Journal of Problem Based Learning in Higher Education

VOL 11, No. 1, 2023 – Page 36-59
10.54337/ojs.jpblhe.v11i1.7375

University Educators' Professional Learning in a PBL Pedagogical Development Programme

Aida Guerra, Bente Nørgaard, Xiangyun Du *

ABSTRACT

This study explored university teachers' professional learning when participating in a pedagogical development (PD) programme. The PD programme, entitled the Aalborg Certificate on Basics of PBL and Curriculum Change, had a workload of 150 hours and ran for four months, involving 23 teachers from Universidad Nacional de Colombia (Bogotá, Colombia). The programme comprised four modules, delivered in a blended mode, and followed a problem- and project-based learning (PBL) approach, as well as being based on PBL principles. This investigation conceptualizes professional learning from the complex learning theory perspective, describing it as a complex dynamic system involving knowledge, motivations, values, attitudes, and beliefs dependent on social and individual contextual factors, and how these can lead to the implementation of alternative teaching practices in classroom (e.g., PBL). Building on that, this work addresses the following research questions: (1) What knowledge and beliefs have the PD programme participants developed about PBL? (2) In which ways do the developed knowledge and beliefs impact participants' change towards PBL? This analysis takes a qualitative approach and uses multiple sources of data, namely participants' portfolios and reflection essays, as well as a qualitative survey. The results show the participants developed a deep understanding of PBL principles and practices by experiencing them through the PD programme, and that reflective

* Aida Guerra, Aalborg Centre for PBL in Engineering Science and Sustainability under the auspices of UNESCO, Department of Planning, and Institute for Advanced Study in PBL, Aalborg University, Denmark
Email: ag@plan.aau.dk
Bente Nørgaard, Aalborg Centre for PBL in Engineering Science and Sustainability under the auspices of UNESCO, Department of Planning, and Institute for Advanced Study in PBL, Aalborg University, Denmark
Email: bente@plan.aau.dk
Xiangyun Du, Aalborg Centre for PBL in Engineering Science and Sustainability under the auspices of UNESCO, Department of Planning, and Institute for Advanced Study in PBL, Aalborg University, Denmark
Email: xiangyun@plan.aau.dk

practice enables continuous professional learning and development. Additionally, their perceived challenges were related to time, as well as institutional support and infrastructures, in addition to student and teacher training.

Keywords: University educators' professional learning, problem- and project-based learning (PBL), pedagogical development, pedagogical belief, and practice

INTRODUCTION

There is currently an international trend for university educators to participate in various pedagogical development (PD) activities in response to the overall call for the development of graduate competences such as critical thinking and solving complex real-world problems, as well as communication and teamwork, among other aspects (Chalmers & Gardiner, 2015). Despite the variation in delivery forms and duration, ongoing PD elements have focused on supporting university educators who are experts in their own disciplines to develop knowledge and skills for effective teaching practices (Bickerstaff & Cormier, 2015; Chalmers & Gardiner, 2015; Saroyan & Trigwell, 2015). While highlighting the transformation from lecture-based teaching to student-centeredness as a common goal of such PD activities, the current literature remains unclear regarding the ways in which university educators learn from their participation in PD activities (Amundsen & Wilson, 2012; Assen et al., 2016; Chalmers & Gardiner, 2015). Recent works have reported concerns regarding linear approaches to organizing PD activities which assume that university educators may learn from short-term, information transition-focused, and context-dependent activities (Postareff et al., 2007; Steinert et al., 2016; Strom & Viesca, 2020). Instead, university educators' learning should be viewed as a complex matter that encompasses multifactorial aspects that interact with each other, such as individual interests, motivations, attitudes, and beliefs regarding the importance of teaching and learning advancements, which play an essential role in their engagement with learning about how to improve their own teaching and actually implementing new teaching practices (Du & Lundberg, 2021a; Strom & Viesca, 2020).

To address such needs, the literature has suggested that PD activities should consider values such as interactions, peer learning and teamwork (Henderson et al., 2012; Kolmos et al., 2008). Even so, it cannot be ensured that participation in PD activities will necessarily lead to changes in constructivist pedagogical beliefs, or even to adopting teaching practices that underscore student-centeredness (Assen et al., 2016; Du et al., 2020a, 2020b, Du et al., 2021b). Therefore, how educators learn from PD activities is dynamic and complex, involving not only how an individual educator may develop pedagogical beliefs that support their motivation and engagement regarding changes in

practices, but also the actual implementation of new ones, during which they encounter potential challenges related to students' reactions, collegial collaborations, and institutional constraints (Borrego et al., 2013; Du et al., 2020a, 2020b; Du et al., 2021b; Henderson et al., 2012; Lee et al., 2014).

