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Impact of a PBL-Based Professional Learning Program in Denmark on the Development of the Beliefs and Practices of Chinese STEM University Teachers*

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This study investigated 35 Chinese university teachers' development of learner-centered beliefs and practices through a six-month problem and project-based (PBL) professional learning program in Denmark using a mixed-method research. Both qualitative and quantitative analyses of the participants' teaching and learning portfolios, which each included six entries, identified a significant change in their beliefs, from teacher-centered domination at the program's start to more learner-centered beliefs by the end (Nine teachers held learner-centered beliefs, seventeen teachers held dual beliefs and nine teachers still held teacher-centered beliefs.). Survey analysis identified a significant change in participants' intended practices at the end of the program. Participants reported a significant increase in using classroom interactions and formative assessment and a significant decrease in using summative assessment, yet content delivery remained the focus of their practices. A significant correlation was identified between participants' beliefs and practices at the program's end, which was not found at the program's start. The results indicate a noteworthy impact of the PBL-based professional learning program on the participants' changes in beliefs and practices, and an association between beliefs and practices was found. However, systemic, individual and cultural factors may constrain changes in teaching practices.

Keywords: China; Denmark; PBL; professional learning program; STEM instructors; teaching practices; university teachers' beliefs

1. Introduction

Over the decades, higher education has made many efforts to improve teaching quality to provide graduates and professionals with the necessary skills and competences for success [1]. One major development has been facilitating the transformation of university teaching and learning from lecture-based to learner-centered [2, 3]. Various professional learning activities and programs have been offered with the goals of enhancing teaching and learning [4]. Accordingly, a rich body of literature has investigated the effectiveness of such activities on the university professors who complete these programs, focusing on changes to either teachers' perceptions, attitudes, conceptions, knowledge, skills and approaches to teaching or students' perceptions of and approaches to learning and learning outcomes [1, 5]. Despite substantial research achievements regarding professional learning outcomes, data on what university teachers learn remains ambiguous and inconclusive; therefore, more research on evaluating the outcomes of professional learning is needed [1, 5–7]. In particular, there have recently been calls for research into university teachers' professional learning in the context of interactive and peer learning[8] and team-based learning [9].

Complex factors may influence instructors' adoption of learner-centered strategies and methods, including personal factors such as motivation and beliefs about teaching and learning and institutional

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factors [5]. In studying the mechanisms and outcomes of change, the individual and social aspects of teacher development are key to developing teachers' beliefs about their role in university teaching excellence [1]. While previous studies have suggested that beliefs can either promote or constrain the adoption of new ideas and strategies [10, 11], the empirical evidence for a relationship between university teachers' beliefs and practices is inadequate. Thus attention to university teachers' development of motivation, values, attitudes and beliefs, and to how this process affects the practices they implement in the classroom, is necessary [10, 12].

This study aims to explore the processes and outcomes of 35 Chinese STEM instructors participating in a six-month problem- and project-based learning (PBL), team-based professional learning program in Denmark. It explores the development of their learner-centered pedagogical beliefs and attitudes and how these values can be associated with the practices they intend to implement. Several terms are used interchangeably in the literature; this study uses "professional learning" to refer to activities in which university teachers participate to enhance their teaching and learning, and to highlight the learning process teachers experience when extending their knowledge, beliefs, skills and practices regarding teaching and learning [1].

2. Theories and Literature

2.1 University Teachers' Beliefs and Practices

Definitions of belief vary. According to Kagan [13, p.423], teachers' beliefs are "the highly personal ways in which a teacher understands classrooms, students, the nature of learning, the teacher's role in the classroom, and the goals of education." Teachers' beliefs are often referred to as what they think about teaching and learning [11], what choices they make and what strategies they develop in response to different situations [14].

According to the literature, teachers' beliefs about their roles are either teacher-centered, emphasizing direct instruction and reproductive and individual learning, or learner-centered, emphasizing self-directed, constructive and collaborative learning [3, 10, 15]. Pratt [16] identified five teaching perspectives: engineering (delivering content), apprenticeship (modeling ways of being), developmental (cultivating intellect), nurturing (facilitating personal agency) and social reform (seeking a better society). Beck [14] proposed three dimensions of teachers' roles: cognitive scaffolding, reflected in teaching methods; stimulation of different learning styles to develop students' competences; and emotional containment relating to teachers' communication and interaction with students. Relating these three dimensions to a study on Chinese-heritage teachers working overseas, Wang and Du [17] found that teachers' roles were defined by how they planned and conducted teaching activities, what they emphasized in teaching and how they perceived their relationship with students and their work environment. This approach to categorizing beliefs offers a multi-faceted understanding of the nature of teachers' beliefs about their roles and the complexity of defining and transforming such beliefs. In addition, teachers may hold contradictory or dual beliefs within their individual belief systems. For example, they may intend to both reproduce knowledge and facilitate learning, dual beliefs which may hinder the effective implementation of educational innovations [18].

2.2 Changing Beliefs

Some researchers view teachers' beliefs as relatively stable and focus on the role prior experiences play in shaping them [11]. Others argue that teachers' beliefs are constantly changing as they are exposed to the new knowledge and skills the profession demands [19]. Teachers' assumptions, however, may be challenged when they compare experiences in a new situation (e.g., reform) with prior experiences [14, 20]. Particularly when teachers change from lecture-based to learner-centered approaches, they must adjust their roles, strategies and ways of organizing activities [21]. For example, rather than telling students the correct answers, based on a constructivist approach, they must help students solve the problem themselves. This requires that teachers accept that students may develop various solutions on their own. Therefore, from a sociocultural perspective, teachers' beliefs may change when they interact with culturally constructed situations, such as new pedagogical methods and professional learning activities [14, 19].

