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In-Situ Educational Research from Concept to Classroom Implementation: A Multiple Paper Dissertation

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IN-SITU EDUCATIONAL RESEARCH FROM CONCEPT TO CLASSROOM IMPLEMENTATION: A MULTIPLE PAPER DISSERTATION

by

David Mark Weiss

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ABSTRACT

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While some educational research is conducted in a strictly controlled laboratory environment, in-situ educational research (i.e., collaborative research in a live classroom) introduces at least two critical negotiations between the researcher and the classroom instructor. First, a discussion is required to determine that the researcher proposed intervention adequately compliments the teacher's existing classroom curriculum plan. The second discussion addresses how the researcher and teacher might co-develop a professional learning course meant to support the classroom teacher using the proposed intervention. A negotiation framework, based on transactional distance theory, was used to guide the discussion about priorities and preferences for the professional learning course. The researcher designed a professional learning course based on discovered user preferences to prepare the classroom teachers to implement problem-based learning (PBL) in a senior engineering thermal-fluids lab course. Pursuant to the professional learning course, the teacher then designed a problem-based learning curriculum and introduced the PBL instruction to his students. Future time perspective, a motivational construct, was considered in a control group/intervention group environment to determine the extent to which the PBL instruction designed by the classroom teacher influenced the connection students made between their experience in the course and their perception a future career as engineers. The results from the mixed-methods study suggested that students perceived the PBL instruction to have a strong connection to their perception of the future as engineers. The perceived authenticity of the PBL problems increased student motivation to complete instruction that was hard for them. Perceived problem authenticity can be increased when problem selection and presentation contribute to student future time perspective.

(202 pages)

PUBLIC ABSTRACT

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David Mark Weiss

An educational researcher sought to collaborate with a classroom instructor to introduce problem-based learning as a new teaching intervention. First, a classroom instructor was approached to consider how a problem-based learning instructional approach might fit with their existing curriculum plan. The researcher and the classroom teacher used a discussion framework to decide together how to best design a professional learning course meant to prepare the teacher to use the new techniques in their classroom. The teacher took the professional learning course and subsequently designed his own problem-based learning course. That course was then delivered to undergraduate students in a college senior thermo-fluids lab course. Quantitative and qualitative data describe how students recognized the connection between the lab course and their perceptions of a future career as engineers. Preliminary findings suggest the researcher and teacher professional learning codesign process contributed positively to the classroom teachers developing and delivering their own PBL course that was perceived by students to contribute positively to their content knowledge, motivation and perception of their future career as engineers.

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In pursuit of this research, I have realized over and over again, that I made a great decision when I chose Dr. Brian Belland for my chair. It has to have been difficult to work with a student who is 20 years his senior biologically, but 20+ years his junior academically. Yet, he has provided skilled and appropriate guidance in a way that resulted in my growth. He has always listened to me as if I were a peer. He treats us all that way. From the very beginning of this 9-year journey, including the Master's degree, he was the one member of the faculty who always supported me in any topic I chose to study. His words of encouragement were like an oasis to me, because, though I have done hard things in my life, this was especially hard because it was so new in such a short period of time. He has taught me by example and his teaching, to be much more open minded about educational topics, to not worry about politics and to try to do the best research I can do at this point in my academic maturity. Dr. Brian Belland has been the perfect chair for me. I am thankful for his role in my development and in my life.

I have been treated very well by this faculty and especially by those who are on my committee. I have received formal and informal feedback that has been helpful and encouraging. Dr. Andy Walker, Dr. Kristin Searle, Dr. Courtney Stewart, and Dr. Kurt Becker have provided great support.

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laws, and 24 grandchildren. They have all been most loving and encouraging. I also have received encouragement from extended family. Each one has been a source of inspiration and even practical assistance. For some who have written their own Master's theses, they have been willing to read my writings and to some extent relive their own pain.

Both my parents are deceased. I hope they are happy about this journey and the new person I have become through the process.

Not many men have a wife who, at this stage in our life together, would have endured this much to see her husband start over in a completely new pursuit, from the bottom of the food chain. I completely over-married 42 years ago. I love you, Cyndy.

Even with all the support I have enjoyed, there are moments of truth, defining moments, when I felt alone and I needed something that no human could provide. That is how it has been for me anyway. So, I owe my deepest sense of gratitude to my God. We each have our own unique relationship to Deity. I have felt encouragement and support in ways that, for me, could only come from a heavenly source. I am living in a new world named, "Can't do it alone." I feel deep gratitude for all, and have bright hope for the future with new knowledge, thoughts and tools. Thanks to all.

David Mark Weiss

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CHAPTER 1

INTRODUCTION

The business of educating students involves addressing the needs and concerns of a number of stakeholders, including government leaders, administrators, teachers and parents (Darling-Hammond & McLaughlin, 2011; Law, 2000). Students are better prepared for the future when their educational experience helps them develop skills such as critical thinking, problem solving, cooperative learning, and technology mastery (Sandoval & Bell, 2004). In pursuit of these goals, educational researchers often propose interventions (e.g., problem-based learning [PBL]) that they believe will promote the development of these skills. Researchers who develop new classroom interventions hope to engage with classroom teachers who will agree to explore new instructional boundaries (Barab & Squire, 2004). Research in the classroom provides first hand feedback about how proposed interventions are delivered by teachers and received by students (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). This multiple paper dissertation describes the journey of a researcher and a classroom instructor as they (a) agreed on implementing a problem-based learning approach in a senior engineering lab course, (b) co-developed a professional learning course to support using PBL in the thermo-fluids lab class, and (c) applied PBL in the lab class. The research is presented in three papers from researcher concept to application in an engineering classroom (see Figure 1-1).

An engineering student's studies are packed with technical courses introducing laws, theories, technology, mathematics, and science necessary to prepare them for advanced engineering courses and their careers as engineers. One assumption supporting

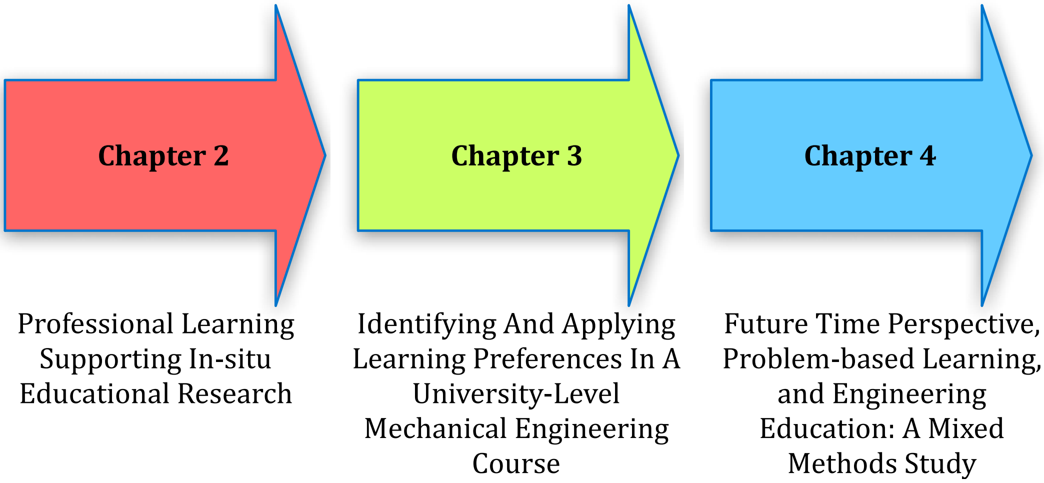

Figure 1-1. Sequence of multiple paper dissertation.

the large technical load that engineering students experience is that technical knowledge adequately prepares students for professional practice (Borrego, 2007; Nakatani, Tsukiyama, & Fukuda, 1992; Sheppard, 2008). However, recent engineering education research suggests that real-world preparation of engineers not only requires the mastering of basic theories, laws, and formulae and the skills to use them but also suggests that students develop other skills and attributes including communication skills, ability to work in teams, problem discovery and problem-solving skills (Borrego, 2007; de Justo & Delgado, 2015; Yusof, Sadikin, Phang, & Abdul, 2016). Augmenting an already full engineering curriculum, heavy in technical knowledge, with additional course content promoting the development of people skills, appreciation of group dynamics, and life-long learning skills presents challenges for both instructors and students alike (Kumar & Hsiao, 2007). Instructors have a limited amount of time in a semester and feel constrained to cover a large amount of material (Rockland, 2000; Ruiz-Gallardo, González-Geraldo, & Castaño, 2016). Students feel burdened to master an already large content load, and therefore experience uncertainty as to how the material they must learn and be tested on today actually relates to their future career as engineers (Ohland et al., 2008).

One way to enhance student motivation to persist in their studies is to magnify the perceived connection between present assignments and a mental picture of their future occupation (Hilpert et al., 2012; Husman, Cheng, Puruhito, & Fishman, 2015). Future time perspective (FTP), a theory connected to motivation, suggests that students are more likely to possess positive motivation toward engagement with difficult studies when instruction promotes a strong present anticipation of their future goals in the selection and presentation of tasks they are engaged with as students today (Husman & Lens, 1999).

PBL can help students experience a stronger connection between present day activities and their perspective of a future career in engineering (Hays, 2008; Kim & Kee, 2013; Mantri, 2014; Perez-Benedito, Perez-Alvarez, & Casati, 2015). As originally conceived by Howard Barrows, PBL promotes future time perspective when instructors carefully consider, among other elements, both problem selection and problem presentation introducing strong connections between their assignments and their perceived future as physicians (Barrows, 1985). Likewise, for engineering students, problem-centered instruction situated in actual or imagined student experience, can paint vivid pictures of the career engineering students hope to have in the future, thus increasing motivation to engage with their present studies (Strimel, 2014; Woods, 2012). Additionally, students value anticipating the practical application of student learning in what to them appears to be an authentic future environment (de Bilde, Vansteenkiste, & Lens, 2011). How might instruction be designed to simulate authentic application of student learning?

Problem presentation in PBL influences a student's perception of problem authenticity and therefore can contribute to or detract from their future time perspective. Two important elements that can contribute to problem presentation and thus a student's perception of problem authenticity are (a) a problem finding element (analysis) and (b) a problem-solving element (design; Lockwood, 2009; Parrish, 2006). An emphasis on problem finding activities (analysis) within a presented problem situation, exposes students to the ill-formed nature of problem situations many working engineers experience daily in their professions (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014). Additionally, rehearsal of problem solving or design activities provides students valuable exposure to the application of engineering principles. In engineering education terms, problem analysis can be emphasized as students confront authentic problem situations and practice *problem finding*, while designing solutions can help students practice and rehearse *problem solving* in the context of engineering skills and knowledge (Nakatani et al., 1992). Instructors can learn how to integrate elements of instruction that include both problem-finding and problem-solving tasks and present them in a way that supports the future time perspective of their students. The challenge for practitioners is to design instruction that reflects both problem finding and problem solving situated in workplace realities.

Professional learning is one method of preparing instructors to feel confident in the application of PBL in engineering classrooms (Avalos, 2011; Barab, Hay, & Yamagata-Lynch, 2001). However, some practitioners complain that the research community places inordinate focus on theory and therefore fails to completely appreciate the day-to-day realities of classroom teaching (Donmoyer, Libby, McDonald, & Deitrick, 2012; Gray, 2013). It is also likely that a researcher, who is removed from the complexity of day-to-day classroom realities, is free to consider potential classroom interventions that, in the day-to-day demands of a classroom, may be overlooked or misunderstood; interventions that may contribute materially to mutually desired learning outcomes (Opfer & Pedder, 2011). What approach to professional learning can bridge the researcher/practitioner gap?

Researchers and practitioners can benefit by mutually creating a temporary informal learning community (Wenger, McDermott, & Snyder, 2002). Within the learning community, researchers and practitioners benefit by mutually considering a common goal, establishing critical common ground, thus finding ways to bridge the researcher/practitioner gap (Cobb, 2000). Often termed cooperative participatory research, classroom teachers see their role as contributing valuable experience and perspective to a research project so that both the researcher and the classroom teacher benefit from one another's input (Mertens, 2009). For example, a cooperative approach between the researcher and the practitioner in the design of professional learning (PL; co-designing of PL) not only addresses how an intervention might be used in the classroom, but also how the design of a professional learning experience prepares the teacher to do so (Gutiérrez & Penuel, 2014).

In any cooperative partnership, the basis of negotiation is found in seeking common ground. This is no less true when considering how a researcher and classroom teacher might co-create professional learning in support of their research partnership. In a partnership focusing on in-situ educational research (i.e., research in the live classroom jointly conducted by the classroom teacher and researcher), the first negotiation between the researcher and teacher addresses the use of a researcher proposed intervention in the teacher's regular classroom. When the researcher and practitioner agree on the use of an intervention and thus share this common ground, the second discussion or negotiation involves how professional learning might be designed and delivered to augment the existing teacher skills, accommodate mutual time constraints, and prepare the practitioner to effectively use the proposed intervention. The purpose of professional learning supporting in-situ research is to help infuse teacher enthusiasm for the use of a researchers' intervention in the classroom and offer support in the use of the intervention. One way to achieve harmony and appropriate individualization of the PL course, is for researchers and classroom teachers to reach an agreement about the PL design approach (Estrada, 2005). Combining the ideas of researchers and the experience of teachers establishes common ground on which both can build an effective PL experience (Webster-Wright, 2009). Steps toward achieving common ground include (a) the researcher and the teacher arriving at an understanding of the benefits of PL, and (b) the application of a negotiation framework to guide PL design process. Guidance as to how to negotiate the co-designing of professional development is scarce.

Professional learning for in-situ research departs from other PL offerings in a number of ways that should be considered as the professional learning design is contemplated. First, PL meant to support teachers engaging in in-situ research is likely to engage only one or two PL participants instead of a department, school or district faculty (Little, 1993). Second, PL for in-situ educational research assumes that a teacher is willing to invest time in PL meant to prepare them to confidently deliver the proposed intervention (Birman, Desimone, Porter, & Garet, 2000). Third, small scale and specialized PL may not be well received by teachers when school is in session or during the summer when lesson prep often takes place (Flint, Zisook, & Fisher, 2011). Fourth, as practitioners become more familiar with the proposed intervention the researcher theory may be perceived as at odds with teacher methods or beliefs currently used in the classroom (Reeve & Lee, 2014). Mutual understanding between the researcher and the practitioner must be sought after. But how?

Moore's transactional distance theory (TDT) provides a high-level structure for a researcher/practitioner discussion about the design of professional learning and therefore the preparation necessary to apply the proposed researcher intervention. TDT originally described learning as a transaction occurring between an initiator of instruction and a consumer of instruction (e.g., where teacher behaviors are separate from student behaviors; Dewey & Bentley, 1949; Garrison, 2000). The discussion between researcher and PL participant about professional learning goals and PL course design that is meant to support in-situ research, benefits from TDT for three important reasons. First, TDT was conceptualized considering strategies meant to optimize instruction for individual learners (e.g., correspondence students) rather than instruction for large numbers of students (Wedemeyer, 1982). Second, TDT also acknowledges the degree to which the target audience exercises learning autonomy with respect to the intended instruction or topic. Third, TDT also introduces dialog and the extent to which the course structure may be adjusted to reflect the impact of dialog on the PL participants' availability for professional development (Garrison, 2003). TDT is a framework around which researchers and teachers can mutually consider the autonomy, dialog and course structure preferences, when designing PL to address common goals guiding a discussion that might otherwise be more difficult without a discussion framework.

This multiple paper dissertation describes, one paper at a time, a research process beginning with (a) a new conceptual framework for researcher/teacher negotiation when co-designing professional learning, (b) a qualitative case study of the use of the framework as a researcher and two instructors co-design professional learning, and finally (c) how students performed when supported by co-designed PL prepared teachers. If you are interested in learning more about the proposed negotiation framework inspired by Moore's transactional distance theory, read Chapter 2. Chapter 2 describes how Moore's transactional distance theory provides a novel negotiation framework around which a researcher and practitioner might co-design a professional learning experience and establish common ground. If you are interested in a mental picture of how the negotiation framework was actually applied, you will want to read Chapter 3. Chapter 3 is a qualitative case study describing how a college professor, his research assistant and the author applied the negotiation framework in the co-design of PL on PBL and scaffolding. Finally, informed by the first and second papers, the third paper is a mixed methods study reflecting an empirical investigation how PBL, as presented in the professional learning course, did or did not contribute to the future time perspective of higher education senior engineering students in a fluid dynamics lab. Those interested in how the professional learning designed in Chapter 3 contributed to the development of PBL units should read Chapter 4.

For a researcher contemplating in-situ educational research (i.e., research in the live classroom jointly conducted by the classroom teacher and researcher), the three papers describe (a) how a negotiation between a researcher and a practitioner regarding professional learning might be structured, (b) how the actual negotiation might proceed, and (c) how the professional learning might actually make its way into the classroom experience for the students. While the people involved, the topics being considered for instruction and the classroom environment might vary from researcher to researcher, beginning with a mental picture of a complete process, from beginning to end, creates a starting point from which a researcher might more confidently proceed.

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CHAPTER 2

PROFESSIONAL DEVELOPMENT SUPPORTING IN-SITU EDUCATIONAL RESEARCH

> Dr. Bryant was thrilled that Julie Jones, a teacher at Intermountain University, was enthused about using problem-based learning in her engineering science class. Pump performance was one of the subjects that she was going to cover anyway, and with the recent breakdown in the town's water supply system, investigating pump performance would be interesting and relevant to the students. She asked Dr. Bryant if it was possible to develop some professional learning so that she would know what to expect and how she should proceed. She also commented, however, that in previous professional learning administered by the university, it was as if the teachers who were on the front lines, had no voice in the content of the course. What teachers experienced on the front lines seemed not to be important enough to inform the professional learning experience. Dr. Bryant was concerned about how he should develop the professional learning and not repeat the disaster Ms. Jones had described.

Introduction

While some educational research is conducted in a strictly controlled laboratory environment, in-situ educational research (i.e., research in the live classroom jointly conducted by the classroom teacher and researcher) is highly contextual, often less predictable and introduces at least two critical negotiations between teachers and researchers (Hoadley, 2004; Kolodner, 2004). The first negotiation when conducting in-situ educational research involves how the intervention conceived by the researcher best integrates with the curriculum plan already prepared by the teacher. The second negotiation between the researcher and the classroom teacher involves how professional learning (PL) might be designed and delivered to meet researcher goals as well as teacher capacity, availability and classroom culture.

The purpose of a PL offering supporting in-situ research is to help infuse teacher enthusiasm for the use of a researchers' intervention in the classroom and offer support as the use of the intervention proceeds. As the relationship between TDT and in-situ professional learning has not been explored, this paper considers the second researcher/teacher negotiation, examining how, within the framework of Moore's transactional distance theory, researchers and teachers might work together to design PL in support of in-situ educational research (Moore, 1986; Garrison & Baynton, 1987). The paper is organized according to the following sections: (1) collaboration between the researcher and the teacher engaging together in in-situ educational research, (2) a brief discussion about professional learning, (3) transactional distance theory as a framework to inform the researcher/teacher negotiation about PL, and (4) guidelines for practice.

Theoretical Background

Researcher/Teacher Collaboration

While design-based research includes a variety of approaches, for the purpose of this paper, the term "in-situ educational research" describes a researcher and an instructor collaborating as they apply the researchers' intervention in the teacher's classroom (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Researcher-teacher collaboration offers the opportunity to bridge the gulf often present between researcher theory and teacher practice (Herrenkohl, Kawasaki, & DeWater, 2010). Researchers desire a number of key outcomes: (a) working with cooperative partners when conducting research, (b) a researcher/teacher relationship that allows for future research opportunities if they are desired, and (c) to receive valuable input from classroom teachers that lead to positive student outcomes resulting from a researcher proposed classroom intervention

(Gravemeijer, 1994; Ulichny & Schoener, 1996). When researcher/classroom teacher relationships are strained, research outcomes are compromised, ongoing research opportunities can be at risk, and important classroom teacher feedback for future research may be limited (Reimer & Bruce, 1993). Teachers, on the other hand, want to ensure that the proposed research intervention topic actually contributes to valued student outcomes (Cobb, 2000). In addition, teachers want their students to perceive them as confident, prepared, and enthusiastic teachers in all aspects of classroom management (Garet, Porter, Desimone, Birman, & Yoon, 2001). Both the curricular negotiation and the PL negotiation contribute to those ends.

Curricular Negotiation

In-situ educational research creates a tacit partnership between the researcher and the classroom instructor on several levels (O'Connor & Sharkey, 2004). The first level involves how the researcher's intervention fits into the curriculum flow that the teacher has planned for the school year (see Figure 2-1). The researcher brings to the partnership methods and assumptions that are based in research and theory (Barab & Squire, 2004; Confrey & Lachance, 2000; Sandoval & Bell, 2004). The classroom teacher contributes experience, instructional momentum and an understanding of pedagogical needs reflected by state and local standards, as well as an appreciation for the educational and cultural diversity of the students (Herman & Banister, 2007; Kolodner, 2004). As a guest in the classroom, researchers introducing an intervention new to the teacher must first seek to find common ground between the research agenda and the teacher's curricular needs (Thein et al., 2012).