This study attempts to explore the complex and simulative nature of how university teachers learn from their participation in professional development activities. The term "professional learning" is adopted to highlight the focus on how university educators learn through a process of participation in diverse activities to enrich their knowledge, beliefs, skills, and practices regarding pedagogical advancement (Saroyan & Trigwell, 2015). In particular, this evaluation investigates the processes and outcomes of 23 university educators from Colombia during their participation in a PD programme targeting implementing problem- and project-based learning (PBL). In collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO) PBL Center, the programme was organized following PBL principles relating to team-based project work on real-world problems, which aimed to provide participants with opportunities to experience PBL as learners through teamwork.

The following research questions were formulated to guide the research process:

1. What knowledge and beliefs have the PD programme participants developed about PBL?
2. In which ways the developed knowledge and beliefs impact participants' change towards PBL?

THEORIES AND LITERATURE

Conceptualizing Professional Learning Through a Complexity Theory Lens

Research on professional learning has been criticized for overstressing disciplinary content knowledge, as well as abstract knowledge about theories of teaching and learning, or instructional strategies (Russ et al., 2016). Therefore, additional important factors that contribute to university teacher pedagogical improvement will be incorporated in the conceptualization of professional learning. Taking a complexity theory lens to the conceptual understanding of professional learning, this study emphasizes the nature of developing, acclimating, growing, and changing. This perspective allows for conceptualizing professional learning with a focus on its involvement of multiple interacting components in a system, instead of only exploring parts of a whole or individual factors. Contrasting with cause and effect as well as linear ways of seeing the world, complexity theory provides a lens through which to conceptualize professional learning as a whole, consisting of relations among numerous factors and their

communications with environments (Morrison, 2008). Rather than an event, university teachers' professional learning is a process of growing and changing diverse connected aspects, including motivations, attitudes, beliefs, knowledge, skills, and actions and interactions. Seeing professional learning systems as dynamic and contextual also makes them emergent and unpredictable (Du et al, 2021a; Garner & Kaplan, 2021; Russ et al., 2016). As such, each individual university educator's professional learning can be understood as a complex dynamic system comprising cofounding and interacting personal, relational, and institutional factors (Garner & Kaplan, 2021; Opfer & Pedder, 2011).

From such a conceptualization of professional learning as a complex dynamic system, university educators' learning demands agency, which should be supported through activities encouraging their roles as experiential, participatory, and proactive individuals. Following this, the professional learning activities in the current study were intended to establish a complex learning environment encouraging educators to make choices in response to diverse situations and contexts and take agentic action to influence their own work, rather than to follow a predetermined sequence of information transmission. In such a complex learning environment, the participants' agency is influenced by their prior experiences and their personal characteristics, which shape how they attain knowledge and skills, and take stances and actions through their professional learning, as well as defining their perceptions on prospective engagement (Garner & Kaplan, 2021; Russ et al., 2016; Opfer & Pedder, 2011).

Highlighting university educator's agency as a core to their professional learning also emphasized the essential role of teacher pedagogical beliefs which to a large extent impact and shape their choices and decision making in practices (Russ et al., 2016; Opfer & Pedder, 2011). Teacher beliefs have been focussing area of educational researcher and widely debated in literature for years, and addressing various issues, namely curriculum, reform strands, and teaching and learning (Savasci-Acikalin, 2009). In overall, beliefs are defined as "one's convictions, philosophy, tenets, or opinions about teaching and learning" (Haney et al. 2003, p. 367), which leads to judgment of truth or falsity of a proposition, inferred "from a collective understanding of what human beings say, intend, and do", and strongly affect human behaviour (Pajares, 1992). Focusing on the connection between educator's beliefs and practices provides an analytics tool to better understand their professional learning (Assen et al., 2016).

Literature Review on Evaluating Professional Learning

University educators' professional learning has been evaluated in various ways. While a large strand of literature has focused on participant satisfaction with PD activities (Stes et al., 2010), several studies have also reported on how university educators, after receiving professional learning, have improved their motivations, attitudes, and

approaches to teaching in relation to student-centeredness (Saroyan & Trigwell, 2015; Stes et al., 2010; Van Schalkwyk et al., 2015). In addition, research has provided evidence connecting the educators' experiences gained through PD activities to their actual implementation of new practices and to the impact on their students' approaches to learning, performance, and outcomes (Du et al., 2020a).

Attention has also been paid to complex factors that have influenced university educators' implementation of student-centred strategies and methods, including personal factors such as motivations, beliefs about teaching and learning, and institutional aspects (Stes et al., 2010). In studying the mechanisms and outcomes of change, the individual and social aspects of teacher development are key to developing their beliefs about their roles as teachers in relation to university teaching excellence (Saroyan & Trigwell, 2015). Teachers' pedagogical beliefs are often understood as being how they think about teaching and learning, which influences how they take stances, make choices, and develop strategies in response to diverse situations (Pajares, 1992; Beck, 2008). Instead of being static, pedagogical beliefs are constantly undergoing change, as well as being shaped by prior experiences, current situations, and future prospects (Beck, 2008; Pajares, 1992). When moving from lecture-based to learner-centred approaches (e.g., PBL), educators are expected to assume constructivist beliefs by adjusting their teaching roles, which motivate and engage them to develop new strategies and ways of organizing class activities (Amundsen & Wilson, 2012; Borrego et al., 2013). While previous works have suggested that beliefs promote and constrain the adoption of new ideas and strategies, the evidence for a connection between university teachers' pedagogical beliefs and teaching practices is lacking (Amundsen & Wilson, 2012; Assen et al., 2016; Du et al., 2020a; Lee et al., 2014).