Changing beliefs about teaching greatly impacts professional learning because beliefs significantly influence teachers' teaching practices [22]. For example, when transforming to a learner-centered teacher, one must move away from transmitting information and towards facilitating learning, espouse a wider repertory of teaching strategies and methods, encourage interactions with and among students and adopt formative assessments [3, 15, 23]. In order to make such dramatic changes, teachers' beliefs and conceptions about teaching and learning must be significantly altered [23, 24].

2.3 Relationship between Teachers' Beliefs and Practices

The relationship between teachers' beliefs and practices is dynamic and complex [11, 14]. While some researchers find that teachers' beliefs influence their

practices regarding strategy choices, organizing classroom activities and assessing students, other studies find gaps between beliefs and teachers' actual practices [10, 15, 20]. For example, teachers who had reportedly shifted from lecture-centered to learner-centered teaching were observed to still prefer using direct instruction and were found to offer correct answers before students found their own solutions [10, 15, 20].

Deep-rooted teacher-centered beliefs are difficult to change [8, 15], which may explain the discrepancy between teachers' beliefs and practices. Lacking confidence in the skills necessary to implement learner-centered methods [12] is another reason change can be difficult to achieve. Teachers may lack experience in implementing new learner-centered methods, and they may also feel insecure about whether students can manage self-directed learning and attain the expected learning outcomes [23]. Teachers may also lack institutional support and resources and have limited collaboration with colleagues [25]. While substantial attention has been paid to unveiling the relationship between teachers' beliefs and practices in K-12 education, more evidence is needed in higher educational settings [10, 12].

2.4 Learning and Change through Professional Learning Programs

Professional learning can be seen as an enabler for teacher change. Teachers' personal motivation and intentional choice are particularly relevant in the context of top-down institutional change [26]. In addition, teachers' individual needs and goals vary, requiring professional learning programs to take participants' individual prior experiences and institutional objectives into account [27] to enable teachers to become agents for change [19]. Furthermore, previous studies also suggest that effective professional learning activities provide interactive activities, continuous feedback and identity development through community building [1].

The literature has also explored factors that hinder teacher change. Windschitl identified conceptual, pedagogical, cultural and political dilemmas encountered in teachers' change processes to a constructivism-oriented and learner-centered curriculum [15]. Bickerstaff and Cormier, drawing from empirical data on how teachers questioned reforms, found pedagogical and cultural challenges that hindered change [27]. Van Schalkwyk, Leibowitz, Herman, and Farmer revealed obstacles to institutional change when individual teachers held beliefs at odds with institutional goals [26]. Difficulties in teaching practice are often related to teachers' lack of beliefs about an anticipated change [25]. In addition, Darling-Hammond, Hayler, and Gardner emphasized the importance of duration on the effectiveness of teachers' professional learning activities [28].

Documenting professional learning outcomes has been done in several ways. Stes, Min-Leliveld, Gijbels, and Van Petegem suggest a theoretically driven and multiple-source, data-driven method for investigating the impact of professional learning on university teachers [5]. Amundsen and Wilson postulated two dimensions for measuring change: the outcome dimension, focusing on teaching skills and methods, and the process dimension, focusing on reflection and inquiry [24]. Chalmers and Gardiner suggested implementing a model that combines measuring processes, input, output and outcomes with contextually relevant indicators [6]. Saroyan and Trigwell suggested aligning these principles when applying a model [1]; for example, the concept of constructive alignment [29] offers a tool to align the methodology of organizing professional learning activities and assessing the outcome of teacher learning and change with the overall objectives of the initiatives. Additionally, exploring the enablers and constraints of professional learning, such as the contextual factors of institutional issues and individual challenges, is important [26].

2.5 PBL and Professional Learning Programs

PBL has been widely implemented around the world as a learner-centered pedagogical approach across all educational levels [30]. While the benefits of PBL on student experiences, motivation and learning outcomes have been studied, research on teachers' perspectives remains limited. In higher educational settings, little is known about how university teachers experience a redefinition of their roles and a revision of their beliefs [10, 21, 31].

Implementing PBL requires restructuring classroom practices and the traditional roles of teaching; thus enormous change is needed for university instructors to shift their roles from knowledge transmitting and directive instructing to facilitating independent, self-directed and collaborative learning [30, 32]. Emerging research suggests that instructors' readiness for change – their beliefs, confidence, positive attitude and motivation about PBL – is an important factor influencing successful implementation [8, 19, 33].

Previous studies also identified challenges to teachers' readiness for instructional change, i.e. constraints in the environment, such as policy and systemic support [8], and teachers' pedagogical beliefs, i.e. how they think about teaching and learning [10, 31]. More specifically, in a societal context where teachers have the cultural ideology of being masters of knowledge, such as in China, it is difficult for teachers to change their beliefs about

these roles to a more learner-centered approach and to share their authority as knowledge sources with their students [17, 34]. This challenge underscores the need to study teachers' beliefs, belief changes and alignment between beliefs and practices when implementing new pedagogical methods and transforming educational approaches.

Instructors who experience PBL as learners tend to be more willing to change their beliefs about their roles and implement PBL [20, 23]. Offering professional learning programs related to PBL has been suggested [35], but little empirical evidence has shown how this can be practiced or how it impacts teachers' learning and change. Therefore, this study focuses on how PBL can be used as a methodology to organize professional learning programs that impact university teachers' pedagogical beliefs and intended practices. The following research questions were examined in this study:

1. What pedagogical beliefs do university instructors hold and what instructional practices do they report?
2. How do their pedagogical beliefs and instructional practices develop through a PBL-based professional learning program?
3. How do their pedagogical beliefs correlate with their practices?
4. What factors contribute to and constrain changes in their beliefs and practices?