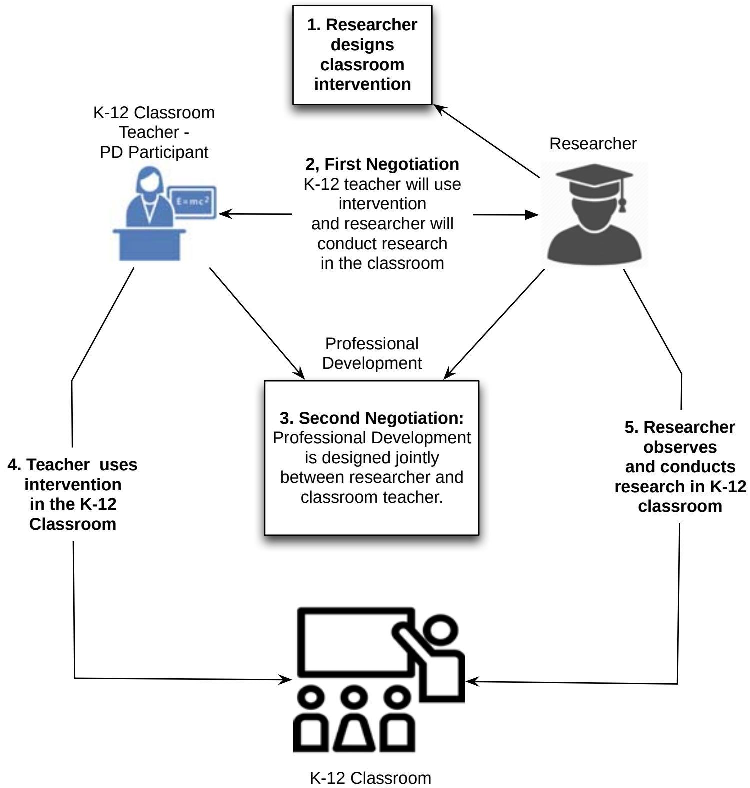

Figure 2-1. Two negotiations between researcher and teacher.

Professional Learning Negotiation

When an appropriate fit is achieved between the researcher's intervention and the teacher's curriculum plan, the second level of the researcher/teacher relationship involves how professional learning might be designed and delivered to augment the already considerable skills of the teacher, while accommodating time constraints during a busy school year. One way to achieve this harmony, or individualization of the PL course, is for researchers and classroom teachers to cooperate in designing a PL approach (Estrada, 2005). The intent of the collaboration should be to bring the ideas of researchers and experience of teachers together in an attempt to establish common ground on which both can build an effective PL experience (Webster-Wright, 2009). Steps toward achieving common ground include (a) the researcher and the teacher arriving at an understanding of the benefits of PL, and (b) using the elements of transactional distance theory to inform the PL negotiation process.

Benefits of Professional Learning

Teachers often begin their careers teaching as they themselves observed teaching as students (Oleson & Hora, 2014; Thompson, Windschitl, & Braaten, 2013). Often oblivious to student perception and lacking formative peer review, teaching can go for years unaided and unimproved (Mundy, Kupczynski, Ellis, & Salgado, 2011). The term "professional learning" infers that teaching is a complex undertaking and that teaching skills along with necessary additions to content knowledge are best learned iteratively, over time, and often reflect educational, institutional and even cultural priority shifts (Avalos, 2011). Also referred to as professional learning, approaches to PL are varied and may include classroom-based workshops, action learning research projects, peer-to-peer mentoring, and inquiry-based PL, all of which can challenge existing notions about both methods of delivery in the teacher's own classroom and instructional content (Brand & Moore, 2011; Glazer, Hannifin, & Song, 2005; Hung & Yeh, 2013). It should be noted that classroom teachers who participate in PL are "students" in the professional learning unit. However, to avoid confusion in this paper, a teacher taking part in a PL course will be referred to as a professional learning participant (PL participant).

Methods of Professional Learning Delivery

An important topic to be jointly considered by the researcher and teacher engaging in in-situ educational research is the method of course delivery such as the use of a formal or informal approach, an individual or group setting, self-directed PL, and/or technology-enhanced PL.

Formal group setting. Traditional PL often occurs in a centrally directed group setting, such as a staff meeting, wherein an instructor interacts with teachers and other participants attending the PL. Participants engage in discussion and facilitating exercises meant to stimulate transfer from the training to the actual classroom (Avalos, 2011; Bolt, 2008). PL offered in groups may be held during regular staff meetings, after school hours, or during summer breaks. Peer-to-peer collaboration is cited as a main benefit inuring from group-based PL designs (Knight et al., 2013).

Informal learning. In addition to formal group instruction, PL leveraging situated informal learning has been cited as a means of leveraging professional learning meant to improve the immediate classroom application of items emphasized in the PL (Hossainy, Zare, Hormozi, Shaghaghi, & Kaveh, 2012; Webster-Wright, 2009). Informal observations made by the teacher are often moderated in trainer/teacher settings or in small groups providing a nexus between formal and informal approaches (Borko, 2004). The informal learning approach for PL is meant to encourage reflection on what is happening in the classroom encouraging learning from day to day practice.

Self-directed professional learning. Beyond informal learning, self-directed PL attempts to democratize inservice training, making it more available while leveraging teacher "will to learn" (van Eekelen, Vermunt, & Boshuizen, 2006, p. 408). Self-directed PL encourages participants to design their own inquiry as to content, methods, technology and other identified individual needs (Mushayikwa & Lubben, 2009). Interestingly, the author found little research suggesting how PL might be designed to support one or two teachers engaged in specialty interventions.

Technology-enhanced professional learning. Research has suggested that PL participants benefit from PL that extends over time thus providing support for intended PL outcomes (Bolt, 2012; Darling-Hammond & McLaughlin, 2011; Opfer & Pedder, 2011). Technology-enhanced PL, such as online PL, not only offers convenience in time and place for the PL participant, but also a searchable reference, as the objectives presented in the PL course are transferred into instruction presented in the teacher classroom (Dede, 2006). Further, technology-supported classrooms themselves require both students and teachers who have confidence in using technology meant to enhance student learning (Donnelly, 2010). PL that leverages technology has the dual effect of modeling for teachers how technology might be used to augment instruction as well as providing just-in-time resources to be used over time after the PL course has been completed (Mitchem, Wells, & Wells, 2003). In addition, when PL is presented via the Internet, the medium itself provides (1) an opportunity to design an individualized high dialog choice for PL instruction that consumes more time, or (2) a low dialog strategy that consumes less teacher time.

While PL has been cited as a key component of education at all levels, some have questioned its effectiveness for a variety of reasons (Borko, 2004; Doherty, 2011; Ebert-May et al., 2011; Fishman et al., 2014; Walker et al., 2012; Wayne, Yoon, Zhu, Cronen, & Garet, 2008). Professional learning that is not situated in the context of the classroom provides questionable alignment between how professionals learn incrementally through their experiences in the classroom and the content of professional learning offerings (Webster-Wright, 2009). Fear of identity restructuring presents a common roadblock to teacher improvement efforts (Krainer, 2015). Lack of opportunity to critically reflect on classroom implementations is yet another reason why PL might be ineffective. The absence of records documenting what actually happens in the classroom makes critical thinking about those occurrences less likely (Darling-Hammond & McLaughlin, 2011; Doherty, 2011; Luhanga, Larocque, MacEwan, Gwekwerere, & Danyluk, 2014). Specific to this paper, some PL participants complain that they are rarely given the opportunity to participate in the design of their own PL offering prior to the PL being delivered (McLaughlin, Pfeifer, Swanson-Owens, & Yee, 1986). Lack of participation or buy-in during the design phase, often leaves PL participants questioning the relevance of the PL to the challenges they face in their everyday work as teachers (Collins, 1990; Doherty, 2014; Krainer, 2015; Yavetz, Goldman, & Pe'er, 2014). A framework that provides teachers and researchers a high-level framework for discussion about PL can mediate concerns about these and other impediments to professional learning (Castro Garcés & Granada, 2016).

Professional Learning Designed to Support In-Situ Educational Research

PL for in-situ research departs from other PL offerings in a number of ways. First, PL meant to support teachers engaging in in-situ research is likely to engage only one or two PL participants instead of a department, school or district faculty (Little, 1993). Second, in-situ educational researchers are asking a classroom teacher to consider implementing an instructional intervention within the normal flow of their curriculum plan for the year. How much time a teacher is willing to invest in PL meant to confidently deliver the proposed intervention, is a difficult question (Birman, Desimone, Porter, & Garet, 2000). Third, small-scale and specialized PL may not be well received by teachers during inservice offerings held when school is not in session due to summer vacation conflicts and time needed to prepare for fall classes (Flint, Zisook, & Fisher, 2011). Additionally, PL conducted during the school year, when teachers are busiest and find themselves under significant pressure, may discourage teachers from investing their outside of class time to prepare to teach a unit that includes a new intervention (Gómez Puente, van Eijck, & Jochems, 2015). Fourth, PL introducing a new teaching intervention may emphasize a contrast between the proposed intervention and existing teacher practices such that researcher theory may be perceived as at odds with existing teacher methods or beliefs (Reeve & Lee, 2014). For example, problem-based learning is a learner-centered approach that stands in contrast to more traditional teacher-centered instruction. In this case, a realistic goal for researchers providing PL would be to help teachers learn to alternate between their traditional teacher-centered instruction and a student-centered PBL approach to learning. Finally, in-situ research assumes that when the intervention is presented in the classroom the researcher is likely present in the classroom serving as a resource addressing unanticipated questions and clarifications with respect to the intervention. Therefore, the purpose of a PL offering supporting in-situ research is to help prepare the teacher in the use of the researchers' proposed intervention as well as providing ongoing support.

Moore's Transactional Distance Theory

Moore's transactional distance theory (TDT) provides a high-level structure for researcher and teacher discussion about PL. TDT originally described learning as a transaction occurring between an initiator of instruction and a consumer of instruction (e.g., where teacher behaviors are separate from student behaviors; Dewey & Bentley, 1949; Garrison, 2000). This separation, defined as transactional distance, is more an ordered qualitative variable than a quantitative variable (Moore, 1972) where courses exhibit higher or lower levels of dialog and serve students with higher or lower levels of autonomy, both of which impact decisions relating to course structure. The concept of distance between the teacher and the learner, called by Moore transactional distance, is described in both geographic and pedagogical terms where the interaction among autonomy, dialog and course structure limits or promotes opportunities for various kinds of interactions and approaches that deliver content (see Figure 2-2). The discussion between researcher and PL participant about PL goals and course design meant to support in-situ research, benefits from TDT for three important reasons. First, TDT was conceptualized considering strategies meant to optimize instruction for individual learners (e.g., correspondence students) rather than instruction for large numbers of students (Wedemeyer, 1982). Since in-situ research is collaboration between a researcher and a classroom teacher, the PL is likely to be designed for an individual PL participant

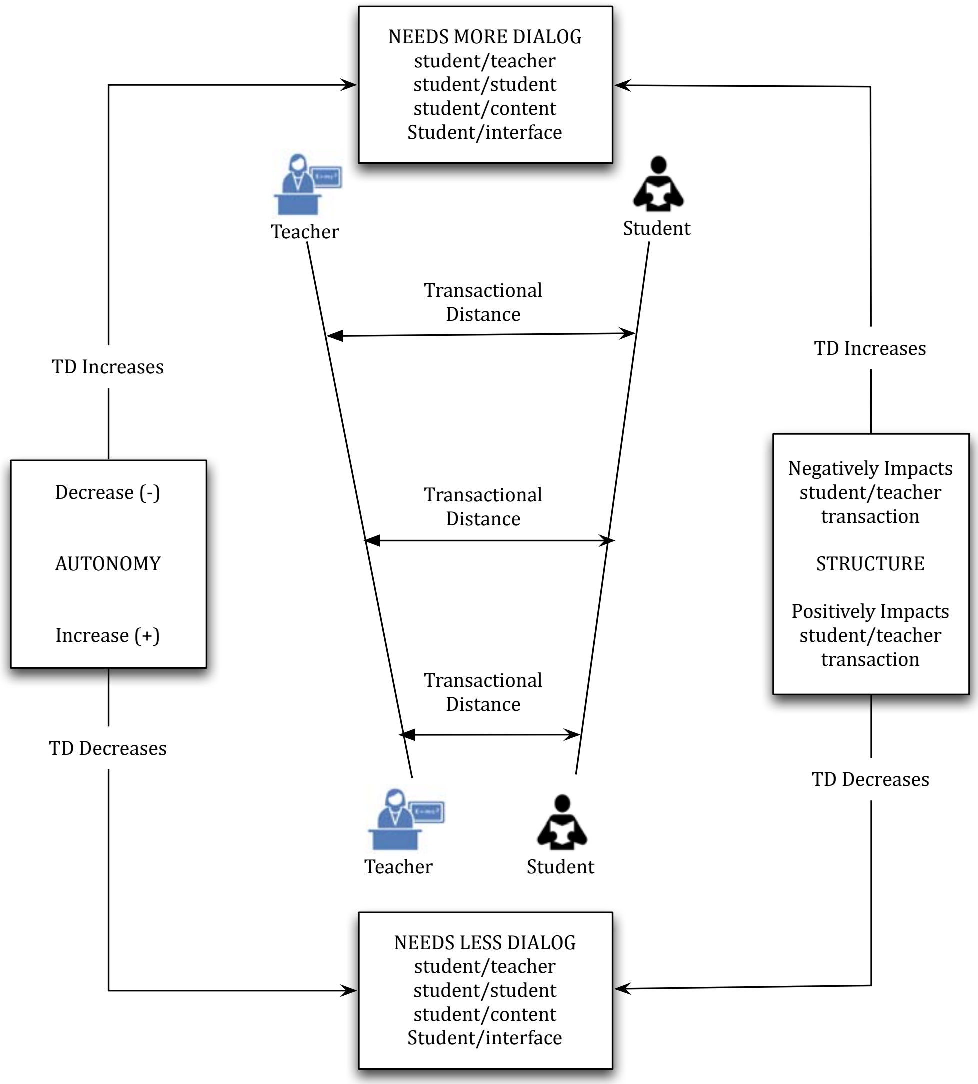

Figure 2-2. Relationship among elements of transactional distance theory.

as opposed to a faculty. Second, TDT also acknowledges the degree to which the target audience exercises learning autonomy with respect to the intended instruction or topic. Autonomy is an important consideration when working with PL participants who view themselves as experienced and knowledgeable about their craft. Third, TDT also introduces dialog and the extent to which the course structure may be adjusted to reflect the impact of dialog on the PL participants' availability for professional learning

(Garrison, 2003). During the school year, time may be a scarce commodity that teachers may be unwilling to sacrifice (McLaughlin et al., 1986). For a teacher engaging with PL, person-to-person dialog, as a means of mediating transactional distance, may be perceived as an expense in time and an inconvenience in scheduling that PL participants are not willing to accommodate (Whitenack & Swanson, 2013). TDT is a framework around which researchers and teachers can mutually consider the relationship among autonomy, use of dialog and acceptable course structure when designing PL to address common goals.

Moore's TDT describes how the interaction among autonomy, dialog, and course structure influences the learning transaction between teacher and learner, identifying both as "joint-inquirers" (Moore, 2007, p. 110). Moore's theory describes learning as an outcome resulting from an interaction between the teacher who prepares instructional options and the learner who evaluates those options as they devise their own unique path through them. Even though the teacher and learner may be separated by distance, for Moore, students are no longer the object of a teacher's instruction, but rather decide for themselves the subject and means of their own inquiry through the use of their agency (Dewey & Bentley, 1949; Garrison, 2000). Therefore, the application of TDT in PL, introduces the idea of providing the PL participant instructional options that may include student/teacher interaction or independent student use of learning activities.

Results from empirical research to validate TDT as a theory have been mixed. Some contend that TDT isn't a theory at all, lacking construct validity (Y.-J. Chen & Willits, 1998; Gorsky & Caspi, 2005). Some research has verified and solidified the interactions among autonomy, dialog and course structure (Saba & Farhad, 2003; Saba & Shearer, 1994; Wheeler, 2007). Blending system dynamics and discourse analysis, Saba and Shearer sought to validate the use of dialog as a means of impacting transactional distance between instructor and student (Beach, 1994; Levinson, 1983). To the degree that dialog is a mediating factor, designing the course to reduce dialog dependency could have an impact on perceptions of autonomy by the participant.

Negotiation Framework

The three elements of TDT, namely autonomy, dialog, and course structure, are well suited to guide a cooperative discussion between a researcher and classroom teacher as they share in PL design decisions (see Figure 2-3). If the interaction among autonomy, dialog, and course structure is poorly managed, transactional distance may grow to the point that the goal of the PL is threatened (Chen, 2001). Therefore, the potential impact of more or less transactional distance is an important consideration when the researcher organizes PL meant to successfully prepare the PL participant to apply the researcher's

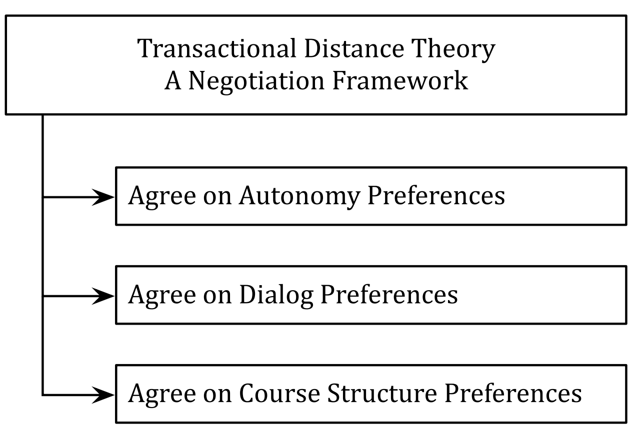

Figure 2-3. Transactional distance theory as a negotiation framework.

intervention in a classroom. For example, imagine a course structure that demands of the student high levels of autonomy, when the student is disposed to function with low levels of autonomy. Transactional distance would increase risking an instructional mismatch. Alternatively, imagine a course structure that is designed for low levels of student autonomy when the student is disposed to function with high levels of autonomy (Deci, Ryan, & Williams, 1996). Again, transactional distance would increase, negatively impacting student motivation (Aluko, Hendrikz, & Fraser, 2011; Gorsky & Caspi, 2005). The opposite cases are possible as well (Moore & Kearsley, 1996). Managing transactional distance requires continual assessment on the part of the course designer relative to all three elements of TDT. Adjustments, to course design and course delivery, including course structure, dialog and autonomy support, are expected to be made by the researcher creating the PL (Garrison, 2000). Discussions between the PL participant and the researcher creating the PL, both prior to and during the PL course, are essential in guiding decisions influencing the balance among the three elements of TDT (Angeli, 2013; Benson & Samarawickrema, 2009; Lee, Barker, & Kumar, 2011).

Autonomy as a Topic of Negotiation

Autonomy is a complex construct but is an essential topic when a researcher and classroom teacher consider together how PL might be designed and delivered (Dierking & Fox, 2013). From the researchers' perspective, an autonomously functioning learner (i.e., PL participant) is an engaged and productive learner (Black & Deci, 2000a). Further, when designing PL, self-determination theory suggests that the PL participant is more likely be guided by the direction offered by the researcher when the PL participant perceives that the PL is designed in support of their personal autonomy (Ryan & Deci, 2000). A balance must be struck between respecting learning autonomy and adjusting the course content based on emergent needs and questions (see Figure 2-4).

While complete autonomy is only a theoretical possibility, Figure 2-5 illustrates how the varying dimensions of Moore's learner autonomy, namely goal selection, plan execution, and progress evaluation interact to provide the learner a sense of autonomy as they engage within an instructional sequence. Therefore, as the negotiation about the design of the PL ensues, the researcher's perception of the PL participants' desire, or lack of it, to function autonomously should inform PL design decisions.

Flexibility vs. rigidity. Autonomy can be viewed as a function of flexibility built into the course structure that enables learner choice (Kanuka, Collett, & Caswell, 2002).

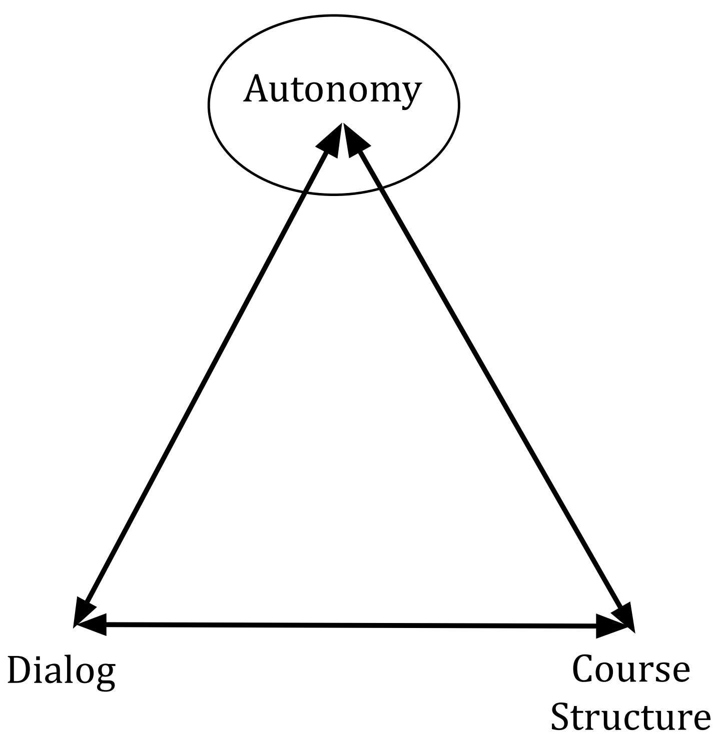

Figure 2-4. Autonomy interacting among elements of transactional distance theory.