Various contextual factors have also been explored regarding how they may support or constrain how university teachers may learn from PD activities and connect their development of constructivist pedagogical beliefs to actual practice through implementing student-centred strategies. Student resistance to new teaching strategies has remained a concern raised by university educators (Borrego et al., 2013; Chalmers & Gardiner, 2015; Lee et al., 2014). Another regards the ways in which new teaching initiatives would be accepted and supported by peer colleagues (Du et al., 2021b; Van Schalkwyk et al., 2015). Additionally, institutional conditions have been addressed by several studies (Bickerstaff & Cormier, 2015; Chalmers & Gardiner, 2015; Du & Lundberg, 2021a; Du et al., 2021b; Henderson et al., 2012; Saroyan & Trigwell, 2015), including how new teaching practices would fit current policy constraints, such as for example, whether a newly developed assessment method for students would be approved, whether there would be sufficient facilities and materials provided (e.g., classroom, class

schedule), and whether there would be new external awards for implementing new teaching practices.

In sum, further attention is needed in reference to university teachers' professional learning regarding not only the development of their motivations, values, attitudes, and beliefs, but also how this process can lead to the implementation of alternative teaching practices in the classroom (Assen et al., 2016; Van Schalkwyk et al., 2015). To address the current critiques in relation to examining either the process (via self-reported reflection) or outcome (via a context-dependent measurement) of professional learning, recent literature has emphasized the importance of connecting the processes, inputs, outputs, and outcomes of professional learning with contextually relevant aspects (Bickerstaff & Cormier, 2015; Chalmers & Gardiner, 2015; Saroyan & Trigwell, 2015). Identifying factors that may support or constrain professional learning is equally crucial, including individual challenges and institutional issues, not only during educators' participation in PD activities, but also the subsequent implementation in practice (Du & Lundberg, 2021a; Henderson et al., 2012; Van Schalkwyk et al., 2015).

DESIGNING A PBL-BASED PD PROGRAMME FOR UNIVERSITY EDUCATORS' PROFESSIONAL LEARNING

Following the suggestion by Stes et al. (2010), this study adopted a theoretically driven approach supported by multiple data sources to explore the impact of professional learning on university teachers. The programme design was embedded in our conceptual understanding of university educators' professional learning as a complex dynamic system, as elaborated above. In addition, the programme design embraced the PBL principles of the Aalborg University (AAU) PBL model (Kolmos et al., 2009) (details see Appendix 1 and 2), which meant transferring its principles to practice and using its potential to foster transformative learning through experience and reflection, as well as participants' ownership and centredness. In this sense, the programme involved more than the cognitive dimension of learning (i.e., knowledge and skills), with the incorporation of social, cultural, and intrapersonal dimensions such as their beliefs, motivations, and self-efficacy (Noben et al., 2021).

While integrating problem-based learning ideas into PD activities for tutors has been practised in the health and medical sciences (Salinitri et al., 2015), little has been studied in regard to the resulting practices, particularly on how the educators actually implement them. Relevant works on engineering educators' professional learning as outcomes from PBL-based PD programmes have suggested that it takes longer than expected to change pedagogical beliefs towards PBL, and the gaps between participants' changes in beliefs and their actual practices may be related to multiple factors. These include an individual's

prior experiences and the prioritizing of disciplinary content knowledge over pedagogical thinking (Guerra et al., 2018; Du et al, 2020a), as well as institutional constraints, including a lack of policy or peer support, and student cooperation (Du et al., 2020a, 2020b).

The certificate was piloted in collaboration with the Universidad Nacional de Colombia, Colombia. The certificated started on 12 February 2018 with 23 participants and finished on 1 June 2018 (Guerra et al., 2018). The participants organized themselves into six groups, which constituted their working teams throughout the programme, resulting in six teaching portfolios, which included participants' teaching designs and their reflection essays as an appendix.

RESEARCH DESIGN

Participants

A total of 23 academic staff from three Colombian higher education institutions enrolled, actively participated in all activities, and completed the programme. Of the 23 participants, 17 were affiliated with Universidad Nacional de Colombia (Bogotá), three with La Universidad Icesi (Cali), two with Universidad Pedagógica y Tecnológica de Colombia (UPTC, Sogamoso), and one was the director of the Colombian Association of Faculties of Engineering (ACOFI). The participants were mainly from engineering and science fields, with exception of two, with one from social services and one from economy and management. Of the 23 participants, eight were female and 15 male. The participants also reported that as teachers their time was mostly spent in lecturing and instruction (25%–75%, N = 17), with small lecture groups, project work and supervision the formats in which they spent much of their teaching time.