3. Designing a PBL-based Professional Learning Program

Aalborg University (AAU) is internationally recognized for its rich experience in implementing a PBL model (integrating problem, project and teamwork) at the institutional level for over 40 years [30]. Starting in 2017, a six-month professional learning program was designed by AAU in collaboration with the China Scholarship Council with the goal of providing professional learning and pedagogical development for Chinese university instructors. From August 2017 to January 2018, a group of 35 Chinese STEM teachers from 10 universities in 5 provinces in central and western China were selected to participate in this full-time program.

Overall objectives of the program included providing participants with knowledge of a learner-centered pedagogy such as PBL and preparing them to implement and transfer this knowledge to peer instructors upon their return for large-scale PBL implementation. Embedded in the framework of constructive alignment [29], the program was designed following PBL principles, meaning participants were expected to experience PBL as learners, learn about PBL-related theories and, most importantly, create a PBL-inspired teaching design that would be implemented at their home universities. Participants were also asked to write a team-based project report including reflection on their learning journey during the program.

Program participants attended academic activities worth 30 European Credit Transfer System (ECTS) credits (equivalent to 900 study hours) over six months. Table 1 presents the activities and assessments included in the program design. Participants worked in five self-formed groups, each supported by a pedagogical facilitator (an expert in pedagogy who was experienced in facilitating professional learning programs) and a subject supervisor (an expert in the engineering and science fields who was familiar with PBL practice).

4. Research Methods

4.1 Participants

All 35 (12 female and 23 male) teachers enrolled in the 2017–18 program participated in the study. Participants held PhDs in STEM fields and worked as assistant (n = 19) and associate (n = 16) professors at their home universities, and had little prior experience with professional learning experi-

Table 1. Program activities and assessment

Program activities	Credits (ECTS)	Assessment
Ten courses (in forms of workshops, lectures and assignments) throughout (months 1–4)	10	Course assignments (essays, reflective discussion, portfolio, etc.)
Individual teaching and learning portfolio (months 1–6)	5	Monthly reflection through a progressive portfolio
Two team projects on teaching and learning 1. Mini project for trial (month 2) 2. Major project (months 3–6)	15	Two team-based project reports Process analysis of team process Oral presentation and defense
Guided observation of AAU-PBL model practice throughout (months 1–4)		Reflective discussion and portfolio
PBL course design that can be implemented at the home university after the program (individual or collaborative) (months 5–6)		Course design and portfolio

Note: ECTS = European Credit Transfer System, 1 ECTS credit = 30 study hours.

ences. Their ages ranged from 29 to 44 and their years of teaching experience ranged from half a year to 20 years.

4.2 Research Design and Data Generation

The prevailing literature on university teachers' espoused theories of action (beliefs) mainly relies on semi-structured interviews and self-reported questionnaire surveys, which have been criticized for constraining the expression of the participants' real beliefs [7]. Teachers' practices, referring to the context-specific knowledge teachers accumulate with practice, are often researched via classroom observations [7]. Nevertheless, understanding teachers' practices in combination with their past experiences, present contexts and future plans requires more sources of data [36]. Therefore, a mixed-method research approach [37] was designed for data generation, comparing university teachers' beliefs and practices at the program's start and end. Three sources of data were generated: to study teachers' beliefs, individual teaching and learning portfolios were analyzed; to study teachers' practices, a questionnaire survey was used; finally, focus groups were conducted to explore participants' perceptions and explanations and triangulate the other two data sources.

4.2.1 Individual Teaching and Learning Portfolio

A teaching portfolio is often used in professional learning to invite teachers to self-record and report evidence of their teaching effectiveness for the purpose of integrating assessment and teacher learning [38]. The PBL program invited participants to write an individual teaching and learning (T&L) portfolio that included their own learning processes and reflections and action plans for teaching. Using guiding questions, the T&L portfolio was designed to promote a progressive process of teacher growth, with each participant submitting their writing on a monthly basis for a total of six entries per participant.

At the program's start, participants were invited to describe and discuss their teaching philosophy, background and prior experience and analyze challenges in their current teaching and learning practices. This was meant to get them to reflect on teaching from the perspective of "who are the students and what are their needs [3]." Throughout the program, participants were expected to document their understanding of alternative teaching methods such as PBL and report on their participation in the program courses and observation of AAU activities. They also documented the process of developing, planning and evaluating suitable PBL-inspired teaching and learning activities in relation to general and specific teaching objectives, subjects, contexts and students' backgrounds using the framework of constructive alignment [29]. Finally, they developed their own action plans as take-home messages. At the end of the program, participants reviewed and revised the completed version of their portfolio before final submission. English was the primary language for writing the portfolio throughout the program and participants were asked to add elaborations in Chinese in the final version if it was necessary for them to express themselves fully.

4.2.2 A Questionnaire Survey

A self-reported questionnaire survey can accurately reveal information about teachers' practices despite the common concern that informants may imprecisely self-report their teaching practices [39]. In addition, questionnaires can help identify instructional practices that are otherwise difficult to observe [2]. A recently developed instrument, the Postsecondary Instructional Practices Survey (PIPS) [2], was adopted in this study to collect data on the STEM instructors' self-reported practices. Developed on the basis of a conceptual framework and critical analysis of existing instruments, the PIPS has been proven to be valid and reliable and provides measurable variables and compatible results with several observation tools. An intuitive, proportion-based scoring convention was used to calculate the scores: (0) not at all descriptive of my teaching, (1) minimally descriptive of my teaching, (2) somewhat descriptive of my teaching, (3) mostly descriptive of my teaching and (4) very descriptive of my teaching. The questionnaire included 24 items and 2 models were used to support the analysis: a 2-factor and a 5-factor solution to distinguish teacher-centered from learner-centered instructional practices.

