1890*) and compared the outcomes with student outcomes from the same US history course taught primarily through lecture/discussion. In both studies, the primary researcher (PBL instructor) taught two FYLC sections, capped at 25 students each, under the theme, "Stepping into America's Past: What Would You Do?." FYLC students were included in the studies due the transitional nature of late-adolescent cognition (Baxter Magolda, 2009; Nelson Laird, et. al, 2014; Pascarella, 2005; Pascarella, & Terenzini, 2005; Reason, Terenzini, & Domingo, 2006; Steinberg, 2005; Tanner, Arnett, & Leis, 2008). Both FYLC sections of HIST 2112 were paired with a first-year seminar that focused on student success skills which was taught by a colleague from the University's First-Year Program. The PBL instructor also taught one regular PBL section of HIST 2112 in both studies capped at 40 students. In the pilot study, a history department colleague used primarily lecture/discussion to teach three sections of the same US history course capped at 50 students per section and used lecture/discussion to teach two sections of HIST 2112 in study two, each with 112 students. The PBL instructor developed and implemented six PBL activities using the steps described above in each of the three PBL sections in both studies. The curricular outline, including the PBL activities, is below.

Unit 1 - The U.S. as an Empire: Global Power Structure (1890-1905)

> *PBL Activity: *The Question of U.S. Expansion: Expansionists vs. Anti-Expansionists* - Simulation/Debate-US Senate Subcommittee Hearing on US Expansion

Unit 2 - Social and Political Dynamics in the Progressive Era

Unit 3 - The Nation at War

> *PBL Activity: *Wilson and the Paris Peace Conference: Constructing the Treaty of Versailles*[1] - Simulation/Debate-1919 Paris Peace Conference

Unit 4 - Economic Expansion of the 1920s, The Depression, Franklin D. Roosevelt and the New Deal

*PBL Activity: *Solving the Problems of the Depression: Constructing the New Deal* - Simulation-Roosevelt's Brain Trust

Unit 5 - America and the World (1921-1945)

*PBL Activity: *The Atomic Bomb: Truman's Decision and Its Impact* - Simulation/Debate: Truman's Interim Committee on Using the Atomic Bomb

Unit 6 - The Cold War and Beyond

Unit 7 - Civil Rights in the U.S.: Tracing Social, Economic, and Political Dynamics in the Last Half of the 20th Century

*PBL Activity: *The Issue of Affirmative Action: The Atlanta Case* - Simulation-Supreme Court Hearing of Affirmative Action Case

Unit 8 - Challenges of the New Century

*PBL Activity: *Group Current Issue Presentations: 1) Healthcare Reform; 2) Immigration Reform; 3) Debt, Spending, Taxes: Balanced Budget Amendment and Entitlement Reform; 4) Climate Change/Energy Policy.* A fifth issue was added in the second study, 5) *Increasing the Federal Minimum Wage*.

(This final PBL activity explicitly targets one of the primary goals of the history survey, connecting the past to the present as students apply content knowledge and postformal thinking skills gained from previous PBL activities to develop solution alternatives to current issues.[2] For example during the *Solving the Problems of the Depression* activity, one group of PBL students was tasked with stimulating business growth and demand. One of the solution alternative they developed was a federal minimum wage which was accepted as part of the overall "New Deal" as constructed and approved by the class. During debriefing the class compared their minimum wage proposal to the Fair Labor Standards Act of 1938. The group that was assigned the Federal Minimum Wage issue at the end of the course applied insights and knowledge gained from the PBL New Deal activity, along with additional research, to develop and share a solution proposal to effectively address the issue of whether to raise the federal minimum wage.)

Each PBL activity took between one and two 75-minutes class periods to complete. Each section of HIST 2112 met two times a week for 16 weeks. In addition to the PBL activities outlined above, the PBL instructor used lecture, discussion, and guided questions (Reisman & Wineburg, 2008) to guide students to construct an accurate historical context of the issues addressed. After each PBL activity, the PBL instructor administered a metacognitive reflection questionnaire (MRQ) to guide students to reflect on the thinking systems they applied during the activity, which were operationally defined on the MRQ.[3] The research team used a similar curricular outline and FYLC structure in the 2019 third study (Wynn, Ray, & Liu, 2019) that measured postformal thinking gains of students in two sections (experimental and control group) of the FYLC, "Stepping into America's Past: What Would You Do?". The only change was the time frame addressed in HIST 2112, which was expanded to 1877 to the present and included a new Unit 1*: An Overview of Post-Reconstruction America (1877-1890)*.