Regarding participation in PD activities, 13 reported participating sometimes, five very often, two always, and three rarely. In reference to activities that increased their pedagogical knowledge and skills, the participants report that they had engaged in reading professional literature (e.g., journal articles, evident-based papers, etc.) (N = 21), followed by undertaking PD courses (N = 13), individual or collaborative educational research on a topic of professional interest (N = 13), participation in workshops (N = 12), informal dialogues with colleagues on how to improve one's teaching (N = 12), and involvement in educational conferences or seminars (N = 11).

Research Methods and Data Sources

Methodologically, this study employed a qualitative research design with multiple sources of qualitative data, namely i) a portfolio and reflection essays, and ii) a qualitative

survey. The aim is to develop a more comprehensive description as well as convergent views of participants' professional learning (Golafshani, 2003; Patton, 1999). The data collection took place during the period of the certificate implementation, i.e., between February 2018 and June 2018. The participants' demographic information, teaching activities, and formats, as well as previous PD activities, were collected before the PBL certificate programme started, whilst the remaining data were collected during and at the end of the programme, as Table 1 illustrates.

Data sources	Type of data	Data on
Survey (pre-PD activities)	Quantitative (close questions)	1. Demographics 2. Teaching activities and formats 3. Previous staff development (participation and types of activities)
Teaching portfolios	Qualitative	4. Teaching philosophy (in relation to beliefs) 5. Motivations and expectations for certificate 6. Teaching challenges 7. Reflections on the workshops 8. PBL implementation and evaluation 9. Impact of the certificate on one's teaching philosophy, competences, and skills 10. Future plans for staff development
Qualitative survey	Qualitative	11. In which ways the teaching portfolio has supported your learning and reflection throughout the Aalborg UNESCO Centre Certificate 12. What aspects of the Aalborg UNESCO Centre Certificate you consider relevant

Table 1. Data Sources and Type of Information Collected.

Both surveys, i.e., the one regarding pre-PD activities and the qualitative one with open questions, were distributed to participants via SurveyXact, and piloted before that by two PBL researcher experts with experience in PBL training and qualitative and quantitative research methods using surveys. Both the teaching portfolio template and surveys were developed based on literature and previous studies involving teaching portfolios and PD evaluations, namely de Graaff et al. (2011) and Dahl and Krogh (2015).

Data Analysis

The data analysis involved deductive and inductive analysis approaches. The deductive analysis took the point of departure from the literature and research questions to define broad themes for analysis, whilst the inductive approach enabled the defining of codes for content analysis (DeCuir-Gunby et al., 2010; Roberts et al., 2019). The latter involved the following steps: i) reading through raw data (i.e., participants' portfolios and reflection essays, teaching designs, and the qualitative survey), ii) identifying emergent

codes in alignment with the themes, iii) coding the data using the codes defined. The deductive and inductive approaches resulted in the code book presented in Table 2.

Themes	Codes
Pedagogical knowledge and practices	Prior PD activities Teaching practices PBL knowledge, skills, and competences
Constructivism pedagogical beliefs	Teaching philosophy Role of assessment, facilitation, and students. Motivation for learning and change Expectations from PBL certificate programme Challenges
PBL implementation	Prior teaching practices and experiences PBL design/intervention PBL implementation and evaluation Support needed
Future prospects and plans	

Table 2. Themes, Codes for Analysis, and Respective Examples from the Data.

The codes generated were revised by a peer expert in PBL and continuing education. The participants' portfolios, reflection essays, and teaching design were analysed using the software NVivo™, version 21, whilst the qualitative survey answers were downloaded from SurveyXact and evaluated using MS Excel.

RESULTS

The results are presented following the order of the research questions, providing answers, and drawing from the different data sources. Note that responses from groups are identified by their group numbers, while those from the qualitative survey are attributed to the number of the respondent.

What knowledge and beliefs have the PD programme participants developed about PBL?

The answer to the first research question is provided in twofold: (i) knowledge participants acquired during the program which contribute to broader understanding through experience what it means problem-oriented, active, innovative learning practices; and (ii) the beliefs they develop during in relation to constructivism and the struggles inherent in transforming current and traditional practices.

Knowledge for problem-oriented, active, and innovative learning practices

In general, the participants reported three main categories of knowledge acquisition through their learning process in the given PBL programme: (1) active learning for small

innovations in teaching practices, (2) a deep understanding of PBL principles and practices, and (3) reflective practice as an enabler for continuous development.

First, the participants referred to the use of active learning strategies to involve and engage students in courses. For example, Group 3 stated that by learning about active learning strategies, they were able to start innovating teaching practices by "combining lecture, discussion, and other activities learning activities" (Group 3).