After expert validation by three experienced researchers, the PIPS's original version in English was used without revision. Administration of the survey was in paper-pencil form. The first author was present to provide translation into Chinese and face-to-face explanation if necessary. All 35 STEM instructors responded to the survey twice, at the beginning and end of the PBL program, approximately six months apart. At the start, the participants responded to the PIPS based on their teaching practices in a course they had taught the semester before participating in the program. At the end, the participants were invited to respond to the same survey, reporting their intended practices for a course after their return to their home institutions.

4.2.3 Focus Groups

To reach a higher degree of trustworthiness and validity [40] in the interpretation of participants'

portfolios and to further explore self-reported practices, focus groups were conducted at the end of the program to confirm meanings and explore reasons and factors for the emerging patterns [41]. Each focus group involved the participation of the majority of the project group members (ranging from six to eight members among the various groups). Each focus group lasted four to five hours and was audio-recorded. The sessions included semi-structured, triangulating and probing questions and discussions of emerging topics. To gain deep insights, the focus groups were conducted bilingually, and the participants could elaborate in Chinese to support their use of English. The conversations were transcribed and translated into English by the first author (the interviewer). During the focus groups, the authors listened to participants' feelings about and experiences of participating in the program, their thoughts on and analyses of what they had learned, their beliefs and belief changes throughout the program and their future action plans. The questions followed interviewing techniques suggested by Kvale and Brinkmann [41]. In addition, confirming questions were asked, allowing opportunities for the participants to elaborate on what they had written in their portfolios. Initial interpretation and analysis of their levels and forms of reflection were triangulated through the conversations and discussions. Furthermore, the authors explored the concerns and constraints participants described in their writing regarding the potential for implementing PBL in their home contexts. This information helped elucidate the conditions, challenges and contextual factors influencing the outcomes of the professional learning activities. Interview questions used included, ''How would you evaluate your own learning during this program?'', ''In which ways do you see yourself differently through this PBL program?'', ''What contributed to this change you have identified?'', ''In which ways do you consider your action plan of PBL implementation realistic for when you return to your home university?'', and ''What are the factors that may support or constrain you in implementing this plan?''.

4.3 Data Analysis

A ''quantifying qualitative data'' approach was adopted to analyze the qualitative data [42]. The method has been well established in the cognitive sciences and was recently introduced to educational studies [43]. Qualitative data were analyzed using an integrated approach that combines both inductive and deductive procedures. First, a theory-driven deductive content analysis [44] was applied using the model of teachers' beliefs about their roles, namely how they teach, what they emphasize and their relationships with students [17] (see Table 2 for coding guidelines). All answers to the same questions were grouped together to discern patterns. Next, a bottom-up approach [41] was used to identify themes and condensed meanings. The authors also read the individual portfolios and used them to follow participants' evolving thought processes. The first two monthly portfolios were used to explore the levels and forms of reflection of the participants at the program's start, which were primarily based on their previous experiences. The portfolios were then reviewed at months 3, 4, 5 and 6 (the final version) to explore the development of teachers' beliefs at different points in the program. Particular attention was paid to contextual analysis to identify condensed meanings and interpret what the participants meant in their given contexts. In this process, we categorized the teachers' writing about their beliefs into teacher-centered and learner-centered for each of the three dimensions. To calculate development and change, the participants' portfolio entries for months 1–2 were counted as the program's start, and a blended result from months 3–6 was counted as its end. During the program's progression, we identified qualitative change from teacher- to learner-centered beliefs. Thus a dual dimension (overlapping both dimensions with contradictory wording or concerns) was created and we added a dual beliefs category (see Table 3 for samples). All portfolio data were coded and rated by the first author following the schemes in Tables 2 and 3. Then, several rounds of data rating were conducted and the Intra-rounds Correlation Coefficient (ICC) analysis was calculated, which measures the degree of agreement among raters on the level of homogeneity or consensus in the ratings [45]. The results of the ICC, comparing the results of different rounds of analysis, were 0.93 for beliefs at the program's start and 0.86 for beliefs at its end, indicating a good level of reliability of the results.

The authors discussed the rating criteria and initial results in detail to reach a common understanding and agreement.

Quantitative methods were used to analyze the following aspects of the survey: (1) a reliability analysis for each factor of the two models – the 2-factor model and 5-factor model – as suggested by the original study; (2) descriptive statistics to identify the means of all 24 items and (3) a non-parametric correlation test (Spearman's rank-order correlation) to explore changes in teachers' beliefs (quantified results of the qualitative data), practices (survey results), and the correlation between teachers' beliefs and practices.

The results of the initial analysis of the individual portfolios and questionnaire surveys were triangulated through focus group discussions. Further

Table 2. Coding guidelines and indicators for analysis of teaching and learning portfolios

Dimensions of teachers' beliefs about their roles	Teacher-centered beliefs	Learner-centered beliefs
How teachers plan and conduct teaching activities	Lectures, demonstrations in lab, explanations, summative assessments	Multiple strategies and methods, e.g., problem-solving, interactions (student-content, student-technology, student-teacher), collaborative work, projects, feedback, formative assessment
What they emphasize in teaching	Knowledge reproduction, discipline-focused content knowledge and related skills	Knowledge creation , multiple skills and competences
How they perceive their relationships with their students	Teachers are "the saints of the stage" Master and authority of knowledge Having a say on the "correct" answers	Student responsibility to, e.g., identify problems, analyze issues, connect theories to practice, and organize learning activities, supported by teacher feedback and suggestions Accepting multiple solutions from students

Note: Synthesized from Assen, Meijers, Otting and Poell; Sabah and Du; Walter, Henderson, Beach and Williams; Weimer; and Windschitl [2, 3, 10, 15, 23].

thematic analysis [41] of focus group discussions explored the reasons behind the identified patterns and the factors contributing to and constraining the participants in relation to developing learner-centered beliefs and practices. Then, all texts were analyzed against emerging themes and compared to the literature. A collaborative approach to analysis was also used, with the authors spending several rounds comparing, discussing and negotiating their interpretations, categorizations and findings before reaching an agreement.