RESULTS AND CONCLUSIONS FROM THE PILOT AND SECOND STUDY

The research team used the *Postformal Thought Questionnaire*-(*PFT*)[4] (Sinnott and Johnson, 1997) to measure changes in postformal thinking skills among groups (pre and post treatment) in both studies, and used two items from an End of Study Questionnaire (ESQ):[5] Question 4-Do you believe you have expanded your ability to think critically as a result of this course? If so, can you explain how your thinking has changed and/or evolved? Question 5-To what extent do you believe you may utilize the thinking skills you may have gained in this course as you continue your education and life in general? The ESQ was also used to measure student engagement and perceptions of content relevance using a Likert scale (1-5) with a prompt for students to explain their ranking. A summary of results from the first two studies indicated the following.

1) The PBL model was significantly more effective than traditional instruction (lecture/discussion) in facilitating postformal thinking as measured by the *PFT*.
2) The PBL model facilitated a significant increase in postformal thinking skills among PBL students as measured by the *PFT*.
3) The PBL model promoted high levels of student engagement.
4) The PBL model promoted the perception among students that course content was highly relevant. (Wynn, 2021)

These results led the research team to conclude that cognitive scaffolding and modeling of postformal thinking operations along with the MRQ were factors that explained significant PFT gains among PBL students. Cognitive and PBL theorists and researchers have argued individuals must be confronted by the diverse perspectives, multiple truths, and contradictions inherent in complex problems and issues to recognize the need for more advanced thinking skills in a problem-solving context (Basseches, 2005; Hung, Moallem, & Dabbagh, 2019; Sinnott, 1989; Sinnott, 1998; Sinnott, 1999; Sinnott & Johnson, 1996). Since the PBL model was designed to prompt students to apply postformal operations as part of the problem-solving process and then use the MRQ to reflect on the effectiveness of the multiple thinking systems they applied during the six activities, the research team concluded the MRQ was significant in facilitating the pre to post-test PFT gains (Wynn, Mosholder, & Larsen 2014, 2016). This conclusion was based on empirical evidence but was still hypothetical. Would PBL students still have significant postformal thinking gains if the MRQ wasn't used? This question prompted the third study.

TESTING THE RELATIONSHIP BETWEEN METACOGNITIVE REFLECTION, PBL, AND POSTFORMAL THINKING

The *PFT* questionnaire was used in the third study to measure PBL students' postformal thinking gains in an experimental (n = 20) and control group (n = 17) FYLC section of "Stepping into America's Past: What Would You Do?" Pre to post-score comparisons reported showed significant PFT gains for both the experimental and control group and no significant difference between mean PFT gains. These results were unexpected and led the research team to conclude that the steps of the PBL model, which systematically prompted relativistic and dialectical operations in the problem-solving process along with PBL instructor modeling and cognitive scaffolding, explained postformal thinking gains. Simply put, within this limited sample, the MRQ wasn't necessary to facilitate postformal thinking gains among control group students. Also, the experimental and control group scores on ESQ 1 (level of engagement) and ESQ 3 (level of content relevance) showed no significant difference between the two groups, with both groups reporting a similarly high level of engagement (Experimental, M = 4.35; Control, M = 4.25) and a similar positive perception of content relevance (Experimental, M = 4.80; Control, M = 4.76), which aligned well with PBL section results from the previous studies (Wynn, Ray, & Liu, 2019).

REFLECTIONS ON FINDINGS AND TIPS FOR IMPLEMENTATION

These studies were conducted in a time of intense political polarization in the United States. One of the most significant observations made by the PBL instructor in all three studies was the extent to which students with very different, even opposing social/political views, respectfully deliberated to reach a consensus on how best to address issues in U.S. history. Students then applied these cognitive and deliberative skills to complete the Group Current Issue Presentations assignment. ESQ comments from two PBL students help frame this dynamic.

> Study 2-PBL Student 19: "One other way that I feel like I have gotten better is collaborating with others to make a better solution. I learned how to reach a solution with people who have very different viewpoints than me." (Wynn, Mosholder, & Larsen, 2016)

> Study 3-Control Group Student 8: "It helped me with finding solutions in a group with diverse thoughts. It will definitely help me with working with people with different ideas to mine and come up with solutions that benefit both sides of an issue." (Wynn, Ray, & Liu, 2019)

This explicit application of historical content knowledge and cognitive skills to address current issues is often lacking in a traditional lecture/discussion-based coverage model. Results from the three studies indicated the Group Current Issue Presentations assignment helped strengthen students' perception that the history survey is relevant to their lives and enhanced their ability to effectively deliberate and develop solution alternatives to solve pressing problems and issues.