Second, the PBL certificate structure and organization enabled participants to experience PBL models, elements, and principles in practice, promoting a deeper understanding of PBL methodology. For example, Group 3 emphasized "that what teachers need to learn is not specific methodologies or ways of doing things in their classes; they need to live the experience where they can see real learning happening" (Group 3). These participants stressed that the PBL certificate programme principles, like experiential learning (see Appendix 1), became central to enabling teachers to develop deep learning when it comes to pedagogical change, meaning it is more important to "experience" the methodology rather than to know about it. This is supported by Respondent 10, who considered the course structure and organization one of its most relevant aspects, which "is coherent with the PBL's principles" (Respondent 10). Group 1 also referred to how self-aware they became of their own behaviour as students in the PBL environment since the certificate used the PBL approaches, stating: "Being a student I was able to see also that I behave just like them" (i.e., like students) (Group 1). Even though we do not have empirical support to suggest in which ways such self-awareness impacts the implementation of PBL and how it supports learning, it is a point worth reflecting on, as well as one to consider exploring in future studies involving PD and PBL implementation in higher education. For example, does the teacher provide additional training and support to students on, for instance, how to organize their learning process when working in teams, such as how to collaborate and how to manage conflicts, etc.?

Additionally, a few participants referred to other PBL elements, like the role of the problem in students' learning. Besides being the driver for learning, Group 2 considered that "PBL is a big opportunity to make the connection in higher-level education with real problems in society" (Group 2).

Third, the participants emphasized the role of reflection as part of the learning process and that it is essential for continuous improvement and the innovation of one's teaching and learning practice. For example, Respondent 20 referred specifically to the teaching portfolio as a relevant instrument, which allowed them to:

> Document our teaching practice, analyse, and reflect on our actions in the classroom, the preparation of this document involves reading theories related to active learning, student-centred learning. It also

> allows us to know about the importance of teaching based on context and experience and the solution to real problems in the environment, that is, teaching for life, society, and the environment. It has been a motivating experience, because in addition it implies an in-depth analysis of my teaching practice and shows a continuous interest in improving our practice through the adoption of innovative teaching methodologies. (Respondent 20)

The importance of reflection in practice was also corroborated by, for example, Respondents 13, 18 and 19, who referred to the help it provided to "manage the progress of my learning and monitor the development of the course" (Respondent 13), "the confidence to apply the adequate and appropriated tools and forms to get the knowledge through the PBL method" (Respondent 18), or "group and individual space to reflect on my goals and teaching practices" (Respondent 19).

Believing in constructivism whilst 'struggling' in transforming traditional practices

The results show three main categories of beliefs: (1) strong holders of constructivism, (2) 'struggles' with transition and transformation, and (3) 'followers' of traditional learning practices.

For example, participants believed that "to inspire and challenge the young minds is as good as it gets in terms of living a meaningful life", with the role of the teacher and education being "to guide and show different ways to create new ideas. It is important the experience and situation used to resolve problems", "to help other people grow and develop professionally", "to develop in the student his capacity to learn autonomously, throughout his life", "to contribute to the increase of a student's tools, to generate well-being. […] I teach because I enjoy sharing spaces of reflection. I believe that education can lead us to a better society, and I want to be part of training people for a better society", with teaching being "the most important means to transform a society. And by education I do not mean only a transfer of knowledge, but an integral formation that involves moral, cultural, citizenship and, of course, intellectual aspects", and involving "co-creation, where the teacher also learns from the students and together contextualizes the situations to give the greatest possible sense to what is done inside the classroom". The above-mentioned statements aligned with the perspectives of autonomous learners, the development of skills, contextual and authentic learning, and the co-creation of learning environments to meet both student and teacher needs. Additionally, a participant from Group 3 added the following: "I am a convinced constructivist, which means that I believe learning is an ever-growing process of understanding by making connections between what we already have constructed and new knowledge, through doing things with this knowledge" (Group 3).

Even though the participants held beliefs aligned with constructivism viewpoints, they struggled with the transition and transformation of their teaching practice and with recognizing the traditional learning experiences that influenced their practice. For example, participants from Group 3 claimed "I hope to learn how to adapt my teaching methods, my assessment and feedback to students and course design", or that "My current teaching practices are influenced by the way I received my own education, which was based on traditional teaching practices" (Group 3).

The "roots" of traditional teaching practices and difficulty of change is also extended to students as Group 3 and Group 5 claimed, respectively:

> Another aspect that I analyse is identifying that the change in the students is difficult, they are accustomed to the orientation of the class in a traditional way and don't have the self-discipline to consult bibliographical references and analyse which is the best option to solve a problem. (Group 3)
> At this stage of the engineering students' training, already at mid-career, they prefer traditional teaching. This leads us to think as teachers that we need to start the PBL approach from the first semesters so that we can change the traditional teaching-learning model to a more active and student-centred process and not the teacher. (Group 5)

In which ways the developed knowledge and beliefs impact participants' change towards PBL?

The results provide insights to this question in twofold: (i) the constructive alignment as a tool for a reflective course and curriculum change, and (ii) awareness of their contextual challenges and needs to foster change. The first draws in the knowledge and experience gained during the professional learning, which lead to a realisation of the contextual challenges and needs participants have to foster change towards PBL.