5. Findings

5.1 Beliefs and Change

Following the works cited in the note below Table 2 on distinguishing between teacher-centered and learner-centered beliefs, we analyzed the 35 individual teaching and learning portfolios according to the 3 dimensions of teachers' beliefs (teaching contents, methods and relationship with students) about their roles [14, 17]. We used an integrated deductive and inductive approach to analyze the six portfolio entries of each participant. According to the indicators included in the coding guidelines presented in Table 2, we categorized the teachers' writing into three levels: level 1, reflecting teacher-centered beliefs; level 2, demonstrating a dual dimension of belief including indicators of both teacher-centered and learner-centered beliefs; and level 3, reflecting learner-centered beliefs. Table 3 provides samples of excerpts from the portfolios organized by category.

At the program's start, most of the 35 participants (N = 28, 80%) were categorized as teacher-centered belief holders (level 1) and 7 (20%) were identified as holding dual beliefs (level 2). At the program's end, 9 (25.71%) participants were categorized as teacher-centered belief holders (level 1), 17 (48.57%) were identified as holding dual beliefs (level 2), and 9 (25.71%) were categorized as learner-centered belief holders (level 3). Qualitative analysis identified a notable change in teachers' beliefs from teacher-centered to learner-centered, with a good number of dual belief holders (7 at the program's start and 17 at the program's end).

A paired t-test was conducted to compare teachers' beliefs at the program's start and end. The result indicates a significant change: program's start $M = 1.20$, $SD = 0.41$, and program's end $M = 2.00$, $SD = 0.73$, $t = 6.99$, $p = 0.000$, confirming the qualitative findings.

5.2 Intended Practices and Change

Cronbach's alpha test results 0.85 for the total instrument. For the 2-factor model, the result of F1 is 0.90 and that of F2 is 0.57. For the 5-factor model, the results of factors 1–5 are 0.78, 0.53, 0.74, 0.81 and 0.40, respectively. The results are close to those of the original study of instrument development.

A comparison was conducted between the participants' self-reported practices at the program's start (based on their prior experiences) and its end (based on their planned future practice). According to the 5-factor analysis (Table 4), the participants reported a significant improvement in developing learner-centered practices in Factor 1 (student–student interaction: program's start $M = 1.86$, $SD = 0.69$; program's end $M = 2.57$, $SD = 0.50$, $t = 4.90$, $p = 0.000$), Factor 3 (formative assessment: program's start $M = 2.25$, $SD = 0.70$; program's end $M = 2.98$, $SD = 0.37$, $t = 5.47$, $p = 0.000$) and Factor 4 (student–content engagement: program's start $M = 2.55$, $SD = 0.79$; program's end $M = 3.40$, $SD = 0.35$, $t = 5.83$, $p = 0.000$). Regarding the two factors reporting on teacher-centered practices (Factor 2 and Factor 5), a significant decrease in the use of summative assessment (Factor 5) was reported (program's start $M = 2.99$, $SD = 0.46$; program's

Table 3. Samples of excerpts from the analysis of teaching and learning portfolios on teachers' beliefs

	Categories	Program's start (months 1-2)	Program's end (months 3-6)
How teachers plan and conduct teaching activities	Teacher-centered (level 1)	The most usual way to teach in my environment is to give a lecture and I believe it is the most common and useful way for students in China. (T9)	I believe that lecture is still very important in my teaching in the future, because my subject involves complicated physics and will be very difficult for students to learn without me explaining to them. (T12)
	Dual (level 2)	I have tried to organize different classroom activities because I think they were more interested in doing something in the class, but I was not sure whether they were correct or not so I need more advice. (T8)	By observing PBL practices here, I can see it works so well with students in Denmark, we should also organize more classroom activities back home, but I am not sure whether our students would support it or participate [. . .] some of them are really lazy, expecting teachers to tell them everything. (T17)
	Learner-centered (level 3)	None identified	Through my experiences these months, observation and learning as a student in the program, I feel so inspired and can see lots of strategies may be implemented in my own classroom. I would like to use a few methods such as brainstorming, letting students work on problems through group discussion during class, fieldwork, and breaking down the grades to several aspects, encouraging them to participate in various activities. I believe my students will benefit from these new ideas. (T31)
What they emphasize in teaching	Teacher-centered	I teach basic physics for year one engineering students; we usually follow the chapters and weeks in the academic schedule. (T14)	I don't think anything can be changed in my subject. The basic mathematics is so important for STEM students and they have to learn the basics solidly before they can move up. In addition, everything has been pre-defined – textbooks and examinations, there is no way I can change anything, although I agree PBL is a good thing, but not fitting my context. (T18)
	Dual	I believe it will benefit students if they can learn more interdisciplinary knowledge, rather than just following the textbooks. I have tried to encourage them to think about how to link the theories of biology and chemistry to real life, for example the food industry. But it is difficult because they need to learn all the basics and theories first before they can do more application. I don't have sufficient class time, so I have to limit all my ideas and only tell my students as suggestions. (T6)	Next semester when I get home, I am going to try it out doing PBL. I will design topics for students and let them work in teams to solve these problems. But I am not sure how much my students can manage, so I will also have to plan lectures to be sure they master the knowledge as requested in case they cannot learn it from doing projects. (T10)
	Learner-centered	None identified	I have always been in doubt that the way we have taught our students can be used in their future life. Now what I have learned here has confirmed this – it is likely not much useful. If so, why don't I try to do something different? In my field of geography, students should work on topics relating to real life and spend more time in the field rather than dealing with theories and textbooks. I will connect student projects with my current research, and I believe PBL will make the course more interesting. (T33)
How they perceive their relationships with their students	Teacher-centered	As university teachers we need to be experts in the field who can provide lots of good knowledge to students. (T21)	After all the discussions and debate during this program, I still believe that a university teacher nowadays should be an excellent researcher with rich knowledge in the field so that students and others will respect them. (T28)
	Dual	When I was a student, being a good student meant being obedient to teachers. But students nowadays are not like that anymore. As a teacher, we should train them to listen to good advice, and to let them become independent; it is not an easy task. (T35)	Now I think a good teacher should not only give students knowledge, but also train them to become independent learners. They should be able to manage many things such as searching for information and conducting the experiments. As teachers our main job should be to tell them whether what they do is correct or not. (T20)
	Learner-centered	None identified	After having been here for six months, I learned that a good teacher should facilitate students to be responsible for their own learning – they should be helped to analyze and solve problems in their study and generate various solutions. I will take this as my principle for teaching in the next step; in any case, the students may find out answers themselves; I will not tell them the correct answer. I will try to remind myself. (T32)