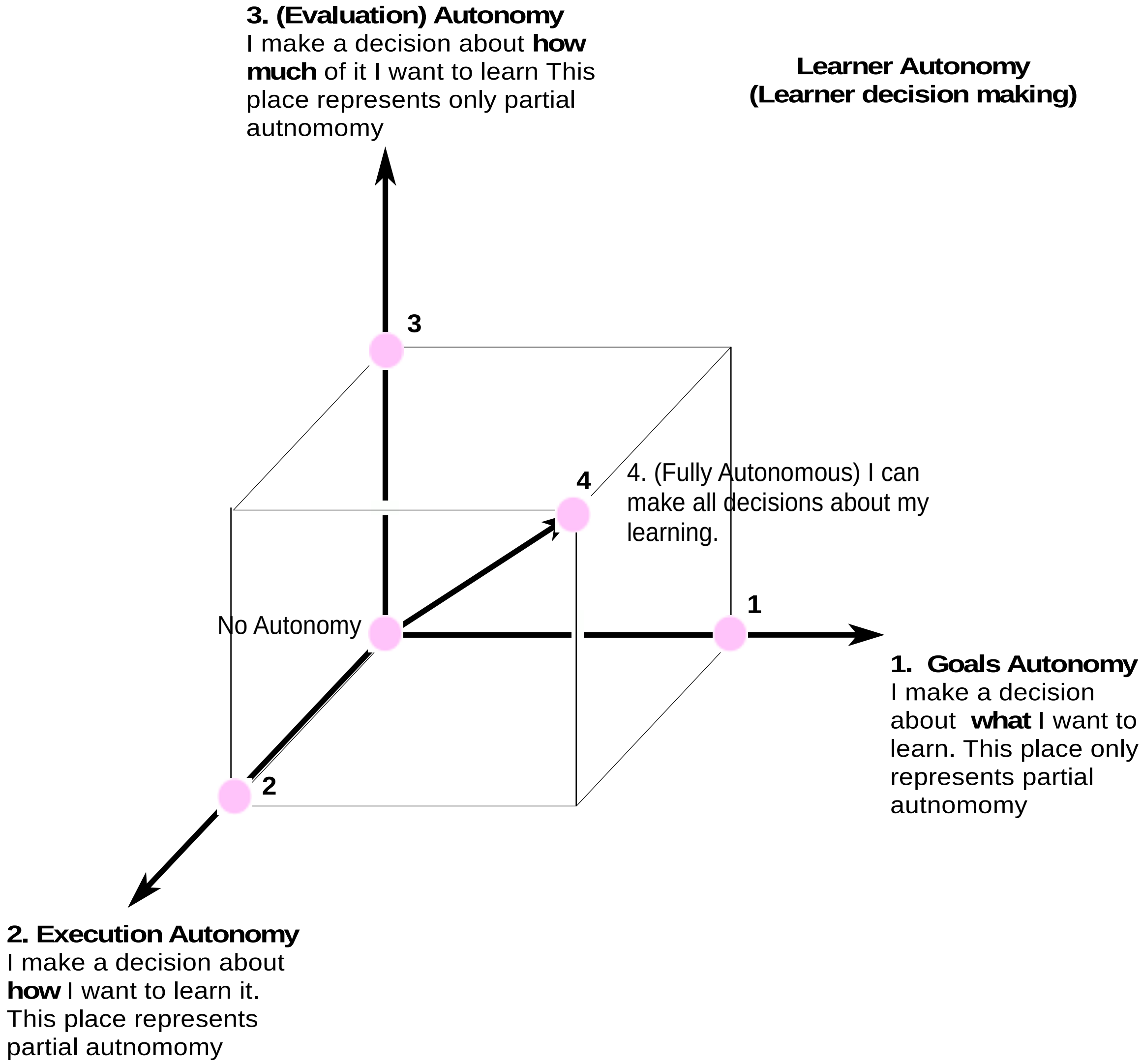

Figure 2-5. Dimensions of autonomy (Moore, 2007).

Thus, the PL participants' desire to exercise autonomy informs how flexibility is designed into course structure and is yet another key data point to explore as part of the PL design analysis. PL participants with higher levels of autonomy possess a greater tolerance for course structure that increases transactional distance, while students with lower levels of autonomy exhibit less tolerance for course structures that imposes greater transactional distance (Duffy & Kirkley, 2003). However, when a researcher senses that the PL participant exhibits high levels of learner autonomy, an opportunity to successfully introduce increased levels of transactional distance may present itself as a course design option. For example, a highly autonomous PL participant may engage effectively with PL and not require direct interactive dialog from the researcher delivering the PL.

Prior knowledge. An additional point of negotiation surrounding autonomous functioning is the degree to which the PL course itself offers instructional choices based on prior knowledge and experience (Wilson & Berne, 1999). Acknowledging the PL participants' prior knowledge with respect to teaching and perhaps the subject matter itself, the PL can be designed so that the PL participant can skip forward beyond elements of the instruction that are not new for them, and spend more time with elements that represent new and necessary information (Avalos, 2011).

Sharing power. When negotiating PL design, one way to avoid unequal relationships in light of learner autonomy is to consider the researcher-PL participant relationship in terms of power (Gade, 2015). Dron (2008, p. 60) described TDT and power by suggesting that "structure equates to teacher control, dialogue to negotiated control, and autonomy to learner control." In-situ educational research assumes that the researcher has spent considerable time developing the proposed intervention meant for the student and likely has a vision for its use in the classroom. From the researcher perspective, this vision for the use of the proposed intervention precipitates the need for PL. In the best of all worlds, the researcher and teacher should work together in shaping the intervention itself. However, the intervention may be new to the teacher. The lack of familiarity with the intervention may translate into an over-under dynamic between the researcher and the teacher when co-constructing the PL. An over-under relationship occurs when the researcher views himself as the expert and the teacher as the novice. When the researcher is perceived as having the knowledge that the PL participant needs, the PL participant can view the researcher as in a position of power. An over-under approach is likely to undermine the relationship of mutual trust necessary for meaningful collaboration and more importantly negatively impact the PL participants' sense of autonomy (Johnson & Johnson, 2009). The researcher and PL participant must share power in furtherance of trust building (Johnson & Johnson, 1989). Therefore, when the PL participant has the opportunity to select goals, learning activities and personal evaluations independent of the researcher, the PL participant experiences learner control (Benson & Samarawickrema, 2009; Garrison & Baynton, 1987). While the PL participant may cede power to the researcher for a variety of reasons, the offer to share power in decision-making about the PL builds trust as decision-making is shared and is a means of supporting learner autonomy (Darling-Hammond, 1990; Gunawardena et al., 2004). Personal autonomy and freedom of choice are both are key elements in adult learning, addressing issues of learner motivation and personal relevance (Knowles, Malcolm, Holton, Elwood, & Swanson, 2005; Lindeman, 1989; Rogers, 1969). However, a researcher may find that the PL participant perceives himself or herself as more or less autonomous than they really are (Johnson, 1981). Therefore, a researcher, who is responsible for providing supportive PL instruction, must be sensitive to the PL participants' propensity to exercise more or less autonomy with respect to the PL. In essence, the relationship between the researcher and PL participant requires trust and mutual understanding. Making PL design decisions that demonstrate respect for the autonomy of the PL participant will contribute to a positive interpersonal relationship as well as PL that is more readily accepted by the PL participant.

Dialog as a Topic of Negotiation

Dialog represents an opportunity for student/teacher, student/student, and student/content communication promoting connectedness and is a primary mediating factor among the elements of TDT (Moore, 1993; see Figure 2-6). With respect to the researcher and PL participant, the negotiation points surrounding dialog would, therefore, include consequences of dialogic approaches, mode of dialog and how dialog itself would contribute to or detract from both researcher goals and classroom teacher realities.

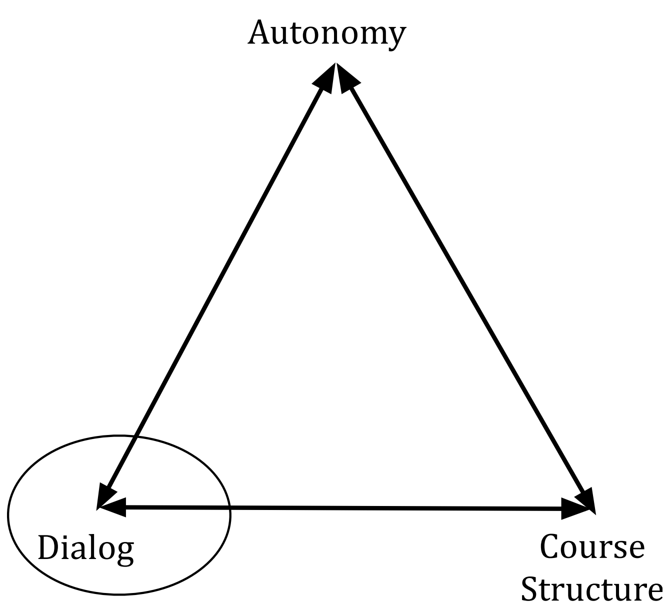

Figure 2-6. Dialog interacting among elements of transactional distance theory.

Consequences of dialogic approaches. It is natural to assume that a PL course should include some form of teacher/student dialog as the primary medium by which transactional distance is mediated (Portree, Evans, Adams, & Doherty, 2008; Shaw & Chen, 2012). It is also evident that dialog is a means of support in the event that learner autonomy is low or when course structure increases transactional distance (Ekwunife-Orakwue & Tian-Lih, 2014). However, from the perspective of PL participant taking part in an in-situ educational research project, dialog may have consequences with respect to time demands and scheduling consequences. Assuming a dialogic approach that is incompatible with the PL participants' real life as a teacher, may introduce unspoken roadblocks. This is because dialogic communication is two-way interaction demanding time and presence from both parties. Dialog can therefore be perceived by the PL participant either as a helpful interaction or an unnecessary time consumer depending on how the PL participant perceives their prior knowledge relative to the topics in the PL (Aluko et al., 2011).

The researcher designing the PL should also recognize and suggest that PL can also utilize monologic dialog (i.e., one-way presentation) which promotes personal reflection or vicarious dialog sometimes referred to as "internal didactic conversation" (Holmberg, 1986, pp. 26-40; Moore & Kearsley, 1996). Where traditional instruction assumes some form of two-way interaction, a monologic presentation does not assume interaction but rather a presentation of ideas without person-to-person interaction. Monologic dialog embodies several key advantages for a student like Russ, (1) it encourages student reflection to a voice inherent in the prepared instruction, (2) it gives the PL participant a sense of control over their instructional choices by offering them a choice to engage or to move on without obligation to respond, and (3) can promote a metacognitive response respecting their personal agency (Ekwunife-Orakwue & Tian-Lih, 2014; Zimmerman, 1995). Some contend that the lack of teacher/student dialog in a PL course inhibits responsiveness to student concerns and questions (Shaw & Chen, 2012). However, when engaging in in-situ research, after the PL is completed and the moment arrives for the researcher's intervention to be used in the classroom, the researcher will likely be situated in the classroom offering research project support. The researcher will be available to the PL participant to engage in a dialog as questions arise regarding the application of the intervention in the classroom.

Mode of dialog. A key element influencing the choice of dialogic approach is the method of instruction that arises out of the researcher/PL participant negotiation. Choices include synchronous face-to-face meetings in person and online, a blended approach that includes both face-to-face and online communication, and asynchronous online discussions as an element of a learning management system or simple email exchanges. While some modes of dialog restrict immediate interaction between the researcher and the PL participant (i.e., PL via correspondence courses or asynchronous internet communication), other mediums, such as video conferencing enhance dialog, even at a distance (Y.-J. Chen & Willits, 1998; Hsiu-Jen Cheng & Hong Zhan, 2012). The presence or absence of dialog in the PL course, must in all events, exist to support positive preparation in the eyes of the PL participant producing enough skill development that the intervention proposed by the researcher is successfully delivered to students

(Castro Garcés & Granada, 2016).

Choices of dialog. Choices of dialog are determined by the mode of communication available and are mediated together by the researcher and the PL participant. For example, a distance education course format, may de-emphasize student/teacher, or even student/student dialog, and lean more toward a mono-logic approach, accentuating student/content dialog or student/interface dialog. Striking a balance between dialog, structure and learner autonomy is a function of ongoing assessment of student progress and development, and form a continuing outline of discussion between the researcher and the PL participant. Forms of dialog, depending on the selected mode of communication, can also represent a time investment. When conducting in-situ research and co-creating PL, all efforts must be made, to be "respectful and active listeners" each contributing and building on the thoughts and ideas of the other (Moore, 2007, p. 93).

Post professional learning dialog. Once the PL has been experienced and the teacher begins applying the intervention explained in the PL course material, the researcher is likely to be present in the classroom providing ongoing support. Therefore, as Figure 2-7 describes, dialog that may have been absent during the PL course, can now occur in a more situated classroom environment. PL participant worries about time constraints in taking the PL course during a busy school year can be partially mitigated by suggesting that the PL itself will be designed so that the dialogic elements that could have been found in the PL will be reduced and become part what takes place as part of the researcher proposed intervention in the classroom.

Figure 2-7. Balance of dialog during and after professional learning instruction.

Course Structure

Once elements of autonomy and dialog have been investigated by the researcher and the PL participant, elements of course structure should be addressed (see Figure 2-8). Moore describes course structure as elements of instruction, the level of responsiveness to student needs, and flexibility relative to learner autonomy (Keagan, 1996; Moore, 1973).

Course structure. Moore's description of course structure includes instructional elements such as course objectives, themes, illustrations, activities, projects, tests, etc. Depending on the topic, the course may want to include core basic knowledge as standard elements combined with topics that the participant articulates of interest to them. However, Moore also describes course structure in terms of two broad but important concepts: (1) the degree to which the course design reflects rigidity or flexibility relative to objectives, strategies and/or evaluation and (2) the degree of responsiveness built into the course to meet the emerging needs of the PL participant throughout the instructional sequence (Keagan, 1996). Rigidity and flexibility define the degree to which PL

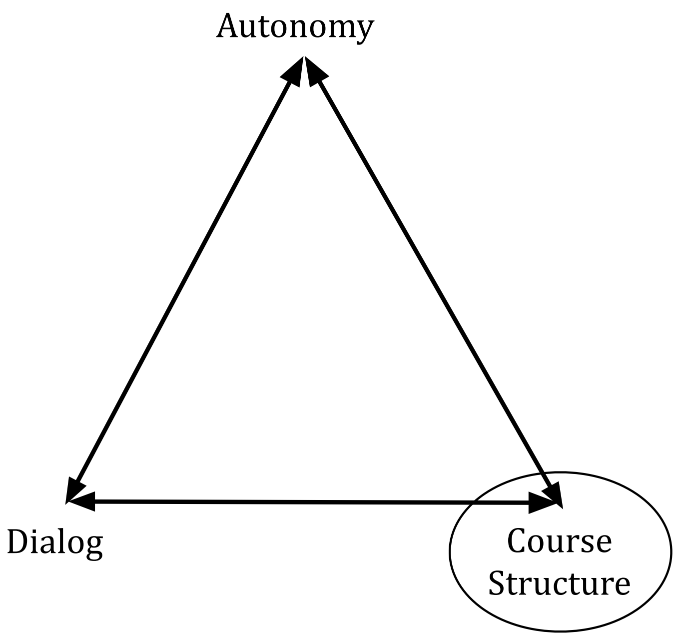

Figure 2-8. Course Structure interacting among elements of transactional distance theory.

participants are guided step by step through dependent instructional steps (rigidity) versus a PL participant choosing their own learning path through the instruction (flexibility). By choosing their own learning path PL participants individualize the PL experience to meet their own learning goals, approach to achieve those goals, and assessment of their learning progress (Anderson, 2013). Responsiveness reflects how the course reacts to the emerging needs of the PL participant during the course. The elements of course structure with respect to flexibility, rigidity and responsiveness are particularly helpful topics as the researcher and the PL participant discuss together how the PL course might best be designed and presented.

Rigidity or flexibility. Rigidity or flexibility is a topic of negotiation between the researcher and the PL participant. Course structures reflecting rigidity are highly structured with dependent steps, where completing the next step requires the completion of the step before it. Flexibility, according to Moore, reflects how each step might be designed as a self-completing whole, whose presentation in the course allows the PL participant to choose steps, skipping forward or backward according to perceived prior knowledge of that topic. As has been previously discussed, rigid course structure can interact with learner autonomy in both positive and negative ways. Rather than the researcher making an assumption about this interaction, a discussion between the researcher and the PL participant regarding step-by-step dependent course structure versus independent activity course structure can assist in developing PL that is more likely to meet the preferences of the PL participant.

Decisions about rigidity and flexibility in course structure may also arise out of constraints on the part of the researcher and the PL participant as co-designers of the PL. The constraints in a PL course supporting a PL participant engaging in in-situ educational research likely include: (1) one teacher taking the PL, remote from other teachers or a faculty environment, (2) a need to both entice the PL participant to engage with the material while respecting their existing skill as a classroom instructor, (3) PL meant to help the PL participant develop skills to support the researchers proposed intervention, and (4) a need to rethink institutional support structures. TDT serves as a framework to consider these course structure challenges.

Responsiveness. The expectation of responsiveness assumed by the course structure, should also be discussed and negotiated. When a PL participant encounters difficulty during the PL, responsiveness in course design provides needed support. Absence of this support may create a negative foundation for the ensuing research conducted in the classroom. TDT suggests that responsiveness is a reflection of dialogic preference as to how the support is provided. Moore described dialog to include teacher/student, student/student, student/content options. As each of these dialogic options may reflect a commitment of time, sense of autonomy and/or prior knowledge, working through these options together provides mutual understanding and clear design guidelines as the PL is co-created.

Guidelines for Practice

A negotiation is a discussion whose aim is to arrive at an agreement regarding one or more topics. When a researcher seeks the support of a classroom teacher to investigate the use of a proposed classroom intervention, a successful negotiation creates vision and direction meant to guide both the application of the intervention in the teacher classroom and the co-development of professional learning supporting the use of the intervention.

The intent of any mutually beneficial negotiation is to explore how all parties find common ground in the interest of mutually acceptable outcomes. While there are as many methods to conduct a negotiation, as there are people, the following questions types offered by Kvale and Brinkman (2008; see Figure 2-9) are helpful examples of questions meant to yield helpful information leading to guiding preferences.

Moore’s transactional distance theory provides a framework for understanding the learning transaction that is likely to occur when providing PL in support of in-situ educational research. Discussions between the researcher and the PL participant should be informal discussions, over time, rather than formal interviews. The following

Types of Interview Questions
Introductory Questions: "Can you tell me…?" , "Do you remember a time?". Meant to yield rich descriptions where the subject is themselves.
Follow-up Questions: A nod, or pause, repeating significant words asking for further elaboration.
Probing Questions: "Could you say something more about that?", "Can you give me some examples of that?" Probing is an attempt to verify understanding of the interviewees comments.
Specifying Questions: "When you did that, what was actually happening, going on?", "Have you experienced this yourself?"
Direct Questions: Introducing topics and dimensions that go beyond the spontaneous descriptions offered so far by the interviewee.
Indirect Questions: "How do you think others view this phenomenon?" Often interviewees will express their own opinion as the opinion of others.
Structuring Questions: "I have another topics I would like to explore." Often used to change topics when a particular topic has been exhausted and it is time to move on.
Silence: Simply being silent can encourage reflection and further comments.
Interpreting Questions: "You mean that…?", "Is it fair to say that you mean…?" Rephrasing a statement and asking for clarification and interpretation.

Figure 2-9. Types of interview questions (Kvale & Brinkman, 2008).

guidelines contained in Figure 2-10, are helpful when applying TDT as a framework for discussion topics between the researcher and the PL participant as they co-create PL meant to support in-situ classroom research. Each guideline includes a sample question meant to open the dialog between the researcher and PL participant as they work together to design the PL approach.

Determine Elements of Autonomy

Guideline 1: Discuss time constraints in light of discerned learner autonomy.

A discussion about time constraints may also shed light on learner autonomy preferences in the design of the PL (Gerard, Varma, Corliss, & Linn, 2011; Lynch & Dembo, 2004). Teachers themselves are the best judge of how much time is available in their schedule

Guidelines for Practice

Understand Elements of Autonomy

- Time constraints and autonomy
- Preference for learning path
- Sharing power in decision-making
- Desire for autonomous learning

Determine Forms of Dialog

- Dialog and mode of course delivery
- Dialogic vs. monologic preference

Determine Course Structure

- Preferred elements of course design
- Rigidity vs Flexibility
- Responsiveness

Figure 2-10. Guidelines for practice.

with respect to engaging with PL. PL participants may desire more say in what constitutes an effective PL approach (Bolt, 2012; Kohli, Picower, Martinez, & Ortiz, 2015). A PL approach that affords the PL participant more autonomy with respect to the time constraint associated with PL, communicates mutual respect and builds trust. This can be addressed by asking a question like, “My current thoughts about the PL design had maybe three modules that each took about 30-45 minutes to work through. What are some of your thoughts?”

Guideline 2: Ascertain the PL participant’s desire to select their own learning path through the material. Presenting learning activities as independent elements from which PL participant can choose, embraces autonomous functioning (Bekele, 2010). With proper labeling and short executive summaries for each topic, the PL participant can skip over topics for which they feel they already have adequate understanding. Therefore, an additional question sequence concerns itself with the degree to which the PL participant prefers setting his or her own learning path through the course (i.e., setting their own goals; Fukuda, Sakata, & Takeuchi, 2011). Follow-up questions asking for a greater description about past learning experiences and explicit learner choice respecting learning activities can provide additional understanding of the PL participants' preferences. This can be considered together by asking: "Some people who have taken PL like to set their own goals and path through the PL topics, while others like to be led in a logical and structured fashion. Can you describe what your preference might be?"

Guideline 3: Sharing power of decision-making regarding PL design. Expressing confidence in the PL participant, including their teaching experience and understanding of the classroom, can be a means of sharing decision-making power through give and take discussion with respect to the design of PL (Breault, 2014; Kohli et al., 2015). Mutual cooperation is essential when a researcher and the PL participant engage together designing in-situ educational research. Further, effectiveness is undermined when power is not distributed equally among participants (Johnson & Johnson, 2009). Therefore, a co-equal input as to PL design is essential. One way to address this idea is to ask: "What more about your students and classroom setting should I understand to help this intervention succeed?" opening a discussion for the PL participant to share preferences that inform the researcher with design ideas.

Guideline 4: Ascertain the PL participants' desire for autonomous learning. Another discussion topic between the researcher and the PL participant concerns elements of autonomy evident in the PL participants' approach to learning. The proposed researcher invention meant for the classroom may be more or less familiar to the classroom teacher. When discussing PL design together, ask questions that bring to light the PL participant's preference with respect to learner autonomy. TDT suggests that PL course structure be considered as if on a continuum (Keagan, 1996). On one end of the continuum PL course structure may be simplified, reflecting flexibility or highly complex on the other end of the scale reflecting rigidity (Wedemeyer, 1982). During a discussion with the PL participant, suggest that the PL course structure might be such that key concepts are presented as choices from which they can choose (supporting a more autonomous learner), or alternatively that the PL may be designed in a step-by-step dependent fashion (supporting a less autonomous learner). With activities from which they can choose low structure on one end of the continuum and high structure on the other end, ask the PL participant which approach, or combination of approaches might appeal to them. Consider addressing autonomy on the part of the PL participant by asking: "Some PL favors built-in flexibility reflecting learner choice, while other forms of PL are more step-by-step learning. Which approach do you think will work best for you?"