Findings from the three studies, along with continued successful student outcomes in the PBL instructor's sections of HIST 2112, indicate the PBL model helps facilitate a potentially transformative social learning dynamic in the history survey. Guiding students to apply relativistic and dialectical operations to collectively address historical issues within the context of problem-solving seems to circumvent the polarizing dynamic that is so pervasive today and helps promote a true community of learners in which students learn to trust each other as problem-solvers and welcome diverse points of view. The social/political divisions that often limit effective problem-solving soften as students deliberate to develop solution alternatives. The collective goal becomes problem-solving rather than simply debating or pushing a specific point of view.

Implementing this PBL model requires an instructional paradigm shift for most history survey instructors, moving from presenting "what happened" to contextualizing turning point issues and guiding students to apply relativistic and dialectical considerations to collectively develop solutions or plans of action and compare them to "what happened," which helps support a deeper, more applicable, understanding of history. The PBL model requires instructors to model postformal operations as part of the scaffolding process and to be open to diverse perspectives and ideas during PBL activities. Pushing a specific viewpoint or opinion limits the opportunity for students to practice postformal thinking systems. Without guidance and practice, many individuals may not gain these more advanced problem-solving skills and may tend to rely on the inadequate thinking systems discussed earlier (Basseches, 2005). This case study was introduced with Steven Mintz's and Lendol Calder's perspective that the history survey course is often regarded as redundant and irrelevant and is failing to guide students to meet general education goals. This PBL model is an empirically tested instructional method that may help history survey instructors actively engage students in relevant and meaningful turning points in history, and in the process, guide them to practice and gain advanced thinking skills that may serve them well as problem-solvers far beyond the university classroom and as they seek solutions to pressing issues in a diverse society.

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Endnotes

[1] Detailed instructional procedures for the *Constructing the Treaty of Versailles* PBL activity are shared in Wynn, C. (2015). A cognitive rationale for a problem-based U.S. history survey. Teaching History: A Journal of Methods, 40(1), 28-42. https://doi.org/10.33043/TH.40.1.28-42

[2] The following directions guide the Group Current Issue Presentations assignment. Read/view the article(s)/clip(s) related to your assigned issue on D2L and gather additional sources to support your research. Your group will have five primary responsibilities to complete during your 35-minute presentation:

1. To provide a brief summary that accurately frames the issue, explains inherent complexities, and includes a timeline of events/factors that have shaped its current dynamics; – 7 Minutes.
2. To summarize multiple, even opposing, views of the issue and explain the rationale and/or reasoning behind those views; – 7 Minutes
3. To present contradictions you believe are inherent in opposing perspectives on the issue and how these contradictory views/perspectives were used as your group developed solution alternatives; – 7 Minutes
4. To present your group's resolution alternative; – 7 Minutes
5. To present challenges or potential impediments to the effective implementation of the proposed resolution. – 7 Minutes

You may use any presentation format (Power Point, Prezi, etc.). You must provide a list of all sources used and present these to the class. Each member of your group must be directly involved in the planning/preparation and presentation of one of the five responsibilities listed above.

[3] The MRQ is included as an appendix in each of the following research articles.
Wynn, Mosholder, & Larsen, 2014 – https://files.eric.ed.gov/fulltext/EJ1112494.pdf
Wynn, Mosholder, & Larsen, 2016 – https://doi.org/10.19030/tlc.v13i1.9567
Wynn, Ray, & Liu, 2019 – https://files.eric.ed.gov/fulltext/EJ1240095.pdf

[4] The *PFT* questionnaire includes 10 statements that represent a different operation of postformal thinking. Participants respond to each statement by indicating the extent to which it characterizes their own thinking (7 = very true, 1 = not true). The sum of the 10 items provides a PFT score. The *PFT* is included as an appendix in each of the research articles (Wynn, Mosholder, & Larsen 2014, 2016; Wynn, Ray, & Liu, 2019) and can be accessed using the links provided.

[5] The ESQ is included as an appendix in each of the research articles (Wynn, Mosholder, & Larsen 2014, 2016; Wynn, Ray, & Liu, 2019) and can be accessed by the links provided.