Table 4. Results of self-reported teaching practices analyzed by the 5-factor model

Factors	Items	Program's start		Program's end		t =	P value
		Mean	SD	Mean	SD		
Factor 1: student–student interaction	P10. I structure class so that students explore or discuss their understanding of new concepts before formal instruction	2.03	0.89	2.77	0.49	4.323	0.000
	P12. I structure class so that students regularly talk with one another about course concepts	1.54	0.78	2.77	0.43	8.178	0.000
	P13. I structure class so that students constructively criticize one another's ideas	1.26	0.85	2.54	0.51	7.678	0.000
	P14. I structure class so that students discuss the difficulties they have with this subject with other students	1.69	0.90	2.66	0.48	5.630	0.000
	P15. I require students to work together in small groups	2.09	1.27	2.09	1.27	0.000	1.000
	P19. I require students to make connections between related ideas or concepts when completing assignments	2.57	1.20	2.57	1.20	0.000	1.000
	Grand mean of Factor 1	1.86	0.69	2.57	0.50	4.90	0.00
Factor 2: content delivery practices	P01. I guide students through major topics as they listen and take notes	3.51	0.56	3.46	3.46	–0.096	0.923
	P03. My syllabus contains the specific topics that will be covered in every class session	3.00	0.77	2.86	0.69	–0.818	0.416
	P05. I structure my course with the assumption that most of the students have little useful knowledge of the topics	2.80	0.76	2.29	1.02	–2.398	0.019
	P11. My class sessions are structured to give students a good set of notes	3.49	0.51	3.17	0.45	–2.735	0.008
	Grand mean of Factor 2	3.20	0.37	2.94	0.91	–1.55	0.12
Factor 3: formative assessment	P04. I provide students with immediate feedback on their work during class (e.g., student response systems, short quizzes)	2.71	0.79	2.71	0.79	0.000	1.000
	P06. I use student assessment results to guide the direction of my instruction during the semester	2.37	1.11	3.29	0.57	4.320	0.000
	P08. I use student questions and comments to determine the focus and direction of classroom discussion	2.23	1.00	3.14	0.60	4.627	0.000
	P18. I give students frequent assignments worth a small portion of their grade	1.97	0.89	2.89	0.63	4.955	0.000
	P20. I provide feedback on student assignments without assigning a formal grade	1.94	1.30	2.86	0.69	3.662	0.000
	Grand mean of Factor 3	2.25	0.70	2.98	0.37	5.47	0.00
Factor 4: student–content engagement	P02. I design activities that connect course content to my students' lives and future work	2.63	1.00	3.51	0.56	4.559	0.000
	P07. I frequently ask students to respond to questions during class time	2.83	1.10	3.57	0.50	3.641	0.001
	P09. I have students use a variety of means (models, drawings, graphs, symbols, simulations, etc.) to represent phenomena	2.60	1.12	3.14	0.69	2.445	0.017
	P16. I structure problems so that students consider multiple approaches to finding a solution	2.54	1.29	3.46	0.51	3.901	0.000
	P17. I provide time for students to reflect on the processes they use to solve problems	2.14	1.06	3.31	0.53	5.843	0.000
	Grand mean of Factor 4	2.55	0.79	3.40	0.35	5.83	0.00

Continued on next page.

Table 4. *Continued*

Factors	Items	Program's start		Program's end		t =	P value
		Mean	SD	Mean	SD		
Factor 5: summative assessment	P21. My test questions focus on important facts and definitions from the course	3.26	0.66	2.94	0.59	2.103	0.039
	P22. My test questions require students to apply course concepts to unfamiliar situations	2.94	0.68	2.51	0.51	2.979	0.004
	P23. My test questions contain well-defined problems with one correct solution	3.06	0.76	2.69	0.53	2.362	0.021
	P24. I adjust student scores (i.e., curve) when necessary to reflect a proper distribution of grades	2.71	1.25	2.49	1.07	0.823	0.414
	Grand mean of Factor 5	2.99	0.46	2.66	0.38	3.32	0.00

end M = 2.66, SD = 0.38, t = 3.32, p = 0.000); however, no significance decrease in the use of content delivery practices (Factor 2: program's start M = 3.20, SD = 0.37; program's end M = 2.94, SD = 0.91, t = –1.55, p = 0.12) was found.