Constructive alignment as pedagogical reflective tool for course and curriculum change

Thematic workshop on course design, the participants were introduced to several curriculum design frameworks, including the constructive alignment framework (Biggs, 2003). Most of the participants used the constructive alignment to redesign their courses and to implement PBL, with particular attention paid to the formulation of the ILOs, the planning of appropriate teaching and learning activities, as well as the student and teacher roles/tasks, and the use of suitable assessment types and instruments. Throughout the programme, the participants were guided by these principles which were used in their progressive project work with the facilitation of their supervisors.

All the groups reflected on their learning benefits from using the constructive alignment principles, which helped them understand and better practise how to structure a course plan. In particular, a member of Group 3 stated that she/he "understood that the first factor of success is the planning of the course, really establishing what the learning objectives are and what are the competencies and skills that the student must acquire at the end of the course" (Group 3). This was also referenced by a member of Group 4, who claimed that "After the course and the intervention developed, I see in a different way the students, assessment and learning objectives of a course" (Group 4). Group 5, for example, referred to the need to prepare new teaching and learning materials, which must be aligned with the necessity for students to develop critical thinking, as the following statement illustrated: "For the intervention it was necessary to prepare a new laboratory guide where each student no longer had the steps that solved the problem, but he had to use his critical thinking and his knowledge to give a solution to the problem" (Group 5). Group 6 noted the need for a continuous reflection and adjustment of PBL practices to ensure students continued to achieve their potential and learn in the best way possible.

Contextual challenges and needs when changing to PBL

The perceived challenges and obstacles to the desired change of beliefs and compatible practices, as well as demands that may support further improvement, as perceived by the participants. Time, institutional support, and infrastructures were among the main challenges referenced by all groups. For example, Group 3 referred to the time needed to support students learning in a PBL environment:

> Then comes the question whether the facilitator or the external supervisor has enough time to dedicate to each of the working groups. It is necessary to be most demanding in the quality of the projects or the problems posed. Implementation will only be possible if there is institutional change and institutional support for it. (Group 3)

Additionally, and in the same quote, Group 3 noted the role of the institution in relation to PBL implementation and change. Support for the implementation is not only related to all the tasks and roles academic staff have within the organization, but to the institution itself. Change should take a systemic approach in terms of institutional movement towards PBL, rather than only at the course level. In connection to this, Group 5 stated that: "It is necessary to train many more teachers in each department or career, so that each iteration of the proposed model can cover a greater number of courses, which in turn covers a greater number of students" (Group 5).

Regarding infrastructures and space, Group 1 noted that "Even though both challenges did go well, the room was not large enough to hold the groups working within during the interventions" (Group 1).

Other challenges related to the perceived roles of teachers and students, as well as their readiness for a PBL environment. From the student side, the participants noted the existence of a preference for traditional teaching methods, as was quoted in the above sub-section. Additionally, there were also issues connected to how students organize their own learning, as well as their motivation and engagement in their own learning processes, as Groups 1, 3 and 4 state. "I would like to know how to motivate students nowadays, I have found this is a challenging issue since new generations do not read much and are hard to engage" (Group 1). "In the traditional groups our students are used to, each one works independently, and only at the end of the semester they meet to unite and deliver" (Group 3). Finally, a suggestion was made that in terms of "Keeping students motivated and being conscious of their own learning process. Assess students and course's progress during the development of the semester" (Group 4). This leads naturally to the need for students' training as well, as the participants expressed, which is particularly important since it relates to the student's role, ownership, and responsibility over their own learning, and it is complementary with the teacher's role, in guiding and facilitating learning. Regarding the teacher's perceived role, the challenges related to a sense of self-efficacy, and the capability to guide students in a PBL environment. For example, Group 5 referred to their own doubts and the effort needed to implement PBL efficiently, as the following shows: "I have some doubts about the method, since I think it will require more effort from the students and the teacher, how efficient is it?" (Group 5). This was corroborated by a member from Group 1, who stated that "[I] conduct a course where the students must resolve real problems. I would like to know how to lead it correctly" (Group 1).

DISCUSSION

This study explores university teachers' professional learning when participating in a PD programme and refers to it as a complex dynamic system involving personal, relational, and institutional factors, leading not only to development of pedagogical knowledge but a change in pedagogical beliefs that argue for the adjustment and transformation of teaching practices towards more student-centeredness. Such a transformation justifies participants' motivations and attitudes towards change (see for example, Savasci-Acikalin, 2009, Assen et al., 2016; Van Schalkwyk et al., 2015). Therefore, and from a complex theory lens, PD activities need to take into consideration such dynamic processes of professional learning and create conditions where participants enact and interact with others and with the environment (see, for example, Assen et al., 2016; Du et al., 2020a, 2020b, Du et al., 2021b). For this reason, the PBL certificate programme is grounded on PBL principles, namely problem orientation, experiential, contextual and collaborative learning, exemplarity and interdisciplinarity, participant- and self-directed learning, and where a group of participants, with the support of a supervisor, change their teaching practices by (re)designing their courses using PBL, and implement and evaluate their

intended developments (Kolmos et al, 2009). Additionally, they reflect and document their learning and processes using teaching portfolios. Taking the point of departure from the analysis of participants' teaching portfolios, combined with their individual answers from a qualitative survey, the results illustrate the changes in their pedagogical beliefs, as well as to what extent they impact the change of their teaching and learning practice through PBL. Furthermore, they highlight the perceived contextual challenges and needs which, from a complex theory perspective, shows the dynamic and complex system participants integrate as well as the cofounding and interacting personal, relational, and institutional factors that affect their agentic behaviour and change process (Garner & Kaplan, 2021; Opfer & Pedder, 2011).