Forms of Dialog

A second discussion topic with respect to the negotiation between the researcher and the PL participant concerns itself with the various forms of dialog and how the use of dialog might best serve the perceived needs of the PL participant. Dialog in TDT includes teacher/ student, student/student, student/content and student/interface (Smith, Smith, & Boone, 2000). That this design of PL is meant to support in-situ educational research, influences which forms of dialog should be employed. As such, there is likely only one teacher, or possibly two taking the PL and therefore student/student dialog may be easily eliminated (Benton, Li, Gross, Pallett, & Webster, 2013). Further, if the PL participant has communicated that available time to engage with the PL is limited, teacher/student dialog may need to also be reduced or delayed until after the PL has been completed and researchers' intervention is being used in the classroom. The PL was developed to prepare the PL participant to return to their classroom ready to use the researcher proposed intervention. The researcher is on hand to provide support in the classroom. More researcher/ teacher dialog may ensue as the intervention is applied in this setting.

Guideline 5: Discuss various modes of delivery and their impact on dialog. Another factor influencing which form of dialog best serves the PL participant is the mode of course delivery. If the PL is to be a one-on-one discussion between the researcher and the PL participant, teacher/student dialog would be appropriate (Brigley, Hosein, & Myemba, 2009). If the mode of course delivery was via the internet, teacher/student dialog would still be possible, but the course set up would need to include either some form of synchronous communication or alternatively asynchronous discussion (Ekwunife-Orakwue & Tian-Lih, 2014; Y.-J. Chen & Willits, 1998). Questions about the mode of delivery also cross over into the previous discussion about learner autonomy. For example, if the PL participant has already indicated a desire for a course reflecting high levels of autonomy, an online asynchronous approach might be a helpful option to explore. This topic can be addressed by asking: "What has been your experience with online forms of PL as opposed to a one-to-one meeting were we get together and work through the issues in a face-to-face manner?"

Guideline 6: Discuss dialogic versus monologic course delivery. If the PL participant expresses a desire to function in a highly autonomous fashion, student/content dialog may best be accomplished through the use of a mono-logic approach (Jonassen & Kim, 2010). The topics may be addressed by simply presenting important information in a narrative format (Latta & Kim, 2009). Stories often engage the learner and can be framed to provide a familiar context in using a friendly, informal voice (Holmberg, 1986). One way to determine which approach best serves the PL participant is to ask, "Can you tell me about a time when hearing actual case studies was a helpful approach to learning for you?"

Finally, the PL participant engaging in in-situ educational research will be reassured by the idea that after the PL is completed and the researcher's intervention is being delivered in their classroom, the researcher will be in the classroom so that dialog may continue.

Course Structure

A third discussion topic concerns itself with *course structure*. Since the topics of autonomy and dialog have already been broached, ideas about course structure should already be forming in the mind of the researcher formalizing the PL. It is instructive to recall that the researcher is performing two functions as in-situ research is being introduced. First, the researcher has designed an intervention for the classroom setting. Second, the researcher is also responsible to proactively engage with the PL participant to co-design a PL approach meant to prepare the teacher to use the intervention successfully in their classroom.

Guideline 7: Preferred learning activities within the course design. Traditional elements of course design are essential topics of discussion between the researcher and the PL participant as they work together to co-design a PL approach. Topics include PL course objectives, course flow, key subjects, instructional element types, mode of communication, assessment, and expectations surrounding support (Garrison, 2000). An important reminder afforded by TDT is the concept of transactional distance. Complex PL course structure with many steps may be overwhelming to the PL participant who is less autonomous while at the same time perceived as a waste of time to the highly autonomous PL participant (Y. Chen, 2001; Moore, 2007). Some PL course structures may provide too many choices or decisions for less autonomous learners (Benson & Samarawickrema, 2009). Accommodation can be built into the PL course, by first seeking agreement between the researcher and the PL participant about PL design so that the PL is clearly focused. Consider together course structure by asking: "Our PL can contain a number of different types of learning activities. Can you tell me which kinds of learning activities are most effective for you? What works for you?"

Guideline 8: Discuss the possible impacts of course rigidity or flexibility. Course structure in TDT reflects course rigidity or flexibility (Keagan, 1996; Kanuka et al., 2002). One way of considering rigidity or flexibility as a topic of negotiation is to discuss whether the course should be highly structured with dependent steps or whether each step might be designed as a self-completing whole. As course rigidity and flexibility are also associated with learner autonomy, previous discussions about autonomy might have already provided hints indicating course design preferences. Therefore, a discussion about course structure might be used to confirm what the researcher has already learned while discussing autonomy previously (Murphy & Rodríguez-Manzanares, 2008). Address this topic by asking: “When you have engaged with PL before is it your own preference to set your own learning goals and activities or have them set for you by the course? As it relates to this PL, which would you prefer?”

Guideline 8: Discuss responsiveness as an element of course structure. TDT suggests the degree to which either the course or the instructor is responsive to students needs throughout the duration of the PL course (Gorsky & Caspi, 2005). Responsiveness designed into the course could mean that the course provides a method of recording PL participant questions or needs, and providing a response in a reasonable amount of time. A response could be defined as something as simple as an email between two parties, or as involved as finding a mutually agreed upon time for synchronous communication and holding questions until that session can occur (Shin, 2003). So that expectations for support are clear between the researcher and the PL participant, the expectations surrounding response time to support inquiries should be a point of discussion. “As questions arise during the PL, we could simply exchange emails, we could use a discussion board kind of approach to record both questions and answers. There are lots of approaches. Which would be your preference when questions come up?”

When considering learner relevance, responsiveness to PL participant needs may be built into the flow of the PL, or postponed until after the PL concludes and the subsequent in-situ research project has begun in the classroom. Postponing some PL participant questions until the proposed intervention is being employed in the classroom may situate both questions and answers in such a way as to more appropriately connect questions to application.

Implications for Future Research

While TDT is lauded by some as a theory by which elements of independent learning can be better understood, others claim that TDT may not be a theory at all needing further research as to the variables involved and their interaction as well as a deeper understanding of Moore's conception of transactional distance (Garrison, 2000; Gorsky & Caspi, 2005; Giossos, Koutsouba, Lionarakis, & Skavantzos, 2009). Still, others suggest that as new technologies are introduced, TDT should be revisited as to its relevance and ability to explain the potential impact of these new approaches (Y.-J. Chen & Willits, 1998; Stein, Wanstreet, & Calvin, 2005). Little has been written suggesting that TDT be utilized as a framework by which PL is negotiated between an educational researcher and a teacher who is implementing a researcher proposed classroom intervention. Further research might illuminate the degree to which autonomy, dialog, and course structure, the three structural elements of TDT, are comprehensive enough as a negotiation framework prior to PL being designed. It is beyond the scope inferred by in-situ educational research to consider how the framework might apply when designing for more than one classroom. Further research might include the use of the framework among multiple classrooms and instructors to ascertain the degree to which instructor learning preferences differ and how that might be addressed when designing PL.

Summary

While the literature is replete with guidelines for developing and delivering PL, this paper introduces PL that is co-developed by the researcher and classroom in support of in-situ educational research they are conducting together. In-situ research is a collaborative effort where the university researcher and the classroom teacher work jointly on a research project. When a researcher designs an intervention for use in a classroom, gaining the support of a teacher is the first negotiation (Cobb, 2000). If the intervention is going to have a chance to succeed, it is likely that some form of professional learning must be provided. The second negotiation is PL created as a mutual effort between the researcher and the teacher that benefits from the researcher's insight into the proposed intervention and the teacher's insight in their students, the priorities of the local school district and the culture of the educational system. Moore's transactional distance theory provides a helpful framework for a discussion between the researcher and the teacher as a PL participant. As a guide for PL course design TDT proposes a balance between autonomy, dialog and course structure (Aluko et al., 2011; Belaja, Boon Sai, & Wei Lin, 2012). When the researcher and PL participant use TDT to guide their discussion, both develop a much better vision for the PL approach than the researcher could develop independent of the guidance of the framework. Co-creating PL results in a teacher more prepared and confident to deliver the proposed researcher intervention in the classroom. In addition, when students and teachers experience positive learning outcomes, the chance for future research opportunities improves.

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CHAPTER 3

CO-DESIGNING PROFESSIONAL LEARNING IN SUPPORT OF A PROBLEM-BASED HIGHER EDUCATION ENGINEERING CLASS: A QUALITATIVE STUDY

Introduction

When conducting in-situ educational research (i.e., research in a classroom jointly conducted by the classroom teacher and researcher), a tacit partnership is formed between the researcher and the classroom instructor. Both agree to (a) investigate the use of a researcher-proposed intervention in the teacher's regular classroom and (b) utilize some form of professional learning (PL). Professional learning is designed so classroom instructor is prepared in the purpose and use of the intervention with classroom students.

The purpose of this phenomenological case study was to describe what happened when a design group, consisting of a professor, his graduate assistant and a learning scientist (the writer) employed Moore's transactional distance theory (TDT) as a negotiation framework to guide us through a co-design process of professional learning. The PL was meant to support the professor and his graduate assistant in the use of problem-based learning in a higher education engineering lab class. The instructors invited the author to work with them as they learned more about using problem-based learning (PBL) in their lab class. After a brief orientation of their traditional course, this writer proposed the use of a computer-based scaffold to aid higher education engineering students as they applied basic engineering theory in the PBL engineering units. The professor and his research assistant conducting the lab class needed support in the application of the scaffold and the principles of PBL that undergird the problem-centered instructional design. Co-designing the PL experience was meant to provide the necessary support and simplified the existing PL course outline (see Figure 3.1) resulted in the following PL course outline.

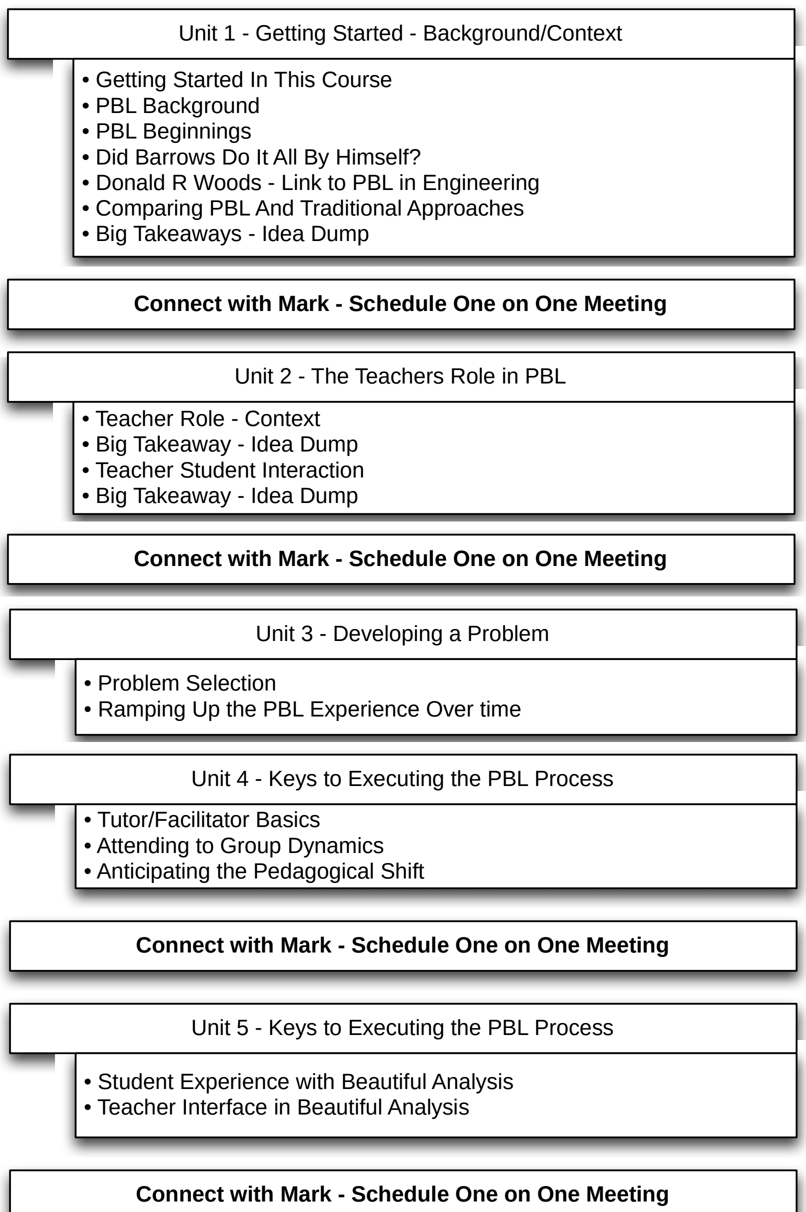

Figure 3-1. Professional learning course outline.

This qualitative study focused on what happened during the PL co-design process and how the design of the professional learning course described in Figure 3-1, came to be. Visualizing how researchers and teachers achieve mutual understanding surrounding professional learning, a researcher may conduct in-situ educational research with greater confidence.

Literature Review

Instructors in higher education are in the forefront of the battle to prepare students to meet the demands of the future (Brancato, 2003). Demands imposed by society, learning institutions, their fields of interest, and students themselves make it increasingly difficult for faculty members to keep pace with innovations in teaching (Darling-Hammond & McLaughlin, 2011). Instructors often begin their careers teaching as they themselves have observed teaching practiced in their prior role as students (Webster-Wright, 2009). Often oblivious to student perception and lacking formative peer reviews, teaching can go for years unaided and unimproved (Mundy et al., 2011). The term "professional development," as it refers to colligate level instruction, infers that teaching is a complex undertaking and that teaching skills along with necessary additions to content knowledge are best learned iteratively, over time, and often reflect educational, institutional and even cultural priority shifts (Avalos, 2011). Also referred to as professional learning, approaches designed to support instructors are varied and may include peer-to-peer mentoring, action learning research projects, and classroom-based workshops, all of which can challenge existing notions about both methods of delivery and instructional content (Brand & Moore, 2011; Glazer, Hung & Yeh, 2013; Hannifin & Song, 2005;). Some suggest that professional learning participants are deprived of a voice in the design and priority of topics associated with faculty improvement efforts and therefore lack enthusiasm to participate let alone implement new approaches to learning (Kennette & Hanzuk, 2014; Sloane-Seale, 2014). In addition, professional learning too often employs one-time workshops when responsive, consistent and persistent approaches have been identified as having greater long term benefit (de Lange, Jackling, & Basioudis, 2013). Yet, while the need is great and the available time for professional learning is scarce, the demand for student development of collaborative, lifelong and self-directed learning skills, as well as problem-solving and critical thinking skills has never been greater (*Next Generation Science Standards*, 2013). These skills and others thrive in active learning environments where students are given the chance to clarify their thinking, refocus their attention, and articulate ideas among themselves (Michael, 2006; M. Prince, 2004; M. J. Prince & Felder, 2006). For example, as applied to the current study, these are among the skills necessary for 21st century engineering students to thrive in the workplace ahead of them (Dunlap, 2005; Mentzer, Becker, & Sutton, 2015). Among the learning approaches defined as active learning, problem-based learning is one approach that when designed well, supports students as they acquire both content knowledge and lifelong learning skills. The challenge is to discover the best ways researchers, whose focus is PBL, can help practitioners learn how to facilitate PBL.

Co-Development of Professional Learning

As teaching faculty have spent years learning their craft in a variety of settings, it only makes sense for researchers to benefit from their experience by proposing a partnership relationship in the design of PL (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). In a similar vein, it is the researcher who has acquired an understanding of the theories, principles and potential benefits of a proposed intervention. Thus, the need for a partnership is evident. When researchers and practitioners collaborate on PL design, the PL course reflects practitioner prior knowledge, including the ecology of the institutional and classroom demands as well as the researcher's understanding of the proposed intervention (Han & Stenhouse, 2015). It is important to explore/understand where to begin in promoting this design partnership and what questions should be mutually addressed.

Transactional Distance Theory

Moore's TDT provides a high-level structure for a researcher and classroom teacher discussion about PL design in support of learning PBL (Moore, 1993). The discussion between the researcher and PL participant about PL goals and course design, benefits from TDT for three important reasons. First, TDT was conceptualized considering strategies meant to optimize instruction for individual learners (e.g., correspondence students) rather than instruction for large numbers of students in a classroom setting (Wedemeyer, 1982). Since in-situ research (collaborative research in a teacher classroom) is a joint effort between a researcher and a classroom teacher, the PL is likely to be designed for an individual PL participant or perhaps a participant and team teacher, as opposed to a large faculty. Second, TDT also acknowledges the degree to which the target audience exercises learning autonomy with respect to the intended instruction or topic. Autonomy is an important consideration when working with PL participants who view themselves as experienced and knowledgeable about their craft. Third, TDT introduces dialog, the variety of forms that dialog can take, and the extent to which dialog impacts the PD participants' time availability for professional development (Garrison, 2003). TDT is a framework around which researchers and teachers can mutually consider the relationship among autonomy, use of dialog and acceptable course structure when designing PL to address common goals (see Figure 3-2). To date, transactional distance theory has not been applied as a negotiation framework around

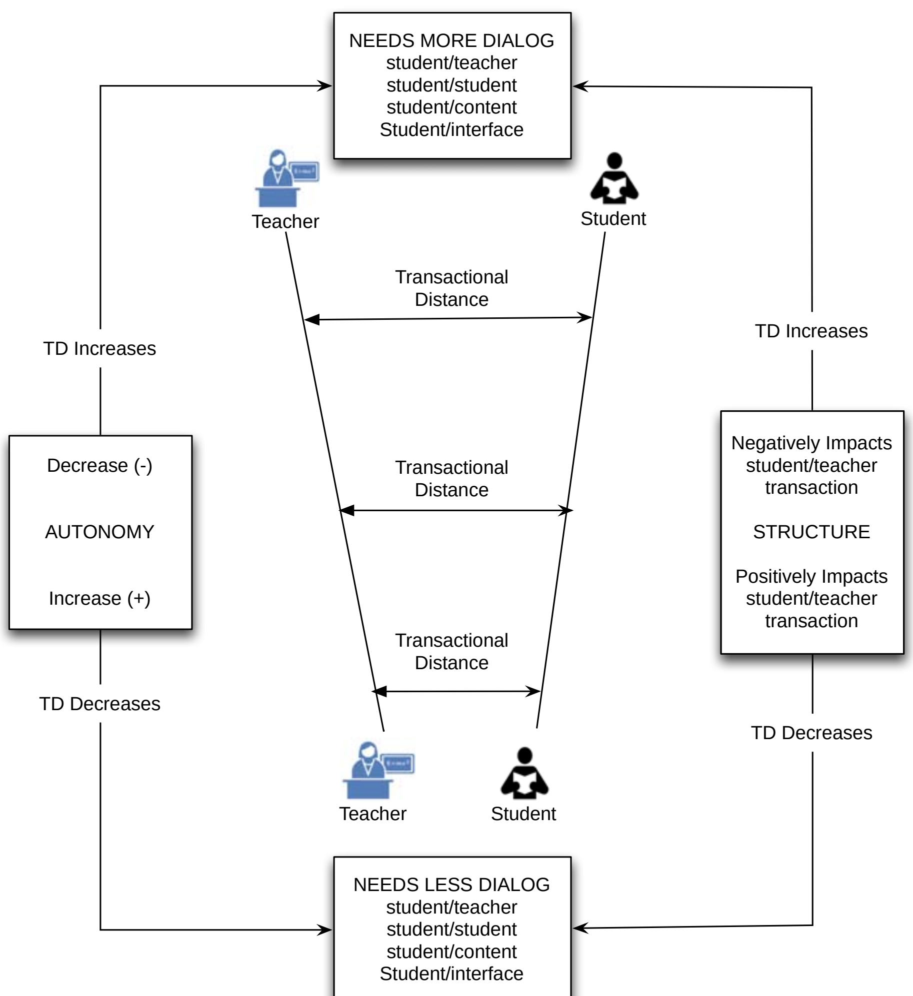

Figure 3-2. Relationship among elements of transactional distance theory.

which PL is co-designed for researchers and classroom teachers, making this study pertinent for researchers conducting in-situ research.

Transactional Distance Theory: As a Co-Development Framework

In some educational contexts, teachers have no formal pedagogical training and largely teach as they were taught. For example, lecture formats in many learning contexts are no longer sufficient to prepare students needing strong problem-solving skills necessary in the modern workforce (Hmelo, 2004). Instructional approaches such as problem-based learning offer students experience with self-directed learning, problem solving and collaborative learning but often require professional learning courses to support teachers new to the practice. However, professional learning in these contexts is often delivered using a single workshop approach that makes unhelpful assumptions about both topics and learning preferences discouraging participation and therefore adoption of new teaching interventions (Darling-Hammond & McLaughlin, 2011). Effective professional learning approaches are also important to educational researchers who seek to team up with a classroom teacher to investigate the use of a teaching pedagogy in a classroom setting. In such a case, one solution to more effective professional learning is a co-development approach where PL participants and researcher work together and inform one another in matters of context, content, application and course design. Co-designing professional learning is centered in two important principles. First, the professional learning course design should be informed by the prior knowledge and experience of both the researcher and the participants in the professional learning course (Lieberman, 2009; Merrill, 2009). Second, the course is more likely to be effective in preparing participants to implement the material, when their learning needs and preferences are understood and reflected in the course design (Avalos, 2011; Birman, Desimone, Porter, & Garet, 2000). Transactional distance theory provides a framework to help the researcher and the participants mutually agree on the needs, content and learning preferences of the participants by addressing the three major elements in the theory, namely, the participant preferences on autonomy, dialog and course structure. The discussion topics under the three elements of TDT are simple and may include follow-on questions if necessary to promote clear understanding during the discussion. The purpose of the discussion under each element of TDT is to learn about needs and preferences of the PL participants without conducting an exhaustive interview that might introduce discomfort or impatience. Further, consistent with Duffy and Kirkley (2003), as the researcher creates the course, and as the course proceeds, additional feedback from participants may provide the researcher information to further enhance the design and content of the course.