According to the 2-factor analysis, the participants demonstrated a significant improvement in developing learner-centered practices in Factor 1 (items 2, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 18, 19 and 20) (program's start M = 2.20, SD = 0.64; program's end M = 2.93, SD = 0.37, t = 2.93, p = 0.000), while no significant decrease was found in their use of teacher-centered strategies in Factor 2 (items 1, 3, 5, 11, 17, 21, 22, 23 and 24) (program's start M = 2.99, SD = 0.30; program's end M = 2.86, SD = 0.39, t = –1.60, p = 0.11).

5.3 Correlation between Beliefs and Practices

As Table 5 reports, the results of the Spearman's rank-order correlation test indicate no significant correlation between participants' beliefs and intended practices at the program's start (r = 0.018 Factor 1, r = 0.025 Factor 2), while significant correlations were identified at the program's end (r = 0.392 Factor 1, r = 0.444 Factor 2).

5.4 Factors Contributing to Change

An inductive thematic analysis of portfolio and focus group data identified several factors that contributed to a change in participants' beliefs and intended practices towards learner-centeredness.

First, the most-mentioned factor was a better understanding of what learner-centeredness means. More than half of the participants (N = 21) described this in their portfolios, and nearly all focus group participants (N = 31) mentioned having a better understanding of student-centeredness. As discussed in one group (G5), ''Before, we talked about student-centeredness all the time in China, as if everyone is already doing it. Through our study here, we see what a truly student-centered environment is, by experiencing it ourselves.''

Furthermore, the group added, ''They (the facilitators) trusted us instead of overseeing us all the time. It is highly beneficial to learn this by doing it ourselves. It made me feel I need to be responsible.'' They also remarked, ''Yes indeed, for the major reports, we had to figure out the topics, issues, and how to work on them on our own.''

Peer learning and teamwork were also noted as representing new ways of professional learning. Learning through teamwork seemed to be a new experience for all participants (N = 35). As they wrote in their portfolios, it became one of the most challenging and troublesome, yet beneficial, ways to learn. With no prior experience, they were confused and had misunderstandings during their mini-projects, but developed learning and coping strategies during the major projects. As discussed in one group (G2),

> I never experienced real teamwork like this. In the first month, we realized we had no teamwork skills even though we used to write papers together by dividing up tasks. The PBL team requires us to spend lots of time

Table 5. Results of correlation coefficient (Spearman's rho) between belief and practice

Practices		Beliefs at program's start	Beliefs at program's end
Program's start	Factor 1	–0.018	0.365*
	Factor 2	–0.025	–0.270
Program's end	Factor 1	0.099	0.392*
	Factor 2	–0.352*	–0.444**

Note: * Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

> sitting and talking together. At first, I thought it was a waste of time, but later I realized that I learned a lot about compromising and communicating.
>
> To be honest, I cried a few times during the process. I felt I had done so much work, but they [the group] did not appreciate me . . . it is better now; we finally sat down and discuss our dissatisfaction and what we wanted. It helped to understand each other.

In addition, other factors, such as critical reflection, were also found to be related to teachers' changing perceptions. Around one-third of the participants wrote in their portfolios that seeing alternative teaching methods caused them to feel enlightened and inspired to try them.

5.5 Constraints Hindering Change

A few factors that challenged participants' change towards learner-centered beliefs and practices were identified, including obstacles at three interrelated and mutually influencing levels: systemic, individual and cultural.

At the systemic level, participants wrote about and discussed the contradiction between government policies that encouraged enhancing students' competencies and the need for university teachers to follow rigid and inflexible curricular standards set by the national higher education system. In addition, each discipline has its own structure and curricular standards. Ten participants who taught first-year basic mathematics, physics and chemistry reported little change in their beliefs and practices. As they explained during the focus groups, there was no possibility for them to change textbooks, schedules, classrooms or exams, all of which were pre-defined by the curriculum. They also had large class sizes of 100–200 students. In addition, the university teacher evaluation system emphasized research outcomes and success in attracting grants, which discouraged instructors from prioritizing teaching. As discussed in a group consisting of seven science teachers (G4),

> We all know that we should provide students opportunities to develop competencies, but it is not realistic since we have to cover all the chapters in the textbooks. Also, exams from my course are from a database and I have no say in choosing how to test my students.
>
> My classes often have over 100 students. It can easily take half an hour if I ask them to organize a group discussion. What would happen if someone from the supervision office witnessed such a chaotic scene? Sometimes they suddenly show up in our classrooms and I could be evaluated with low scores or be considered incompetent for teaching.
>
> Our students are lazy and unmotivated. They may think I am a lazy teacher who is not well prepared to give a lecture. Maybe PBL is better to be used for senior students who are more mature to handle it.

Some of their concerns were also related to individual factors. Both sources of qualitative data found that their individual beliefs played an important role in producing a change. As shown in Table 3, approximately one-third of the participants still held teacher-centered beliefs at the end, which may partly explain why they could not engage in changing their practices. During the focus groups, this category of participants (who held teacher-centered beliefs) was found to be most resistant to implementing PBL in their home settings. A number of participants (N = 17) were identified as having dual beliefs, which may be related to the "dilemma" they discussed in the focus groups – although they experienced new ideas in their belief systems, they still struggled with whether they could implement PBL. Those who reported significant changes in beliefs and practices engaged in discussions on how to implement PBL during focus groups. The distribution of the three categories seemed to have no relation to the teams, with the exception of the one team mentioned above. In addition, no significance in gender was identified in any quantitative data analysis, although the qualitative data suggested that there were more females among those who appeared to be most interested and engaged in PBL implementation.