This study provides a few practical implications, chiefly related to participants' level of pedagogical knowledge, as well as their beliefs and expectations, in addition to the understanding of PBL principles and practice, the teacher's role in a process of change and the PBL environment, and the need for a reflective practice for continuous professional learning and development. First, while the participants reported certain levels of learning about pedagogical knowledge and changes in pedagogical beliefs, obstacles remained which hindered the desired level of comparative changes in teaching practices. This indicates that university institutions should not only expect teachers to change automatically by attending certain PD activities, but rather should provide the required conditions to support the actual implementation of changes (Brownell & Tanner, 2017; Du et al., 2021a). Second, the outcome suggested that it takes time for university teachers to change their pedagogical beliefs and practices, which indicates that professional learning is a continuous and long-term process. Third, future PD activities should highlight the phases involving the implementation and evaluation of changes by requesting that university teachers document the outcomes regarding student learning, which should be the ultimate goal of PD activities and educational development in general (Desimone, 2011; Guskey & Yoon, 2008). In terms of the pedagogical and professional development levels, it is important that the training adjusts to participants' knowledge and understanding, and does not take for granted that all higher education teachers will understand the pedagogical language. For example, PD training is outside the teachers' field of expertise and discipline. Therefore, it is of the utmost importance to make sure they have a good foundation, and contribute to a solid basis of pedagogical knowledge. PD programmes should take a "practise what you preach" approach and use the learning principles and methodologies intended for participants to learn about as the core of the programme structure and activities. The learning should be made explicit by having participants experience and constantly reflect on their learning process.

This study has a few limitations and suggestions for future research. First, the outcome remains temporal due to its context and small size. Follow-up studies could meaningfully

further explore how change may happen and what may constrain or support it. Second, this analysis relied on certain types of qualitative data, namely participants' group portfolios and a qualitative survey. Other types of data could have enriched the descriptions provided in this examination, as well as corroborated further some claims. Future works could employ other data sources, such as, for example, narratives to explore how individual teachers grow and enact their professional agency in the process of professional learning. Third, this evaluation took place in one single institute, so additional ones could investigate different social and cultural contexts, and their relationships with professional learning. From an empirical perspective, more data could be collected, using different methods, namely focus group interviews, to explain in depth some of the learning aspects that emerged from the empirical data, such as, for example, the experiential learning that participants underwent and how it impacted their beliefs in relation to PBL and change processes, or the constructive alignment framework. However, the timeline of the PBL certificate programme and access to the participants limited the collection of the data as well. Nevertheless, this evaluation provides some insights and raises a few hypotheses and questions that could be further investigated. For instance, future works could include longitudinal studies, where these participants would be followed over time to explain the ways in which what they learn through PD programmes is implemented in practice and sustained through time, and if not, why. In addition, comparative analyses could be relevant, because there are contextual and cultural aspects to professional development not only at an institutional level but also at disciplinary and country ones. This could provide a better understanding of what different teachers from various disciplinary areas, or countries, value and believe, and consequently assist in adjusting the training to their needs and contexts. Further, it may also be meaningful for future studies to compare outcome of educators' pedagogical beliefs in relation to their practice change through different types of PD activities.

CONCLUSIONS AND RESEARCH PROSPECTS

The results highlight three main outcomes of the PBL certificate programme that impacted participants' professional learning. First, the programme helped them to understand and use the constructive alignment framework to redesign and implement PBL in their courses. This is particularly important given that constructive alignment is a fundamental pedagogical concept with which an educator can restructure their courses and make them more student-centred, as well as enabling deep learning and the performance of higher and more complex cognitive tasks. Additionally, the framework also allowed participants to consider different dimensions when (re)designing their learning and teaching practices, like the ILOs, activities, role of the student and teacher, physical spaces, assessment, etc. It provided a holistic perspective and made their course design more purposeful, and explicit. Second, the learning principles that ground the

certificate programme as well as its structure enabled participants to learn as students do when in a PBL environment, namely in a collaborative, exemplary, experiential, and contextual manner. This not only allowed them to become immersed in their learning process, but also to transform their pedagogical beliefs and values for more student-centred learning. The participants were critical of their own limitations and challenges, at individual and institutional levels, and consequently found strategies to cope with them. Third, the transformative learning nature of the certificate programme facilitated in transforming their views regarding education and their roles as educators, at student, institutional and societal levels. For example, the participants highlighted co-creation and collaboration with students, and the concept of education as a profession, but one which also meant they could contribute to addressing societal problems, as well as questioning traditional models of education and the need to break them and move forward to more student-centred learning environments. From a complex learning theory perspective, the results show the dynamic nature of participant learning processes, where the interplay of multiple components taking place not only at an individual level (e.g., knowledge, a sense of agency, motivation, pedagogical belief, etc.), but also in connection with the surrounding environment (e.g., collegial and institutional support, infrastructures, policy-making, etc.), where the degree of curriculum change and practice is also contextual and culturally dependent (see, for example, Morrison, 2008).