Research Questions

Theory suggests that successful PL experiences are achieved when the researcher who is preparing the PL instruction carefully attends to participant needs and preferences for learning (Darling-Hammond & Sykes, 1999; Hawley & Valli, 1999). The design of professional learning is then informed by what is learned through the negotiation between the researcher and the practitioner. In this study, I investigated how the negotiation process, prior to and during the professional learning experience, unfolded as the professor and research assistant learned how to apply principles of PBL in a senior engineering lab class. The questions that guided this study are as follows.

1. How and why did PL design goals evolve during negotiation between a researcher and instructors?
2. How was engaging in PL negotiation experienced by instructors and researchers?

Methods

Setting and Participants

The study was conducted on the campus of Intermountain University (IU; Note: to protect participant identities, all names and some identifying details have been changed) situated in a largely rural environment. The institution awards bachelors, masters and Ph.D. degrees in a variety of fields including in engineering. The design group participants included three individuals: (1) Dr. Trudeau, an assistant professor in the mechanical engineering department; (2) his research assistant, Russ; and (3) the author. The assistant professor and research assistant manage an on-campus lab focusing on thermal fluid behaviors. Department leadership also participated to provide context regarding departmental engineering education history, goals and directions. Beginning with Dr. Ford, department head, the author used snowball sampling that led to the inclusion of Dr. Monson and Dr. Donald, both members of the department of engineering education, and Mr. Jones, a retired research manager at the university with extensive research experience at multiple major universities in the U.S. (see Figure 3-3).

- Dr. Ford - White - Male - Department head - MAE
- Dr. Trudeau - White - Male - Assistant Professor - MAE
- Russ - Male - White - Graduate Research Assistant - MAE
- Dr. Monson - White - Female - Assistant Professor - Eng. Education
- Dr. Donald - White - Male - Associate Professor - Eng. Education
- Mr. Jones - White - Male Retired Faculty - College of Engineering

Figure 3-3. Participants.

Dr. Trudeau. Dr. Trudeau completed his Ph.D. at MIT, worked for a time at another university, but found his home at Intermountain University. Dr. Trudeau and the author had both formal and informal discussions about teaching generally, his interest in teaching, as well as his trepidation about "practicing" new approaches on students. It was recorded in field notes that past experiences with innovations resulted in less than acceptable teaching evaluations and that experience seemed to introduce a sense of reluctance toward experimenting. Nevertheless, our formal interviews and informal discussions made clear that for Dr. Trudeau, teaching has always been an interest. A primary goal for Dr. Trudeau has been providing students with experiences that disrupt their normal learning patterns and demand their attention:

> One of the things I'd like it to be is like students always complain that it's disorganized and I'd kinda like to have a reason why that's okay. Does that make sense?

Dr. Trudeau desired to strike a balance between providing real world ill-formed experiences for students that include challenging course problems and acceptable student evaluations of the course. Dr. Trudeau seemed to be naturally curious in both science and instruction, which probably opened the door for this research project.

Russ. Russ was a graduate research assistant for Dr. Trudeau. When I asked Russ about how he and Dr. Trudeau began working together, he explained to me that he obtained his undergraduate degree at the same university where Dr. Trudeau formerly worked and began his graduate program with Dr. Trudeau there. When Dr. Trudeau moved to Intermountain University, he transferred with him. Russ is in the final two semesters of his doctoral studies, conducting research in thermal fluids behaviors. Russ described himself as, “a fluid dynamicist.” Even within mechanical engineering people ask me questions and I’m not so good because I focus so much on this one area.” Russ has a mild and friendly disposition and students really like him. He is very comfortable in front of a group. Russ enjoys his studies, but at the same time looks forward to trying his hand at teaching someday.

> I’d like to work for the Navy for a while but I would love if I could find just a small school and, like I said before, try and make a niche for myself. It’d be a fun thing to say, ‘OK, let’s try and work up a problem-based approach in our curriculum and set ourselves apart by doing that’.

In total, I interviewed four individuals including Dr. Ford (department head in the Department of Mechanical and Aerospace Engineering), Dr. Monson (associate professor in the Department of Engineering Education), Dr. Donald (associate professor in the Department of Education) and Franklin Jones (a retired member of the department and former manager of research grants). The common theme among them, with respect to instruction was the pressure from the university, the college and the department to give attention to priorities other than innovating in the classroom.

The phenomenological approach within this case study attempted to describe the experience of the design group with the PL co-design process, from their point of view or perspective. The study is intended to benefit those whose research includes supporting a partner classroom teacher when using new teaching intervention in their classroom

(Moustakas, 1994). Among the qualitative methods, the case study approach pursued an intensive view of a "bounded integrated system with working parts" leading to a holistic description from which patterns and themes were articulated (Stake, 1995, p. 2; Yin, 2006) The "boundedness" of this case study was defined as the design group participants (i.e., the engineering professor, his research assistant, and the author; Glesne, 2015).

Data Collection

In keeping with a qualitative research methodology, multiple forms of data were collected. This allowed for triangulation in the data analysis (see Figure 3-4).

Procedures. Prior to beginning PL material design, the researcher met with college and departmental leadership and faculty and conducted interviews about the history of the college, current emphasis regarding engineering education, and use of problem-based learning within the department (see Appendix A). Because of Dr. Trudeaus's commitment to completing his tenure packet, his involvement in design discussions was limited to several informal meetings, on and off campus, to discuss PBL and the co-design process. Russ, the research assistant and the author, met multiple times to discuss PBL and the co-development of the professional learning. The design discussions were guided by the transactional distance theory framework and commenced with a discussion about the possible design of the PL approach (see Figure 3-5). The high-level topics included autonomy, dialog and course structure included in a semistructured interview sheet (see Appendix B). Follow-up questions guided by the Kvale and Brinkmann (2008) format provided clarification in terms of needs, preferences and possibilities for the PL approach. The author organized the PL

- Charts and drawings promoted visualization of data
- Lists of preferences
- Member checking to validate participant input
- Gathering and coding of archival documents
- Use of coding software (MaxQDA12)

Figure 3-4. Analytical methods.

1. Interview with Department leadership

2. Context Discussion - Design Group
   a) Innovations currently used in engineering class instructional approach
   b) PBL approaches used to date
   c) Hoped for benefits of expanding the use of PBL
3. Professional Learning Discussion
   TDT Discussion Framework
   a) Discussion questions surrounding autonomy
   b) Discussion questions surrounding use of dialog
   c) Discussion questions surrounding course structure
   d) Invitation to include PL preferences not discussed
4. Review for understanding

Figure 3-5. Design-team discussion.

Within a week after the PL was concluded, a semi-structured post interview was conducted with Russ and recorded for transcription and analysis. Questions reviewed the design discussion questions and how that discussion guided the actual PL experienced by Russell (see Appendix C). After the PL was finished, positive comments by Russ led Dr. Trudeau to request one-on-one time to understand more about PBL and how it would be applied in the upcoming lab class. Eventually, after the classroom portion of the research was concluded, Dr. Trudeau asked to be included in the PBL professional learning course so that he could consider using PBL in a graduate course in the coming fall semester. The author used the same question format during this interview that had been previously used with Russ. This discussion was also recorded, transcribed and coded for inclusion in the analysis.

Semistructured background interviews were conducted with four engineering faculty to increase my understanding of engineering education at IU and engineering more broadly. (see Appendix A for interview questions)

Audio recordings. Audio recordings were made of the interviews, which were then transcribed, imported into a qualitative analysis software package (MaxQDA-12), and coded.

Observations. With permission, classroom observations were made of those classes taught by interviewees. Often there is a distinction between what people say they do and what they actually do in the classroom. Observations provided additional context needed to understand the full meaning of the interviews.

Documents. Various documents were gathered to provide background information on the college, departments and interviewees such as college and department goals and standards, class syllabi, curriculum vitae's, and student instructional supports such as examples of projects and class projects.

Field notes. Field notes were used to stimulate the researcher's memory when a more formal written description of events was recorded sometime after the events took place (Burgess, 1982).

Data Analysis

Data analysis followed the approach of Miles and Huberman (2013): (a) data collection, (b) data reduction, (c) data display, and (d) conclusion drawing/verification. The theoretical lens through which all analysis was conducted is phenomenology, according to which thick description provides faithfulness to lived experience, the uniqueness of events, and contexts influencing the participant view of their experience (Yin, 2015).

The author/researcher is included among the members of the design group, which introduces ethical, strategic and personal biases into the research process (Locke, Spirduso, & Silverman, 2013). The author is a Ph.D. candidate at IU who came to the department after 30 years in business, largely as a business owner. Interested in education for years, and as a member of the Recreational Vehicle Industry Association's national education committee, the author experienced educational approaches that worked and some that did not work in business and leadership training environments.

No doubt, the author's own positionality as a PBL researcher influenced the choice of content and the deference the other members of the design team offered in PL decisions. It was anticipated that additional professional learning with respect to PBL would contribute to, rather than detract from the engineering instructional setting.

Results

Intermountain University and Engineering Education

IU was founded in the late 19th century as part of the land grant initiative instituted by the Morrill Acts of 1862 and 1890. The College of Engineering at IU includes six departments and over 4,000 students. The emphasis on instruction is secondary to research and grant writing. Also, Dr. Donald noted that a tension exists between traditional instructional approaches and newer forms of instruction:

> To me right now, the major change is…two points of emphasis. The first one is education with technology. The second, there is a big push right now on active learning, including problem-based learning. Problem-based learning is one form of active learning.

Still, change occurs at a very slow pace. Dr. Donald describes it this way, "I think the changes are very gradual. Nothing happens overnight. Probably there is some change in the method of teaching, for some faculty, but not for all."

The Mechanical and Aerospace Department, the second largest department in the college, is located in the main engineering building which is a hallway with glass-enclosed displays containing visual representations of current engineering research, and artifacts of various senior engineering projects. With respect to instructional innovation Dr. Ford noted:

> I don't have time for innovations, or small groups…. We have so much content to cover and giving more quizzes, trying these other things…it's just not necessary. What we do works. And I haven't seen anything better.

Dr. Ford feels that the emphasis on content during instruction is so great that new instructional approaches are seen as no better than traditional time-tested approaches and, therefore, unnecessary.

Problem-Based Learning and Engineering

When asked if the department was familiar with problem-based learning as an instructional approach, faculty members that were interviewed looked incredulous and answered in approximately the same way to the same question. I asked, “So does this department use PBL?” to which they responded, “Of course, we do problem-based learning.” I continued, “So you do small groups?” They responded “No we don’t do that very often. We mostly use large classes.” I asked further, “Do you give them authentic real world open ended problems?” They replied, “Sure every day.” I then asked, “Are there multiple solution paths to a problem?” Thoughtfully, they said,” Well yes in some cases there can be different solution paths.” And so, the conversations went. However, when visiting the classrooms and personally, the researcher observed that instructors were writing formulas (problems) on the white boards, or on overhead devices, and chaining equations together, taking an answer from one equation and inserting that as a variable in another equation. The ideas of linking equation solutions one to another made sense to me. The author had heard from Dr’s Ford and Trudeau that many of the engineering classes drilled students on formulae that hadn’t changed in 40+ years or longer. It finally became clear that when using the term PBL, the engineering instructors interviewed defined PBL as solving math problems. Students in engineering work lots of math problems lacking future career contexts.

Existing Lab Course

The senior lab course is a 2-credit-hour course and is designed to be low stress on both the instructors and the students. It is meant to be comprehensive but low on both time and study demands. The class is organized into groups named after the various houses found in the Harry Potter novels. Within each of these groups, sub groups of two or three students were organized to work together throughout the semester and engage with six themo-fluids units during the course (see Figure 3-6). Dr. Trudeau and Russ designed this course to focus on thinking through the engineering process because in their minds, this more closely aligns with real world engineering practice. Additionally, the course is designed to help students learn how testing equipment error can complicate arriving at trustable solutions to engineering problems.

Decisions About PBL Essentials in Professional Learning

The purpose of this professional learning co-development process is to discover and meet learner needs and preferences while delivering professional learning that prepares participants to use PBL. Dr. Trudeau and Russ were new to PBL, which meant

1. **Major and minor losses.** (Understanding and quantifying how pipe geometry leads to pressure losses in piping systems)
2. **Thermodynamic work**. (Understanding and measuring the equivalence of mechanical and thermodynamic work, as well as the connection between work and heat transfer)
3. **HVAC**. (Understanding and working with psychrometrics and gaining a feel for the difAcult balance between relative humidity and temperature when heating and cooling air mixtures)
4. **Pump performance**. (Gaining a feel for how pumps work and their tradeoffs, ie understanding the relationship between delivered pressure, Aow rate and pump efAciency)
5. **2D conductions**. (Estimating and measuring 2 dimensional heat transfer in metals, while gaining an appreciation for the pros and cons of analytical and experimental results)
6. **Aerodynamic drag.** (Gaining insight into drag measurement while learning about imaging and image processing techniques)

Figure 3-6. Lab units.

to me that some elements of the course content needed to provide a basic understanding of PBL. The essential PBL topics I identified included: (1) A history of PBL, and the key people involved in its development, (2) other engineering related disciplines that have successfully applied PBL, (3) problem-selection and presentation, (4) how to provide effective tutor support instead of instruction, (5) how students would use the "Beautiful Analysis" scaffold and experience it, and (6) how instructors use the proposed PBL scaffolding software. Through the interview process with Russ, the author hoped to not only discover his learning preferences, but also any additional PBL learning needs he might anticipate.

Considering Together Autonomy

As the interview process began in a quiet lab room, questions about preferences with respect to learning autonomy were put forward. As the negotiation about the design of the PL ensued, comments about the participant's desire to function autonomously were meant to inform the PL course design decisions.

> Mark: For people who have learned about PBL, sometime when they go through a professional learning they like to have, to set their own goals. Kind of make their own path through the professional learning and other people like a logical structure step by step. They want the instruction or the approach to go step by step.

> Russ: I think I like step by step. I think we want a little bit of user choice in the class, maybe some kind of structure but a little more freedom.

Making one's own way through the course seemed to concern itself with pace and the selection of which step to study. The author began thinking about some kind of online approach to professional learning that did not include dependencies demanding completion of each step before beginning another. By not tying each step to some kind of completion dependency, the learner could plan his own way through the course, which would honor any desires he had to function autonomously. A course that would give him more freedom to engage with the content on his own terms seemed to be a priority. Russ did not indicate a desire for some kind of formative assessment, but the thought came into the author's mind.

Later during the post interview, we reviewed together how Russ perceived autonomy in the course.

> Mark: When we first talked about the design of the course, we explored the idea of going step by step, so that you had to complete one before the other, versus, being able to skip around and kind of work your way through the course on your own. And if I got it right, you kind of wanted to be able to skip around, so I designed the course that way. How did that work out?
>
> Russ: It worked out great. Just like I said I wanted it. There was a logical order, but I could go anywhere and do anything I wanted.
>
> Mark: And so, this approach worked out good for you?
>
> Russ: Yeah it did. There's more to PBL than I thought, but once it was explained it made sense. And Dr. Trudeau and I want to do more of this.

The interview questions about autonomy seemed to foster understanding between Russ and the author. In addition, being attentive to his time demands and his learning preferences really seemed to promote trust. It gave us an opportunity to focus more on getting it right and not being right. The author/researcher also began to perceive that honoring Russ's preferences contributed to him owning the learning experience, which appeared to be an expression of autonomy, competence and relatedness.

Summary

A researcher might be offended when a PL participant says, in a way, “I don’t need to meet with you face to face to learn what I need to learn.” With this in mind, the emphasis of instructional delivery moved away from my personality as an instructor and my face-to-face presentation skills, to how I might deliver content in an online course that might be both interesting and confidence building. Taken to the extreme, self-directed learning would mean that students were self-educated (Moore, 1986). Peters (1998) suggested that control must be shared between the institution, its representatives and the learner. The co-design process was a shared-control process that promoted a certain respect for one another’s ideas, which created a positive partnership relationship where different ideas could be explored. One solution to begin sending the message that we were sharing control of the course design was to begin with a discussion about Russ’ learning autonomy preferences.

Course Design Decisions with Respect to Autonomy

Questions about autonomy confirmed that Russ was confident enough about the topic and his skills as a learner, that he could make his own way through the course if the design would offer him the freedom to do so. Russ made it clear that he wanted to set his own pace, not to slow and not too fast, something he could do if the course design provided that kind of latitude. The following were course design decisions about autonomy:

Share control with the co-design partner. Online course design needed to provide Russ freedom to choose by presenting content in short segments, easily scanned, and linked to additional information such that a deeper exploration of the topic would be possible and even desirable.

Providing feedback that supported his choices about autonomy. The element of meeting regularly would be the primary means of providing feedback to Russ so that he could decide for himself if he had learned enough or needed to know more or understand the content better. The author/researcher had not anticipated one-on-one meetings as a feedback option on Russ' part, so he needed to think about how their face-to-face meetings would be organized. After some thought, the author decided to apply the best practices of a PBL tutor during meetings, by asking prompting questions that replicated how the expert might gauge his progress through the material.

Considering Together Dialog

Dialog represents an opportunity for student/teacher, student/student, and student/content, student/interface and student metacognitive communication that promotes connectedness and is a primary mediating factor among learner autonomy and course structure (Moore & Kearsley, 1996). With respect to the researcher and PD participant who are co-designing the professional learning, the negotiation points surrounding dialog would, therefore, include consequences of dialogic approaches, mode of dialog and how dialog itself would contribute to or detract from both researcher goals and participant needs and preferences.

During the exploratory interview, dialog was addressed:

Mark: What has been your experience with online forms of PD as opposed to a one-to-one meeting where we get together and work through the issues in a face-to-face manner?

Russ: I think the perfect classroom for me, if I could choose my own education, the perfect classroom for me would be like some teacher sitting in the corner and I'm reading a book, right? And I'm like what does this mean and they are like "yeah," and I go back, and....

Mark: Provide you possibilities. So if you have questions as you just described... about things during the course, you just described a scenario where if you could read a book and have a teacher sitting in the room, to answer questions as they came up. So, that, so you know we could do that same thing. You could if you come up with a question we could have you put it in the course, in a discussion board, if we did the online component. We could also set it up where you'd fire me an email.

Russ: Yeah that would be great.

Mark: So what kind of communication is going to help you answer your questions in a timely way?

Russ: Email is really good. My preferred way is if we are in a room together. But just for time and I think that would be a lot more difficult, especially for me.

The additional mention of time constraints caught my attention. It would only create more tension if the author/researcher forced some kind of PL approach on this participant just because it was convenient or was a personal idea of what PL should look like. He liked the idea of one-on-one interaction, but for him that would take too much time. It was his ideas surrounding his environment and priorities that I needed understand and honor, instead of forcing upon him instruction that he might feel obligated rather than excited engage with. The author/researcher sketched in his field notes the following image that represented my understanding of his preferred learning environment (see Figure 3-7).

It was clear that a face-to-face discussion, from time to time, would be an

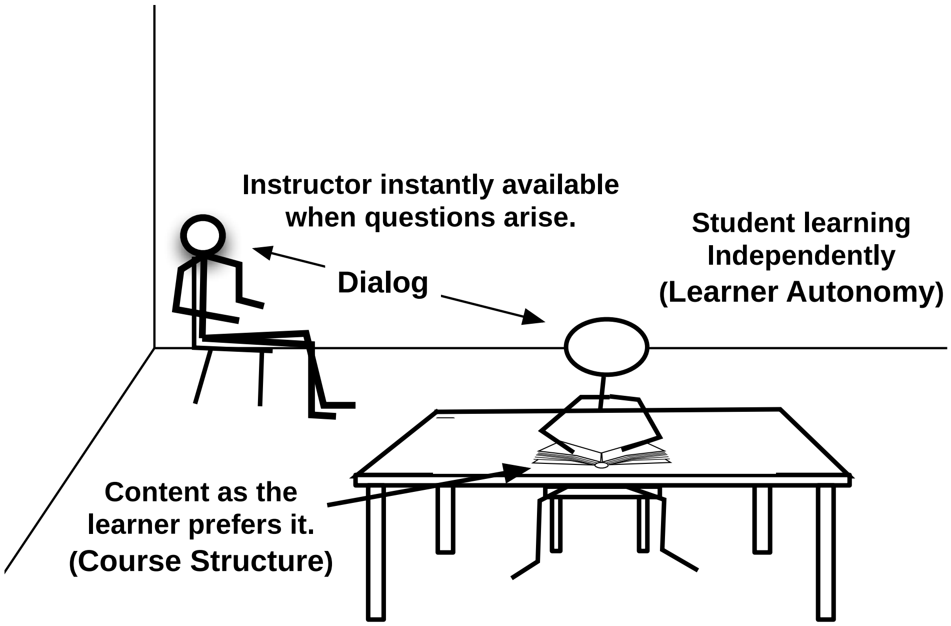

Figure 3-7. Russ' preferred learning environment.

approach to suggest and discuss. It was decided to split up the course into 3-5 units and between units meet in the lab to discuss, face-to-face, the content he had covered and check his understanding of it in a more informal manner. The end-of-unit conversations certainly provided a type of formative evaluation for Russ. The informal discussion approach was non-threatening. Further, our discussion followed a *problem first* PBL structure rather than a traditional *information first* instructional approach. We had identified together the problem of understanding PBL so he could use it in the classroom. In a sense, it was also like a flipped classroom approach for professional learning. He would read the material and prepare for a face-to-face meeting where we discussed material and emphasized key points to promote understanding.

Dialog also concerns itself with the mode of interaction between the researcher and the participants. As there are multiple means by which ideas can be exchanged, the preference of the participant can also provide clues about learning autonomy and course structure preferences.

> Mark: And in terms of, there's lots of ways to do it online, there's lots of reading then there's more reading going on, you can have stories, case studies, you can have talking head. You can have audio, you have a podcast that you can download…

> Russ: Yeah I like to go at my own pace. I get frustrated, feel like, when things are going too fast or too slow. I like reading and I like studying examples. Sometimes I get more interested in actual events as opposed to just loads of information.

> Mark: But so, you mentioned a kind of combination where maybe we do some stuff online and then after 2 or three sessions, or whatever we come together and talk and then that kind of gives you a chance to clarify some things covered during that 2 or 3 weeks. It sounds like it would be good if you could just email and say what about this and what about that? Right?