These dilemmas can also be related to cultural values. The historical and traditional ideology of teachers as masters of subject knowledge is still a prevailing value among university teachers in China. In addition, in contemporary Chinese society, students are treated as customers and teachers as service deliverers, as reflected in citations above and in Table 3.

6. Discussion

The results of the study address the literature gap identified by Amundsen and Wilson regarding how teachers' beliefs and practices change over time at the university level [24]. With evidence from this mixed-method research, the outcome of the study supports the view that professional learning can impact teachers' beliefs and practices [1, 7]. The quantitative analysis results also confirm previous findings related to beliefs and instructional practices on a large scale, particularly in STEM contexts [12, 22]. Nevertheless, the results of the study do not contradict other literature reporting discrepancies between beliefs and practices [10, 15, 20]. The dual beliefs [18] identified in the qualitative analysis indicate that the teachers struggled in the change process. Some still held beliefs that represent high levels of control, such as teachers being the knowledge authority in the classroom [18].

This study has several implications. It fills the literature gap [35] with evidence of the effectiveness

of using a PBL methodology to organize professional learning activities. Participants' experiences as learners in a PBL environment contributed to a deep understanding of what a learner-centered environment means and the benefits and challenges students may encounter [23]. Their teamwork experiences helped them better understand collaborative learning and peer learning [8, 9] and develop engagement for critical reflection [30]. When instructors have experienced teamwork, they are more likely to promote collaborative learning in their teaching practices [9, 12]. Thus, the outcome on the teamwork effect also indicates that professional learning in teams should be further supported at universities to promote high-quality teaching and prepare students for the changing job market [9]. In addition, the program design was embedded in a solid theoretical framework, as suggested by Amundsen and Wilson [24] and Saroyan and Trigwell [1], and integrated a constructive alignment framework [29] and PBL principles [30], contributing to the documentation of the effects on participants.

The study also identified a dilemma for the participants. On the one hand, these Chinese university instructors are passionate about engaging in pedagogical change in response to current societal needs for graduates in China. On the other hand, their enthusiasm is constrained by socio-cultural factors, such as the historically defined social image of the teacher as a knowledge authority in society [17, 46] and the contemporary role of university teachers as providing a service to students, who are seen as customers of the university [34]. In addition, institutional pressure to conduct research also limits teachers' commitment to pedagogical innovation [34]. These identified constraints suggest that when university teachers are encouraged to participate in professional learning programs and pedagogical innovation, their workload should be reduced in order to support their activities.

A few constraining factors were identified in this study on systemic, individual and cultural levels. While the participants were excited about learning through a PBL model, they had internal and external reasons for experiencing a dilemma regarding changes of beliefs and practices [10, 15, 23, 25, 27]. In a system where university teachers are mainly evaluated by their subject expertise rather than pedagogical competency, it is difficult to motivate teachers to focus on teaching and learning pedagogy [19]. The discrepancy between providing university teachers with professional learning opportunities aiming to implement a learner-centered pedagogy and maintaining existing evaluation and other institutional teaching policies deserves more research. Actions such as creating a new institutional culture through changes to the evaluation system and other forms of support may be needed [26, 27]. Furthermore, the societal conception of the teacher as the authority of knowledge also should be addressed in China [17, 34, 43, 46].

This study has the following limitations. First, although it provides insight into university instructors' development of learner-centered beliefs and practices during their six-month experience of a PBL-based professional learning program through a mixed-method research, the results of the study remain provisional because they were conducted in the context of participants' experience in Denmark; they may change their beliefs and ideas when their environment changes [26, 27]. In particular, this study mainly investigated the participants' intended practices after having participated in the PBL program. What they actually do upon returning to their home environment may not resemble their stated intentions, given the institutional constraints they reported. Therefore, longitudinal studies to observe these instructors' practices and their effect on students' learning would be meaningful. Another limitation of the study is the relatively low reliability of the test results of the PIPS instrument on teacher-centered factors. Although the results are close to the original instrument results, the small sample size was not adequate for validation purposes. In addition, while the research design offered unusual approaches to data generation, i.e., a quantifying analysis of qualitative data on beliefs and a self-reported survey on practices, due to the small sample size, the results demand further validation through follow-up studies.

7. Conclusions

The study investigated 35 Chinese university instructors' development of learner-centered beliefs and practices through a six-month PBL-based professional learning program in Denmark. Mixed-methods research was conducted, as suggested by the reviewed literature [1]. Both the qualitative and quantitative analysis of the T&L portfolio of each participant identified a significant change in their beliefs from teacher-centered domination at the program's start to more learner-centered beliefs at the end, with 9 participants holding learner-centered beliefs, 17 holding dual beliefs and 9 still holding teacher-centered beliefs. The questionnaire analysis found a significant change from the participants' prior teaching practices to their intended practices at the end of the PBL program. While the participants reported a significant increase in using classroom interactions and formative assessment and a significant decrease in using summative

assessment, content delivery remained a primary focus that influenced their intended practices. A significant correlation was identified between the participants' beliefs and practices at the program's end, though not at its start. The results indicate that the PBL program had a considerable impact on the participants' change of beliefs and intended practices and on aligning the two.

In conclusion, the outcomes of the study indicate that the goal of pedagogical transformation can be achieved within the current design of the PBL professional learning program, offering evidence for changes to both beliefs and intended practices. However, this is still far from actual changes in student learning practices; hence, institutional support is crucial. While this study focused on pedagogical development, the degree to which these teachers become agents for change at their home universities requires longitudinal research and possible revisions to the current program.

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