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APPENDIX 1

Overview of the Aalborg UNESCO Certificate course on the Basics of PBL and Curriculum Change (Retrieved from Guerra et al., 2018)

Modules	Format	Description	Duration
I. Introduction and preparation	Online and self-study activities	In the first phase, participants have a two-hour online introduction to the course. The introduction marks the beginning of the course. In the following 10 days, participants should go through the course literature and online resources. The material addresses the topics of: PBL principles and models, other active learning strategies, curriculum design, curriculum change. As part of the preparation, participants also need to start the documentation process through a portfolio.	2 weeks (10 days)
II. Thematic workshop	Face-to-face, thematic workshops	A series of thematic workshops in which participants experience, reflect on and develop further understanding of PBL theory, culminating with the design of a PBL activity. Each workshop provides knowledge, exemplary exercises, group work, plenary discussions and feedback to design the intervention. The workshops themes are, for example: 1) PBL practices and models 2) Course and curriculum design 3) Assessment of and for learning 4) Facilitation and PBL skills 5) Portfolio as a reflective documentation instrument 6) Designing a PBL activity	4 days
III. Experimentation and evaluation	Online supervision sessions, group work and self-study activities	In this module, participants plan and implement the PBL activity designed. The implementation process, as well as its evaluation, must be documented as part of the portfolio. To support this process, the participants have on-line support and supervision from the Aalborg UNESCO Centre. By the end of the five weeks, participants should upload their portfolios for examination.	5 weeks (25 days)
IV. Examination	Online	The examination is done according to the Aalborg University frame of provisions. At least two members compose the examination committee: the supervisor and an external examiner. The grading is pass/ fail. On passing the examination, participants are granted the Aalborg UNESCO Centre certificate.	1 day

APPENDIX 2

Applying PBL Principles to the design of the Aalborg Certificate Course Approach (Adapted from Guerra et al., 2018)

PBL learning principles	Aalborg Certificate on Basics of PBL and Curriculum Change
Cognitive approach: • Problem-oriented • Project • Experiential • Contextual • Reflective	**Problem orientation**: The point of departure for participants' learning is the definition of teaching aims and challenges that they want to address. **Project**: The learning process is not carried out through a project. However, the learning and PBL implementation process is documented through a portfolio. **Experiential**: Several activities are developed and centred on teachers' experiences, namely the definition of teaching challenges, as well as the design of PBL implementation, workshops, hands-on exercises, etc. **Contextual**: By using participants' teaching challenges as the point of departure, learning is placed in the context of their institution, disciplinary field, and teaching practice, with the aim to improve. **Reflective**: Reflection is constant throughout the programme, where different activities and tasks are set up for participants. Typically, they were asked to consider how and why what they have done, experienced and learned can be used to address their teaching challenge. The reflection tasks and activities could be carried out at an individual level, such as in end workshops and in a form of personal notes, and at a group one, such as through status seminars and group portfolios.
Content approach: • Interdisciplinary • Exemplary • Theory and practice	**Interdisciplinary**: Interdisciplinary learning is addressed at two levels: content and collaboration. In module ii, which comprises thematic workshops, groups are formed which might include participants from different engineering fields. Furthermore, the content of the course relates to a discipline that is not engineering, i.e., learning theories and pedagogy. **Exemplary**: The overall goal of the course is to provide a basic understanding of PBL and curriculum change. Consequently, the course, especially the workshops, includes hands-on activities which are illustrative of PBL principles and curriculum elements (e.g., facilitation, teachers' and students' roles, assessment and learning outcomes, evaluation, etc.) and how they can be used to design a PBL activity for practice. The frameworks and exercises are exemplary of how a PBL curriculum should be constructively designed.

PBL learning principles	Aalborg Certificate on Basics of PBL and Curriculum Change
	Theory and practice: The course includes the design of a PBL activity, with the aim of implementing it in practice. The design of the PBL activity encompasses theoretical knowledge of, for example, PBL curriculum design, constructive alignment, problem design, facilitation skills, etc.
Collaborative approach: • Team-based • Self-directed and participant-directed	**Team-based**: While module i (introduction and preparation) is aimed at the individual, in module ii participants take part in a workshop on collaborative learning and group formation in which groups are formed for the rest of the course. By working in groups, it is expected that participants will learn from each other, for example, by communicating and sharing points of view, strategies, and understandings of PBL. **Self-directed and participant-directed learning**: Participants have ownership over their learning. They are the ones who decide what should be changed in their teaching practice and how.