> Russ: Yes, exactly.

Miscommunication is often a source of learner frustration and dissatisfaction. The dialog questions prior to the design of the PL course prompted important input from Russ, that when applied to the professional learning course, would contribute to his capacity to use the PL in his lab class.

Building on the preceding interview questions, a third consideration we considered concerned itself with dialogic versus monologic course delivery (Holmberg, 1986). This question addresses the participant's preference with respect to learning through (1) an ongoing dynamic conversation between the teacher and the participant versus (2) a monologic approach where the participant prefers to receive content and engage in a meta-cognitive conversation about ideas and personal experience (Schank & Morson, 1995; see Figure 3-8).

Russ' description of the perfect classroom for him suggested a preference for a

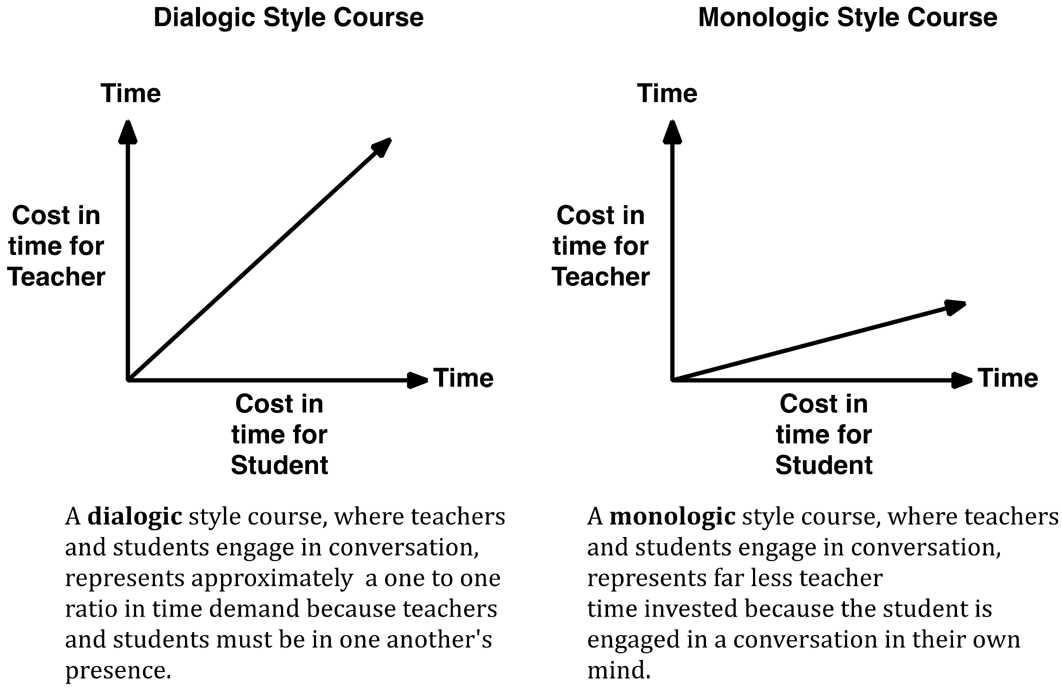

Figure 3-8. Comparison of dialogic and monologic style courses.

monologic approach with respect to the PL course combined with dialogic options to (1) reach out via email for clarification from time to time and (2) meet together in his lab room from time to time for a review of the material, to make sure his understanding would contribute to the effective use of the PL material. In our post PL discussions Russ confirmed that this approach was consistent with his learning preferences while still offering a suggestion.

Mark: As far as dialog is concerned, we decided to have meetings after the end of 3 units in the professional learning course. How has that worked out?

Russ: Great, it has worked out great. I think the discussion helped me solidify the ideas. And I can ask questions.

Mark: How has the time demand worked out? Has it been appropriate considering all you have going on?

Rudy: I think it was just about right. I can read fast and the stories kind of illustrated the points.

Mark: So not too time-demanding?

Rudy: No, not at all. Just right.

The combination of dialogic and monologic styles of communication is an approach I would never have considered on my own. The fact that Russ made this suggestion that worked out well had several positive consequences: (1) Russ was reinforced in making contributions to the course, (2) our relationship of trust was strengthened because he learned that I would listen and I learned that his ideas worked, (3) I learned a new instructional approach, just because I listened, and (4) Russ came to know that the author did not need to be the expert in PL design. We both could contribute to the PL design.

Summary

Decisions about dialog concern themselves with more than student-teacher verbal exchanges. Modes of dialog along with decisions about dialogic versus monologic approaches are also important considerations. In addition, various forms of dialog also represent various levels of time commitment. Our discussions about dialog informed course design by identifying first, that email was a good mode of dialog when questions arose because it was efficient for him, but he also wanted to leverage face-to-face interactions to solidify his own thinking. Second, he was mostly comfortable with a monologic approach to dialog, which meant to me that as far as course design was concerned I would need to consider more carefully content presentation, i.e., what he would read online and how that written instruction would be presented to keep his attention. I would not be able to rely on my face-to-face presentation skills or my personality.

Course Design Decisions with Respect to Dialog

Russ expressed that available time was a concern for him, as he was also a PhD Candidate and a Graduate Research Assistant with classroom/lab responsibilities. Still, he had a sincere desire to learn about PBL and expressed his commitment to learn by offering an hour a week for 14 straight weeks to do PL, more time than I had initially thought he would offer to the course. Had I not asked, I would likely have made some kind of assumption leading to his perception of the course being too much or too little. Listening and understanding Russ' instructional preferences with respect to dialog led to decisions related to dialog in the course.

Feedback through email and face-to-face meetings. I listened to Russ as he expressed his preference that the course provide immediate feedback when questions arose through email communication and to have regular face-to-face meetings after segments of the PL were completed, meant to check and elaborate on his understanding of the presented content. The author/researcher also felt that using less time than 14 weeks would end up being a plus for Russ, respecting his time demands outside of the PL course while also giving him a sense of confidence that he was mastering the necessary material quickly. The combination of email and face-to-face meetings was an approach the author/researcher would have never thought of in designing a PL course, had Russ' feedback not been elicited.

Monologic versus dialogic approaches. Another dialog preference that Russ expressed was that the PL course include a combination of monologic and dialogic interactions. The monologic approach, for Russ, promoted within him a meta-cognitive dialog when engaging with the material. A dialogic approach provided mutual feedback in the co-design process when he sent emails for questions he needed to understand before our meetings, and as we met together to process his learning and augment topics he needed to learn more about.

Considering Together Course Structure

When the words "course structure" are immediately considered, often the first thought is to consider course content alone. The researcher should be judicious about providing basic understanding of key content related principles and ideas central to the PL topic, as well as inquiring about participant's specific learning requests on the topic. However, Moore goes beyond elements of instruction (such as objectives, themes, illustrations, sequencing, activities, projects, tests and assessments) and emphasizes individualized instruction by including (1) the level of responsiveness to student needs and (2) flexibility relative to learner autonomy (Garrison & Akyol, 2015; Saba & Shearer, 1994). Moore's idea of responsiveness is best understood in the context of correspondence learning where teacher activities and student activities were separated by time, geographic distance and pedagogical approach. Moore suggested that finding ways to reduce this separation or "transactional distance" would aid the independent learner in completing and benefitting from learning activities. Flexibility, according to Moore, represents how the course might be designed to avoid a one size fits all approach, so that students could exercise more autonomy in the course. By making their own decisions about pacing their own learning, setting their own goals, visiting topics they perceive are of greatest interest to them and receiving appropriate feedback that was as close in time to the learning activity as possible, PL participants play a role in individualizing the instruction to meet their needs. In terms of the traditional thinking about course structure, several topics were discussed. The amount of time Russ would have available would impact course structure design decisions:

Mark: I've done this and sometimes we've broken things up into modules and spent maybe, a module would command about 30-40 minutes of your time. How does that, ...

Russ: For me?

Mark: What do you visualize in terms of learning about, do you have a time constraint?

Russ: Yeah I think 40 minutes of time would be enough.

Mark: How many of those modules do you think?

Russ: Um,

Mark: or is it hard to say because the topics aren't listed yet.

Russ: It's hard to say but how many would I have time for?

Mark: Yeah Yeah,

Russ: I think I could answer that. I think I could do one a week for 14 weeks.

Mark: OK. That's a lot. We can have different kinds of learning activities we can have quizzes, readings, podcasts, talking head…. What's most effective for you? You've kind of said, I heard you say reading.

Russ: Yeah reading, I think that's probably…combined with face to face interactions, I like to double check that I am not misunderstanding.

Mark: Do you feel in terms of preference or suggestions that would help me design something… I am going to do the legwork for you…but do you want a general introduction to PBL, do you want historical, do you want, operational, those are some of the early choices, or do you want me to focus more on how PBL applies in an engineering setting?

Russ: I think general would be good. General background. I think some history of how it applies, that would be good as well.

As has been stated, since dialog is a mediating element among autonomy and course structure, the discussions we had about dialog had already informed to a large degree the responsiveness element of course structure. Russ defined "immediate enough" by suggesting that responsiveness would include (1) email interactions would be responsive enough and (2) occasional face-to-face interactions for additional clarification.

Flexibility, the degree to which autonomy, dialog and course structure can be modified to respond to participant needs, was evident first and foremost through the co-development process itself. The co-development process had the potential to create a relationship between the researcher and the participants, that encourages discussion and sharing of ideas both formally and informally before, during and after the PL experience. Additionally, if the co-development process is well executed and received, the need for modifications in the PL course can be minimized. Still, as a participant experiences a co-designed course, suggestions and additions can be discussed. The co-design process encourages interaction with ideas and preferences. In this case, as we were discussing the use of the software in his engineering lab course, he made this suggestion:

Russ: Yeah, that could be interesting. Maybe I already told you about this one, I wanted to do one where I could think up...it's hard to do in engineering because everything is so visual, but I thought it would be really great if I could come up with podcast that reinforce the basic concepts of every lecture… it's just kind of reviewing stuff and you just kind of see if like...just walking to school and back we can listen to it. I don't know.

Mark: So, here's what we can do. Pretty easily, actually. I think pretty easily.

You could create a podcast and put it up on a private You-Tube account and link to it.

Russ: I'll just put it in there.

Mark: And then put the link in there.

Russ: Yeah.

Mark: And I think I can make the link using a media tag to where it opens the actual video.

Because of the relationship of trust developed during the co-design process, additional ideas for instruction were addressed and considered. Russ felt comfortable suggesting the use of a podcast as instructional support. The author/researcher felt comfortable recommending we use a private YouTube channel to get that done. Flexibility in course structure was demonstrated in our co-development process as both of us were willing to consider suggestions about how the course might proceed, before, during and even after the course had been delivered, consistent with Moore's conception of flexibility (Goel, Zhang, & Templeton, 2012).

Summary

As it relates to course structure, Russ largely ceded decisions about PBL course content to me, as the researcher. I felt that Russ was largely deferring course content decisions to me as we both knew that PBL was a focus of my graduate studies, although we did discuss options for topics in the course. With respect to responsiveness, our discussions about dialog, made clear his desire to be able to seek clarifications via email which was an expression of a fairly immediate response when necessary, but to also discuss content together face-to-face periodically throughout the course with was much less time sensitive. Flexibility was implied through the co-development process itself and through our face-to-face meetings where his comments and level of understanding could be evaluated and responded to.

Flexibility in course structure. In terms of flexibility (willingness to adapt the course as needs arose) the regular face-to-face meetings provided opportunities for me to inquire as to how the course was meeting Russ' needs and what changes might need to be considered. In addition, the email option was also a source of important course feedback. The author/researcher received one email from Russ where he had some questions about navigation in the course. We met face to face, and I offered him assistance to resolve that concern.

Introducing PBL software: Beautiful analysis. An additional decision the author/researcher had to address was the timing of introducing the computer-based scaffold he would use as he introduced PBL to his senior lab course. The author/researcher decided that the best time to introduce Russ to the software was after he had completed the background elements of PBL in the professional learning course. The author/researcher took this approach so that he would better understand why the software was designed as it was. During one of our face-to-face meetings the author/researcher walked him through the log in process as if he were a student so that on his own time he could log in again and become familiar with the student experience.

Mark: I want to show you something. We'll go here. I just want you to consider… this is some software. I am showing the student part….

Russ: Do you have to enter the prompt to get that as the user? Or was the information already there?

Mark: The way the software works is the teacher has some amazing control. The interface gives me a choice of what items here I'm going to show. It also gives me a choice of what I'm going to show.…

Russ: That's really cool.

Mark: From that, they can start working together on what is really going on. This software is meant to, I guess, make this reasoning process kind of specific. So, if in engineering, which they do, have a whole bunch of problem solving processes in engineering, I found out, you could put a seven-step process in here put a two-step process in here, put a process specific to mechanical or specific to fluid dynamics. How should a person think through this?

In a subsequent one-on-one session, we spent time going through the teacher interface where teachers can define classes, enter students, create courses. Having had a student experience, learning what the teacher does in the software to create that experience made more sense.

In the post interview, the author reminded Russ of the interview questions and about his course structure preferences. The author then asked him how the approach we took worked out for him.

Russ: It worked out great. The material was interesting, especially the stories, and.…

Mark: How about the time demand? The demands of the course on your time?

Russ: It worked about just about right. Yeah, it was good.

Mark: We talked about possibly adding quizzes from time to time. Kind of low stakes quizzes where you could see how you were doing. I never did that.

Russ: Actually, I think that would have been good. A good addition.

Mark: How about the face-to-face meetings and the use of email?

Russ: Our meetings have been really helpful if for no other reason than for me to figure out if I was understanding and how to use this stuff in a classroom setting. Those conversations were also helpful.

The author had written in my field notes that Russ enjoys writing short stories in a writing group about once each week. I confirmed with Russ that a narrative format of many of the topics in the course would appeal to him. Both Barrows and Woods had many stories in their writings that I could include in the course to illustrate the principles of PBL.

Summary and Implications

It is my intent with this research to assist readers as they consider co-designing PL as they engage with in-situ educational research. Much of the literature with respect to professional learning includes an assumption that courses are designed as if the designer already knew what the participant needed to know and how the participant wanted to learn (Castro Garcés & Granada, 2016; Darling-Hammond & McLaughlin, 2011; Gutiérrez & Penuel, 2014). It is true, that professional learning is often designed in support of institutional requirements leaving little room for flexibility in content. It is also true that reaching out to a group of PL participants to ascertain their learning preferences can result in conflicting guidance when designing professional learning. However, with the demand for government, district, school and parent accountability in the classroom, and an increasing demand for in-situ educational research, flexibility in both PL content and instructional approaches is possible and even desirable (Flint, Zisook, & Fisher, 2011). This research suggests that researchers and practitioners can both benefit from professional learning that is co-designed, leveraging their unique and individual strengths.

This research also sought to describe for a researcher and PL participant, how a discussion among research partners might begin and develop, resulting in a successful collaborative relationship. With the absence of an established discussion framework for co-developing professional learning, beginnings may be awkward and halting. I uniquely proposed the use of Moore's transactional distance theory as a discussion framework from which learning preferences may be discerned. The author selected this theory because of its suitability for a teacher/student relationship that addresses the connection among three central ideas of the theory, namely learner autonomy, various forms of dialog and elements of course structure. "Context matters" when considering instruction (Barab & Squire, 2004, p. 1). Therefore, the overriding question addressed by this study is how the actual discussion among research partners might proceed so that learning context, as well as individual needs and preferences may be mutually understood. The framework provided by transactional distance theory and open-ended questions associated with each element of the theory provide a high-level outline by which both researcher and learner can come to understand one another, and discover together preferences on autonomy, dialog and course structure.

Cooperative participatory research implies that the researcher and the classroom teacher conduct their research together (Cobb, 2000). When a new intervention is being tested in the classroom, whether it be one that is recommended by an institution or proposed by a researcher, the partnership between the researcher and the classroom teacher may extend beyond the PL into the actual classroom where the proposed intervention will be applied. Some research conducted in the classroom has the researchers implementing the intervention while the teacher plays a subordinate role

(Cobb et al., 2003). In-situ educational research can also prepare a teacher to play the leading role while the researcher plays the subordinate role as the intervention is applied. I found that using TDT as a discussion framework was effective in promoting trust, understanding and a creative environment that translated into a teacher well prepared to lead in the application of a new classroom intervention.

Some PL participants perceived having no voice in either content or course delivery decisions (Darling-Hammond & McLaughlin, 2011; Thompson, Hagenah, Lohwasser, & Laxton, 2015; Webster-Wright, 2009). In contrast to these assertions, the research findings suggest that TDT as a discussion framework provided ample opportunities for both the researcher and the PL participant to voice decisions about learning preferences and content decisions. In addition, course flexibility as conceptualized in TDT (Shannon, 2002) and applied in this discussion framework introduced permission among participants to share ongoing design feedback meant to promote effective course context and learner relevance.

Often professional learning is introduced with the purpose of effecting institutional change. While this study was not a response to an institutional priority to apply PBL in the classroom, I can easily imagine that the relationship of trust that was developed among the participants could only help, not hinder an environment conducive to refashioning institutional priorities (Hung & Yeh, 2013; Opfer & Pedder, 2011).

Cobb and Bowers (1999) suggested that learning should be the result of active student construction and engaged learning processes. In this study, the use of TDT as a discussion framework promoted the construction of ideas and engagement with the learning process for both the researcher assembling the PL and the participant engaging with the PL. Content mastery in PL is more likely when learning preferences are considered and combined with reliable content.

References to professional learning suggest both formal and informal approaches to the development and cultivation of successful learning communities (Lieberman, 2009; Wenger, McDermott, & Snyder, 2002). The design group in this study represented a small learning community. Still, the co-development process we experienced seemed to include both formal and informal elements hallmarks of effective communities of practice (Slavin, 1989; Wenger, 1999; Wenger et al., 2002).

I tried to be open to the idea that some topics essential to successful PL might not be addressed in the high-level framework provided by transactional distance theory. For example, while not formally addressed in the literature, during each meeting, small talk about topics of common interest set a collegial tone for our discussions. While taking the time to relate on a more personal level may be considered self-evident, often focus and time constraints discourage a more personal approach. Small talk is one topic not explicitly included in the TDT framework (see Figure 3-9). Common discussion guidelines such as active listening, summarizing and confirming ideas, staying on track, even when researcher and instructor may wander off topic, are important elements of a

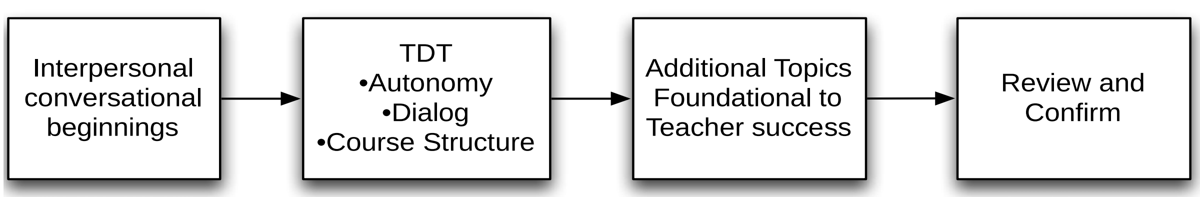

Figure 3-9. Elements of co-development not in transactional distance theory.

productive co-development meeting and would need to be added to the TDT framework approach. In this study, to the degree that the use of PBL and a computer aided scaffold was anticipated to be used in the teacher classroom, the inclusion of PBL basics and the use of the software from both a teacher and student perspective are also elements added to this design, that may only tangentially be connected to TDT's idea of course structure. Another topic not directly considered by TDT, but which, based on participant feedback, the author omitted in the instructional design, was the addition of formative feedback that would activate learner autonomy and encourage the participant to reevaluate their own learning and perhaps reset learning goals, if necessary (Berger, Rugen, & Wooden, 2014).

This research offers a view into how researchers and classroom teachers might work together when considering the implementation of a researcher proposed classroom intervention, and how professional learning might be co-designed to support that effort. Based on the results of the study, other researchers should take courage when conducting in-situ educational research that requires professional learning to support their teacher-partner.

Limitations

The author/researcher acknowledges several limitations to this study. Dr. Trudeau and Russ were willing participants who expressed a desire to learn more about PBL and were open to the idea of co-developing PL. Not all professional learning experiences are benefitted by enthusiastic and willing partners. The author saw no need to dampen their enthusiasm as a way of benefitting the study. Dr. Trudeau was completing his tenure packet during this study and was unable to participate in the PL course until after the study was completed. It may seem that having only one PL participant to work with simplified the design process. However, after the study was complete and Dr. Trudeau expressed interest in engaging with the PL course, the author conducted the same interview with him as the author did with Russ, and to my surprise, rather than make wholesale changes to the course, his preferences only required simple additions. One reason for this was the assumption of autonomy in the design, which precluded instruction steps with dependency built in. When learner autonomy is respected, the burden shifts away from learning activity sequencing to labeling and presenting activities so that the learner can make clear choices suitable to their perceived prior knowledge. In addition, the PL design group was small, as is often the case when conducting research in a classroom. As this design group was small, generalizing these results to larger groups may not be as fruitful. However, attending to the needs and preferences of learners and avoiding assumptions about learning biases wherever possible seems to me to be a sound strategy for any approach to PL design. The design group participants were white, male post-secondary teachers, representative of many departments within engineering. The group members had broad experience in their field as opposed to pre-service teachers or teachers new to instruction. My positionality, as previously described, surely influenced the choice of a participant-centered approach, openness to not being center stage as an instructor, listening for queues and preferences, and interest in engineering having hired and designed products in my past business experience. The author attempted to be careful and true to the TDT framework with a desire to learn for myself if the approach had shortcomings. It was impossible for me to be completely attentive to my thought processes and undetected adjustments. The author tried to be aware and resist any such temptation.

Conclusion

When seeking to understand College of Engineering and departmental direction for faculty in setting priorities for balancing research and instructional innovation, an engineering faculty member at Intermountain University pushed back on the idea that instructional priorities were all his choice. When the author asked about his hesitation to place a greater emphasis than the department currently does on instruction, he replied that it was "not just the department, that's the whole university. That's not my decision, that's not the Dean's decision, that's the President's decision" suggesting that in some sense his hands were tied when considering promoting among the faculty instructional improvement priorities. For those who feel less constrained by their institutional environment, and even for those who do, this study marks a path upon which researchers and classroom teachers may build as they work together to prepare students for their future.

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CHAPTER 4

FUTURE TIME PERSPECTIVE, PROBLEM-BASED LEARNING, AND ENGINEERING EDUCATION: A MIXED METHODS STUDY

Introduction

For many years, the pursuit of engineering degrees has differed from other professional degrees such as law or medicine. Preparation to engage in real-world engineering tasks occurs in only four or five years of undergraduate work, while other professions such as medicine and law require many more years of study (Kerr, Von Glinow, & Schriesheim, 1977). Some courses, commonly referred to as "gatekeeper" or "barrier" courses, lead many students to drop out of engineering majors including minorities, women, and otherwise qualified students (Borrego & Bernhard, 2011; Summers & Hrabowski, 2006; Toven-Lindsey, Levis-Fitzgerald, Barber, & Hasson, 2015). Key to persistence in studying engineering is finding utility value in the instruction (Bathgate, Martinez-Frias, & Stark, 1978; Durik, Shechter, Noh, Rozek, & Harackiewicz, 2015; Hulleman, Godes, Hendricks, & Harackiewicz, 2010). Future time perspective (FTP) contributes to the utility value of instruction when instructional tasks are perceived to have strong connection to the future students envision for themselves (Hilpert et al., 2012). Some versions of PBL can contribute to strong present anticipation of engineering students' future career goals by (1) exposing them to problem situations taken directly from the workforce and (2) connecting engineering theory and content knowledge to these authentic problem contexts (Jonassen, 2011; Loyens, Magda, &

Rikers, 2008; Mantri, 2014). The purpose of this paper is to investigate how PBL, taught with the assistance of a computer-aided scaffold, contributes to students' future time perspective in a senior engineering thermo-fluids lab.

Theoretical Background

Motivation

Motivation refers to a student's desire to choose, persist at, and complete a learning task (Ambrose, 2010; Bekele, 2010; Pintrich, 2004). Some problem-based learning designs place a significant emphasis on presenting problem situations through simulations (H. S. Barrows, 1999). Similarly, in an engineering setting, instructional sequences designed to provide real world representations reinforce the mental image a student has of his future as an engineer, contributing to expectancy value (Streveler, 2008). A reinforced mental image of the future increases the benefit a student perceives on their instructional tasks and hence their motivation to do and persist in doing (Zebardast, Besharat, & Hghighatgoo, 2011).

Future Time Perspective

Psychological time perspective considers an individual's experience with the past, present and future (Frank, 1939; Lewin, 1942). Future time perspective is the degree to which a person integrates their perceived future into their approach to present day activities and decisions (Hilpert et al., 2012). The elements that encompass future time perspective and its impact on student motivation include the perception of (a) how fast the future is approaching, (b) the connection of present activities to the future, (c) the value that current activities bring to the perceived future, and (d) the extent to which a person's goals are found in the time horizon they have set for themselves (Husman & Lens, 1999).

Many instructional approaches are perceived by engineering students to be unconcerned for the need to create connection between present-day tasks and a student's perception of their future, i.e., future time perspective. This indifference has been observed to induce increased stress and apathy among students that often leads them to drop out or switching majors (Husman, Cheng, Puruhito, & Fishman, 2015). Careful selection of instructional approaches can strengthen the connection between student activities and their perceived future helping students persist through difficult learning segments.

Problem-Based Learning

Among the various problem-centered approaches to learning, problem-based learning, as proposed for medical education by Dr. Howard Barrows, introduced key elements found useful to the development of engineers (Barrows & Tamblyn, 1980; Woods, 1994). Noticing poor information recall among third-year medical students but high motivation when they interacted with patients, Barrows decided to introduce first- and second-year students to patients and their problems to increase motivation and instructional relevance. Traditional PBL learning groups consist of 4-8 students and a tutor who, as a member of that group, provides students both process and content prompts to facilitate group learning of both domain and theoretical knowledge (Dolmans, Janssen-Noordman, & Wolfhagen, 2006; Dolmans, Wolfhagen, Hoogenboom, & Vleuten, 1999;

Walker et al., 2011). PBL has been adapted as an instructional method in engineering settings (Barreto dos Santos & dos Santos da Silva, 2015; Johnson & Hayes, 2016; Jonassen, Strobel, & Lee, 2006; Mantri, 2014; Mingxin & Faghri, 2016; Servant & Dewar, 2015; Warnock & Mohammadi-Aragh, 2016; Woods, 1994). In an engineering setting, PBL would have engineering students receive problem situations sourced from engineering situations in the workforce. Problem investigation includes fact and constraint gathering, analysis, identifying and applying theory, listing design options, knowledge gathering, and testing, and articulation of final designs and support for those choices.

PBL has been found to contribute to the learning environment needed to prepare next-generation engineers for problem-solving in an uncertain future by addressing both the what and the how of delivering instruction (Strimel, 2014). In a recent survey, employers placed more weight on experience over academic credentials, suggesting that graduates are not always prepared to enter employment lacking the ability to solve complex problems (Worker, 2012). Experience applying knowledge in authentic, real-life settings and situations is critical (Henrich, 2016). While there are many versions of PBL, Barrow's PBL approach can offer simulations of two kinds of reasoning skills namely (a) problem finding skills and (b) problem management skills (H. Barrows & Pickell, 1991; C. E. Hmelo, Gotterer, & Bransford, 1997; see Figure 4-1).

Experienced engineers confirm that authentic daily experience requires both types of reasoning skills emphasizing the problem first approach (Worsley & Blikstein, 2017). For example, it is rare in an engineers' day-to-day work to be warned to study a certain

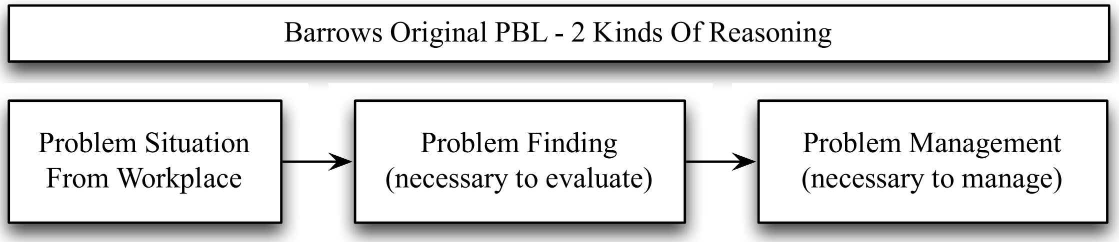

Figure 4-1. Two kinds of reasoning.

topic prior to a customer presenting a design challenge. Therefore, PBL-informed engineering instruction could provide significant value by replicating authentic career environments using problem first approaches combined with situations drawn from the workplace.

Scaffolding

The PBL approach to learning benefits from instructional support in the form of scaffolding (Belland, Glazewski, & Richardson, 2008; Ge & Land, 2003; Xun & Land, 2004). Scaffolding is often supplied by the teacher, a tutor/mentor, a peer or even technological resources assisting students as they struggle with difficult processes or content (Belland et al., 2008; Cho & Jonassen, 2002; Hmelo-Silver, Derry, Bitterman, & Hatrak, 2009). Scaffolding support facilitates cognitive, metacognitive, procedural and conceptual processes (Hannafin, Land, & Oliver, 1999). Recent research indicates that computer-based scaffolds positively influence student learning (Azevedo & Hadwin, 2005; Belland, 2010; Belland, Walker, Olsen, & Leary, 2015). For example, Belland et al., in their meta-analysis found that computer-based scaffolds led to an average effect of g = 0.46. However, how future time perspective is affected? by computer-based scaffolding supporting PBL has not been considered.

Study Questions

This mixed methods study addresses the gaps in knowledge related to engineering instruction, problem-based learning and future time perspective. The specific research questions were as follows.

1. How and why do pre-post changes in future time perspective differ between the experimental and comparison groups?
2. How do engineering students perceive the connection between their instructional activities and their future careers as engineers?

Methods

Participants and Setting

The setting is a senior mechanical engineering lab class at a higher education institution in the intermountain west. The class was taught by a professor in the college of engineering assisted by his graduate research assistant. A total of 33 students (32 males and 1 female, which is largely representative of the field) agreed to participate in the study. The mechanical engineering professor and his lab instructor had worked together for four years and employed various innovative approaches to teaching fluid dynamics. However, neither the professor nor his lab instructor had formal experience in facilitating a strictly problem-based learning unit.

The control and intervention groups were randomly assigned. Within the intervention and control groups, students were randomly assigned to workgroups of two to three students. These groups persisted throughout the study and the semester and worked together formally during lab sessions and informally outside of lab sessions. The students met as an entire class 6 times, at the beginning of each lab unit (see Figure 4-2).

Design

A mixed-method case study design was utilized as both quantitative data and qualitative data answer questions that could not be answered separately from one another (Creswell & Clark, 2010). The sequential explanatory design was chosen for the following reasons: (a) small sample ($N = 37$), (b) the quantitative FTP measures were further explained by qualitative interview data, (c) integrating quantitative and qualitative results was meant to shed additional light on the perceptions of the student groups, and (d) the qualitative interview instruments were largely developed as a result of the collected quantitative data (Creswell, 2014; Makrakis & Kostoulas-Makrakis, 2016; see Figure 4-3).

Qualitative data meant to triangulate findings included log files from the computer-aided scaffold, semistructured interviews at the conclusion of the units,

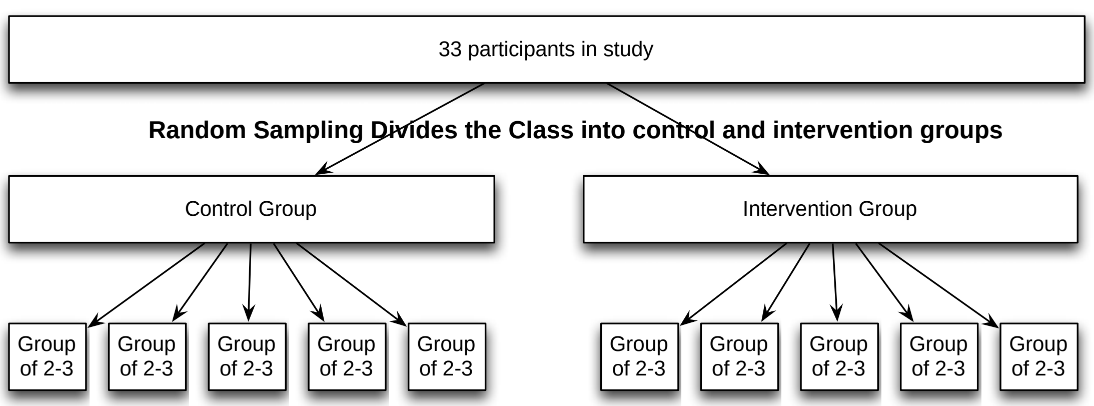

Figure 4-2. Random assignment into study groups.

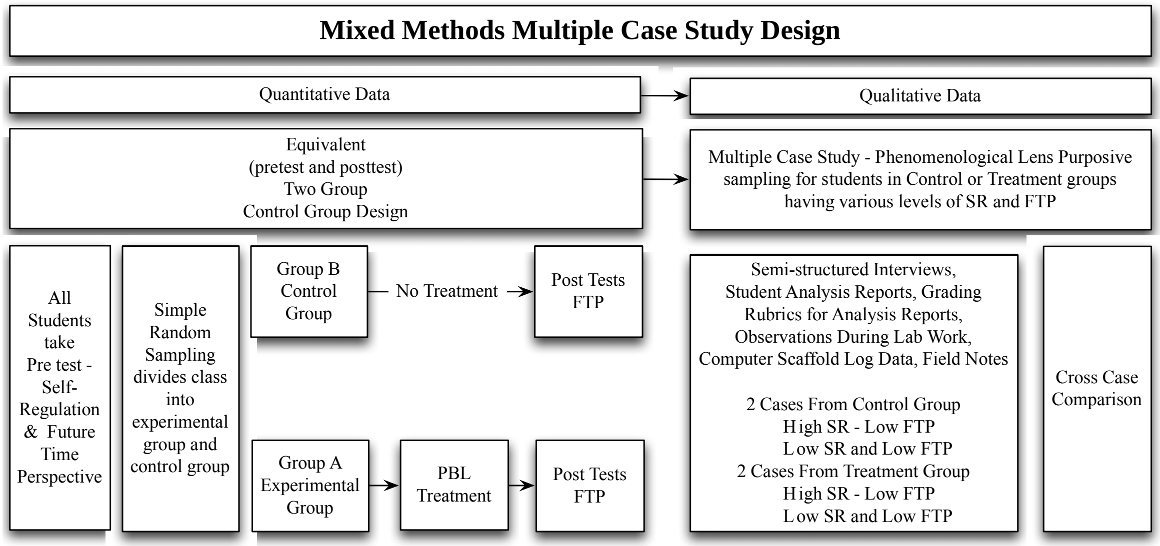

Figure 4-3. Research design.

observations of the students engaging with their lab work, field notes, student reports for each unit and grades associated with their work.

Instruments

Self-regulation questionnaire. The Learning Self-Regulation Questionnaire measures how older students learn in settings such as college or medical school courses. The survey was administered as a pretest to determine autonomously or controlled self-regulated behavior and as a source of purposive sampling for the qualitative data collection (see Appendix E). In past studies, the Cronbach's alpha reliabilities were 0.75 for controlled regulation and 0.80 for autonomous regulation (Black & Deci, 2000; Williams & Deci, 1996). With permission, scale questions were slightly adapted for engineering students in a senior engineering lab. In this study, Cronbach's alpha reliabilities were .774.

Future time perspective scale. Future time perspective is a student's perception of the future and how it is integrated into the present (Husman & Lens, 1999). The scale consisted of 27 items with the following subscales: connectedness, extension, speed and valence using a 5-point Likert scale and was developed for college level students (see Appendix D). Connectedness in this study occurs when students make a connection between instructional activities and their future career as engineers. Extension is the amount of time that is contained within the students perceived time space. For example, for a student who sets a 6-month time horizon, events that occur beyond a six-month time space may be perceived as “far away” and have less impact on student motivation. Speed refers to the perception of how fast time moves, specifically how fast the future is perceived to be approaching the present. Valence is the importance people place on goals attainable in the future. In a previous study, Cronbach’s alpha coefficients were 0.72 for the valence subscale, 0.82 for the connection subscale, 0.72 for the speed subscale, and 0.74 for the extension subscale establishing overall reliability for the scale (Husman & Shell, 2008). In this study, the research question relates to the topic of connection. The Cronbach’s alpha for the connection subscale in this study was 0.752. The Cronbach’s alpha was 0.810 overall.

Qualitative Measures

Semistructured interviews. Semistructured interviews were conducted with participants of both the traditional instruction group and the PBL instruction group (see Appendix F). As future time perspective reflects an individuals’ perception of current activities with respect to their future goals, interview questions focused on their perceptions of unit activities and how they were or were not aligned with their vision of their future career. For example, “Can you tell me about the unit activities and your ideas of a career as an engineer?”

Computer-based scaffold data logs. Data logs were created as each student logged in and used the scaffold. Data topics recorded in the log include date and time codes, http request parameters including referrer page, content type, client browser, client IP address, client name, method type, categories, and student data added to program.

Engineering analysis. At the conclusion of each unit, students were required to complete a write up of their analysis and conclusions. The professor and teaching assistant provided a list of items to be included in the analysis.

Unit Structure

Students were randomly assigned to a control group and a treatment group. These groups were further divided randomly into study groups of two to three students each. A unique syllabus described the expectations for each group (i.e., control vs. experimental) that included traditional instruction for the control group and a combination of traditional and PBL instruction for the treatment group.

This study involved two topic units: (1) heating, ventilation, and air conditioning (HVAC); and (2) pump performance. Each unit was 2 to 3 weeks in length making up a 4- to 6-week period. The problems presented to students were designed and provided by the instructors, and were similar in subject matter but different in presentation, consistent with PBL as an instructional method. The traditional approach for each of the two topics had students read a chapter in a textbook, answer a 15-question quiz about the reading, conduct experiments in the lab and complete a write-up on their work in the lab. The PBL approach (a) presented a problem situated in an authentic post-graduation work engineering environment, (b) provided various types of resources for students to use as they choose including internet links to resources, references to textbook chapter text, and suggested research topics, (c) the use of the scaffold to organize their analysis, hypotheses and discovered learning needs, (d) time in the lab to conduct tests and examinations, and (e) the requirement to do a write up that addresses the problem presented at the first of the unit. This process was conducted twice in a six-week period, once for each of two units (see Figure 4-4).

Materials

Computer-based scaffold. Web-based software was created for the purpose of this study. A design combining metacognitive and strategic scaffolding included the following web-based pages: (a) a login page; (b) selection of courses assigned to the student; (c) a course page, a menu of resources on the right of the screen, and for each

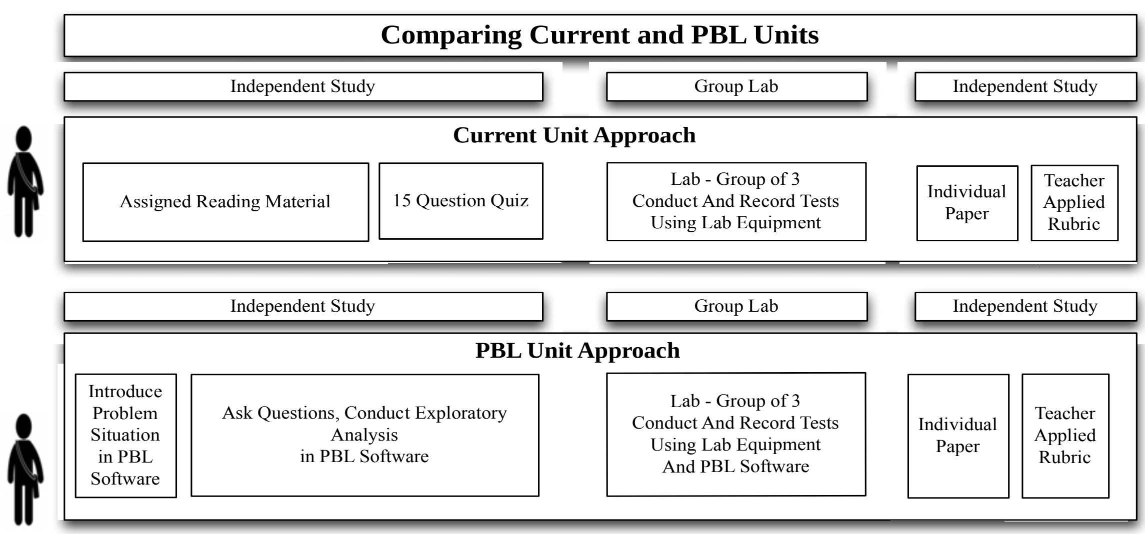

Figure 4-4. Unit structure.

resource, items attached to each resource; and (d) a summary page that summarized student work (Ahmed & Zaneldin, 2013; see Figure 4-5). The summary menu item listed how they reasoned through the problem, and provided formative feedback throughout each of the units (Schnepper & McCoy, 2013). The problem-solving approach utilized in the software is construed as a means of problematizing, which provides students and the study group important context that includes the entire process, process steps already accomplished, and work yet to be done (Reiser, 2004; see Figure 4-5). One important goal of PBL instruction is that participants create valid evidence-based claims both for the problem definition itself and possible problem solutions as well. The summary page was designed to assist students in the organization of their analysis, design and problem solutions (Bell, 1997; see Figure 4-6). In addition, for each choice made by a student throughout their experience in the unit, a log entry was inserted into a database, by

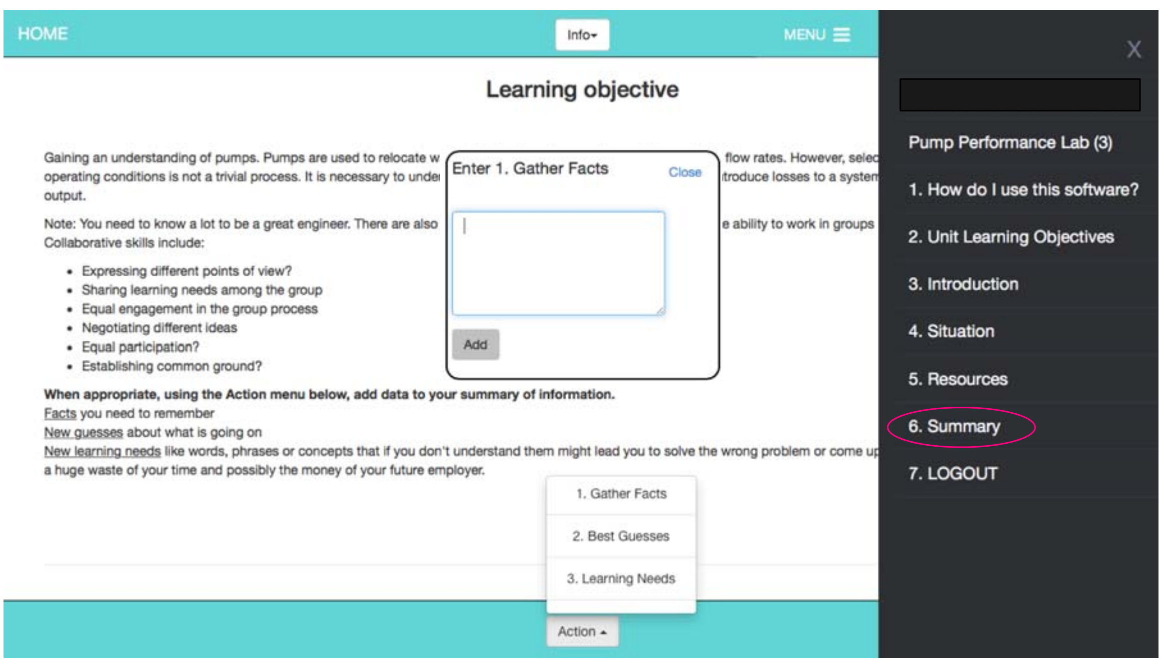

Figure 4-5. Beautiful Analysis software.

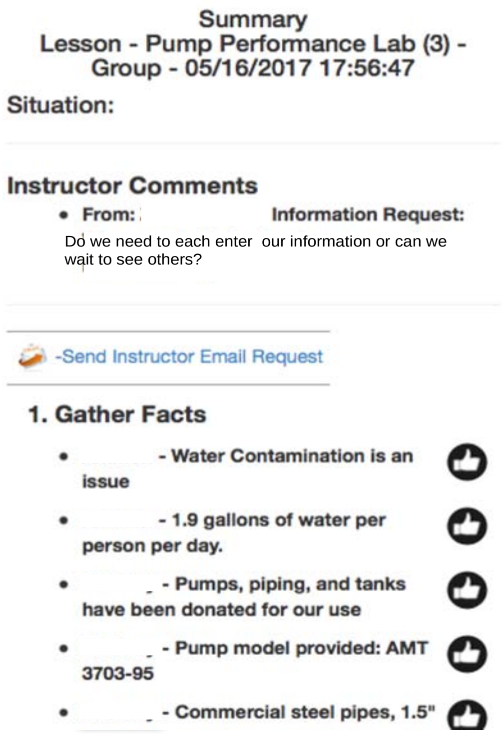

Figure 4-6. Summary page of software.

student, group, topic, class, and teacher categories. Finally, in a traditional medical PBL setting, students working in small groups receive the support of a group tutor (Ates & Eryilmaz, 2010; Servant & Dewar, 2015). Unfortunately having many tutors was not feasible in a large university engineering class. Instead, we provided the benefits of a PBL tutor through technologically enhanced teacher scaffolding where one teacher provided prompting support for many students.

Analysis Strategies

Mixed methods analysis in this study sought to sequentially investigate quantitative and qualitative data so as to understand the influence of problem-based learning engineering lab instruction on student's future time perspective. Quantitative data provide a picture of future time perspective prior to and after the PBL instruction for the treatment group and the control group. The qualitative data further described student thoughts, attitudes and perceptions with respect to their future time perspective. Additionally, the data describe how the instruction transformed students' thinking about their future careers as engineers.

Quantitative Analysis

Repeated-measures analysis of variance (ANOVA) assessed if mean differences exist on future time perspective scores in both the control group (guided by traditional instruction) and the intervention group (guided by PBL instruction; see Table 4-1). Repeated-measures ANOVA was used to measure one continuous dependent variable measured two times. In this study, the continuous dependent variable is future time perspective scores, measured two times, once prior to the instruction and once after the instruction. The assumptions were that the dependent variable must be normally distributed and continuous/interval. Prior to the repeated-measures analysis, normality of distribution and homogeneity of error variances and independence assumptions were tested, indicating that the analysis approach could proceed as designed.

Table 4-1

Repeated-Measures ANOVA Variables

Independent variable	Dependent variables	
Intervention type	FTP pretest	FTP posttest
Categorical	Continuous/interval	Continuous/interval
Traditional		
PBL		

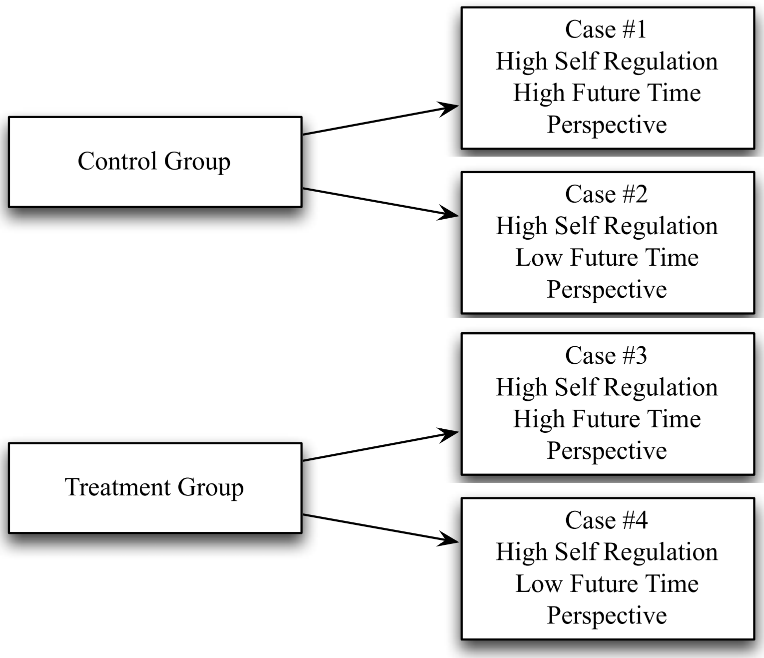

Figure 4-7. Purposive sampling.

Qualitative Analysis

The case study approach is a description of a single bounded unit and is widely used in many forms of research to answer how and why questions (Yazan, 2015). In this study, the bounded unit is a senior engineering lab class. Based on purposive maximum variation sampling, a subset of students was selected to be interviewed at the conclusion of the unit (see Figure 4-8). Qualitative measures included a variety of data providing a more descriptive view of the connection students make between learning activities and their imagined future. Data integration and cross-case comparison provided additional thematic clarity (Gerring & Cojocaru, 2016; Seawright & Gerring, 2008). Qualitative data included transcripts from student interviews, field notes, observations, student project documents and trace data of students' usage of the computer-based scaffold. Major coding categories were derived from self-regulation literature to initially include

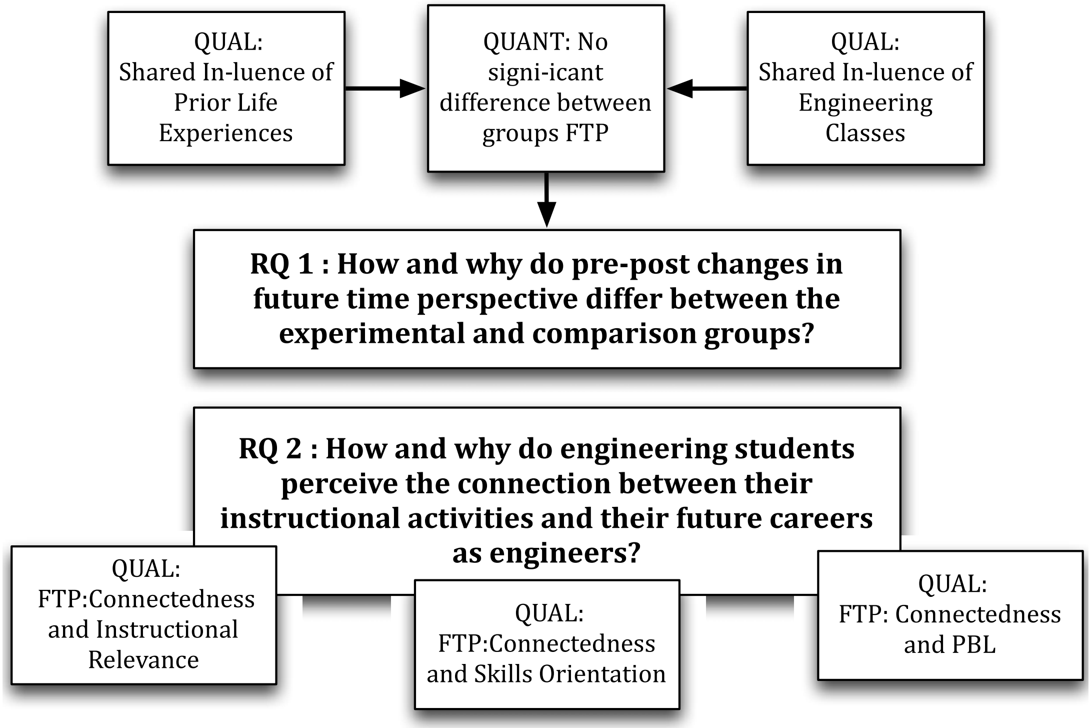

Figure 4-8. Results map.

controlled regulation and autonomous regulation and from future time perspective literature including connectedness, extension, speed and valance. Other emergent categories were added to the analysis software (maxQDA12) as the analysis proceeded in order to address the research questions and understand how each group experienced their engineering unit (Bloom, Carter, Christian, Otto, & Shurat-Faris, 2004; Gee, 2014). Once data were collected, qualitative analysis incorporated (1) data display, (2) data reduction, and (3) conclusion drawing and verification to address research questions meant to understand how the participant groups engage with traditional engineering instruction or PBL and how FTP is influenced (Miles, Huberman, & Saldana, 2013). A phenomenological lens was employed to focus on how the treatment group and the control group experienced the engineering units from their own perspective (Moustakas, 1994). Suspension of judgment with respect to the researcher was necessary when conducting analysis, setting aside as much as is possible, any researcher bias while focusing on factors that account for how the engineering units were separately experienced (Miles et al., 2013).

Results

RQ1 - How and why do pre-post changes in future time perspective differ between the experimental and comparison groups?

Quantitative Results

Assumption check - data analysis. First, graphical analysis of the normal Q–Q plot graph was used to ensure the data was normally distributed. Skewness and kurtosis value between −1 and +1 is an indicator that the data is normal (George & Mallery 2000). Afterwards, I conducted preliminary examination of descriptive statistics (e.g., mean, standard deviation, minimum and maximum values (see Table 4-2). Future time perspective scores for both groups increased slightly over time, with the traditional instruction group increasing at a faster rate during the course. However, repeated measures ANOVA indicated that the differences were not statistically significant.

Qualitative Results

While it was hypothesized that the PBL group and the traditional instruction group $F = (1, 31) = .346$, $p > 0.05$, $ES = 0.33$, indicating that neither instructional approach had a stronger effect on student's future time perspective scores (see Figure 4-9). would generate different future time perspective scores, the results demonstrated that

Table 4-2

Descriptive Statistics

Scale	Instructional categories	Mean	*SD*	*N*
FTP Pretest	Traditional	88.18	8.719	17
	PBL	89.25	7.076	16
	Total	88.70	7.870	33
FTP Posttest	Traditional	89.47	7.203	17
	PBL	90.13	9.344	16
	Total	89.79	8.184	33

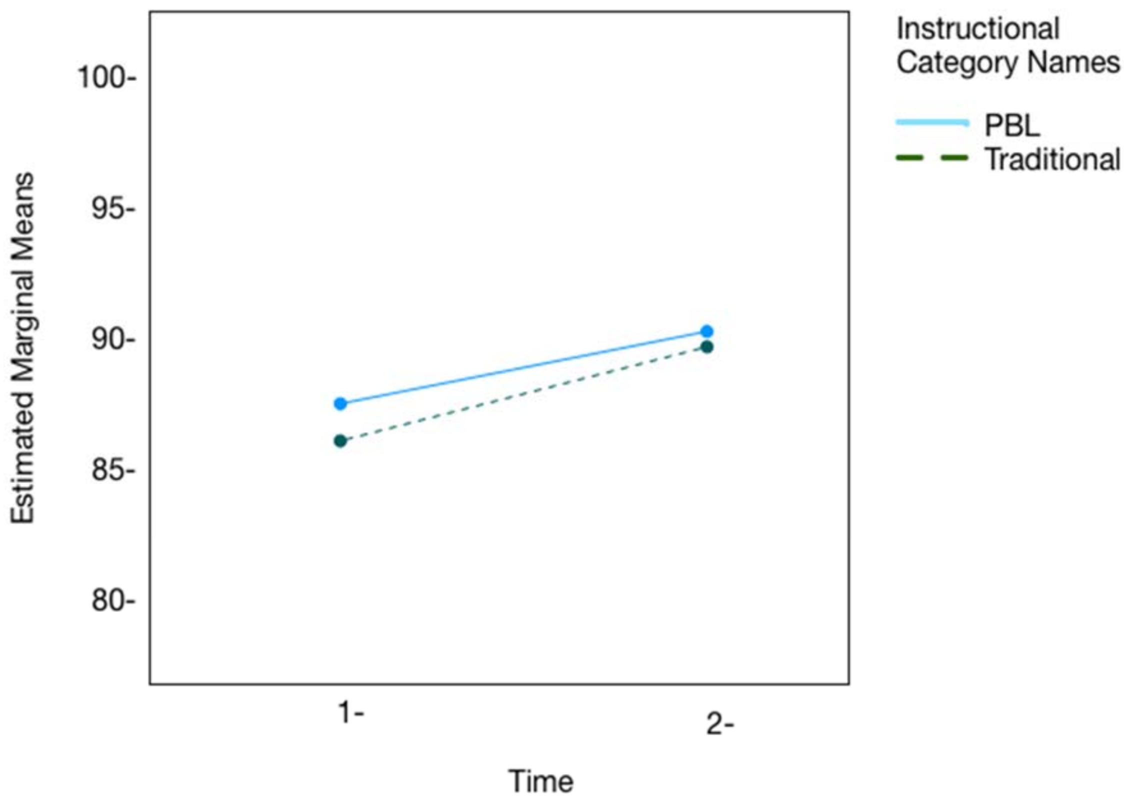

Figure 4-9. Means stratified by time and group.

there was no significant difference between the two groups. There are a number of possible reasons why the two groups had similar future time perspective scores that became evident during the post-interviews. Students in both learning groups shared common life experiences within and outside of their senior lab class that influenced future time perspective scores. Experiences in their youth, K-12 educational experiences, and classes taken in pursuit of their engineering degree contributed to student perceptions of their future. All students interviewed were graduating with degrees in mechanical engineering in only a few weeks.

It might be expected that parental influences would have shaped their career perspectives. However, only one student's parent had completed a bachelor's degree, (although the student could not remember what it was) and worked in a science related field. The balance of the students' parents were all employed outside the home, had received high school diplomas, and were not working in engineering-related fields.

Youth experiences. In all four cases, the students commented during the post-interviews that during their middle school and high school years, seeds were planted that led to their eventual pursuit of an engineering degree. For example, Mike (note: all names have been changed) commented about the beginning of his interest in engineering saying,

> In High School, I took an *Auto Desk Inventor* class where we used *Inventor* and I really enjoyed that and I think that's where I first started thinking about it.

All the students interviewed had educational and extracurricular experiences that influenced their decision to pursue an engineering degree. For example, computer aided design (CAD) and car repair were activities where they used their hands to design, fix things and "make stuff." Hands-on experiences were particularly powerful in creating a vision of a future career in engineering. Among the various engineering fields, all participants admitted to choosing mechanical engineering because they imagined that mechanical engineering would have them producing prototypes and building things “mechanically and structurally.” One student said:

> You come into it thinking that I am going to be the inventor that you always see on TV and such. But it’s more analytical computer work sitting at your desk than actually making prototypes.

In all cases, these students began their degree with an initial idea of what they thought engineering would be in their future. Their ideas about the future contributed to their motivation to pursue their engineering degree even when initial impressions turned out to be incomplete or incorrect. These early intimations of a career path influenced student’s educational plans.

Engineering classes clarified their perception of the future. For all students, perceptions of their future careers changed in one way or another due to classes they experienced during the pursuit of their engineering degree. Some students began their studies with a clear goal, while others knew they wanted to pursue engineering writ large, but were not sure which engineering field to pursue. Mike first decided that he wanted engineering to be part of a career in the Navy. Later in his studies, Mike refined his ideas and decided his career in the Navy would include “nuclear power and propulsion.” Other students, made early career goal decisions but based on class experiences considered a change of direction, as they were not yet settled on their career niche. David said:

> Composites, I really liked. That could be an area that I really go into. And then my senior project, I’ve been working on medical instruments. I have been working with doctors, in making a medical device. So that’s been pretty gratifying. And fun to do, and I kind of learned a lot doing that one and that’s

> kind of been an area that I thought ‘well maybe I should try and go into the medical field as far as making medical devices’.

For this student, his senior design class experience expanded his vision of the future by presenting options he had not considered before. For other students, class experiences helped them realize that certain fields would not be part of their future career niche. David compared his mechatronics class to pump performance, and decided that electronics and controls were not a path he wanted to pursue:

> In my mechatronics class right now, that hasn’t been really a successful class to me, because I haven’t been able to understand the material very well, so I haven’t been able to apply the material to the project that I am doing and understand it.

As would be expected, exposure to a variety of class experiences influenced students in making decisions about their future.

RQ2 – How and why do engineering students perceive the connection between their instructional activities and their future careers as engineers?

Of the four FTP constructs associated by Husman and Shell (2008) as central to FTP, connectedness provides a self-regulative effect as students construct the vision of their future and related activities contributing to that vision. Personal goal setting is, by definition, activity oriented in the future. In order to evaluate the extent to which present day activities connect to a perception of the future, individuals must first have some sense of clarity around their future goals.

Perceived instructional relevance and connectedness. Students in this class articulated varying degrees of clarity about their future goals and therefore varying degrees of connectedness between instructional activities and their future goals (see Table 4-3). With respect to career goals, early in their lives each participant had

Table 4-3

Students' Future Time Perspective Scores

Student pseudonym	Instruction category	FTP Pretest	FTP Posttest	FTP Level
David	PBL	100	102	High
Bill	PBL	87	97	Low
Fred	Traditional	92	94	High
Mike	Traditional	75	80	Low

experiences that began to shape their vision of the future. Their memories of early ideas of their future careers included hands on activities, creating and building, high school aptitude tests, fixing things around the house, and working on machines like cars and home appliances. Some students narrowed and clarified their career goals for the future early in their schooling, while others still had not found their niche. David was graduating within two weeks and still had not found his area of interest:

> My goals for the future are, I'd like to, I haven't really found an area, inside of mechanical engineering that really interests me, so I would like to explore different jobs and maybe find my niche, and then potentially I would like to do more school, maybe get a masters in the area that I like.

David understood his future within the mechanical engineering profession in broad terms. Therefore, identifying courses that were relevant and connected to his goals was difficult for him. When asked which part of his education connected best to his future David commented:

> I don't know yet…so I still don't know. I think that depends on the job a lot. But I would say, I probably won't remember much. I mean I've learned a lot of the basics, but kind of like I said earlier, I've just learned how to teach myself and how to problem solve. I definitely don't remember everything that I've learned. That I have been taught, but I know how to teach myself…. I know how to learn a lot better.

For David, his lack of clarity around his future career, made it difficult to establish the career relevance of instructional activities. He added, “so I think, depending on the job [in the future], just from the experience that I’ve learned from college, I will be able to learn it pretty quick.”

Other students, however made stronger connections between their course work and the future they envision as engineers. Both Fred and Bill commented:

> I definitely think that fluid flow is important for engineers and so the fluids classes, I think heat classes are important, um and I think structural. I think those three pillars. So I think those are going to be the big things that contribute to my future.

Bill had clarified the class categories that would contribute to any future he expected as an engineer. Fred added:

> If I was to pick the most useful…. I think like probably just the basics, like statics and like solid mechanics, like those seemed to provide the base for everything else you do.

Both Fred and Bill are clear about their future as engineers and therefore are clear about which courses contribute to that future.

Skills orientation and connectedness. Rather than information or content, students identified basic skills they had developed as creating connection to their future careers. David said:

> Interviewer: What parts of your classes, do you see as relevant to your future?
>
> David: I think that in general most of them taught me, mostly how to teach myself and how to learn… how to problem-solve.

David’s comments echo those of other class members regarding skill development as an important outcome that they hope will contribute to their future careers. Trace data from the computer-based scaffold indicated that he made significant use of the reasoning prompts, demonstrating engagement with the analysis associated with the PBL learning process. With only a few weeks before graduation Mike commented that some skills learned in class apply outside of class in ways that build confidence:

> What skills...? I'm trying to think of how to say it. Just like being able to brainstorm and think about a problem and then being able to solve it has been pretty big in my life--you know, to my life in general. Just recently I went ice-fishing and I was like, "How do I figure out how deep this is?" I was like, oh, I could take the diameter of my spool, figure out how many cranks it takes to bring it up from the bottom and do a little bit of math and bamm, I knew how deep it was. And I was at 34 feet and I went to talk to my dad and he had the depth finder and he had like 33 feet. So... that's kind of how I feel like [skills] will apply and it's going to benefit my future life in similar matters. I won't... a lot of things are probably pretty minor, such as finding how deep a lake is, but it's just being able to brainstorm and figure out, I can. I can do this. I can figure it out.

Mike developed engineering skills that connected to his life outside of the classroom. These skills helped him grow confidence in his engineering abilities. Instruction that invites the practice of engineering skills outside of the classroom, even informal practice, can support students' belief in their future careers as engineers.

Students developed other skills in class that they connected to their future as engineers such as writing, people skills, and persistence:

> Mike: I've definitely improved my writing skills. I was not a very good writer...still am not a great writer, but I've definitely improved.
>
> David: So I have learned how to work with others. To get something done that would take a lot longer, a lot longer. It's faster with other people.
>
> Bill: A lot of the other skills? Putting in the time, I think when you, when I actually get out in to the field, I think it will feel like a relief compared to what I have put in here. Putting in the time on these assignments…
>
> Fred: I think being able to create a mathematical or a computer model for problem or for a scenario is one of the most important. Like the 2-D conduction lab where we had to create a mathematical model that predicted the temperature distribution.

For some students, the connection of their education to their future is largely in learning skills such as people skills, persistence, and mathematical modeling skills when faced with problem.

PBL instruction and connectedness. Students exposed to PBL instruction experienced both traditional and PBL units and therefore were in a unique position to compare the two approaches to instruction and describe the connection between PBL their perspective of the future (see Figure 4-10).

Perception of problem authenticity and FTP. When Fred was asked which of the two approaches assisted him in clarifying a vision of his future as an engineer, he responded:

> So the [PBL approach], related it to real world problems that I thought were very realistic, and I thought, “well, I could end up working in HVAC. This is something I can easily do.” And some of the other labs, I thought “this is unrealistic and I won’t ever do something like this.” So I liked the fact, that the [PBL approach] labs could be... were very relevant, to real world things. And so some of the other labs I don’t think you could tie into [the] real world.

Fred related the PBL instruction to future career possibilities even to the point of considering an alternate career path in HVAC. Bill also described his experience with both types of instruction:

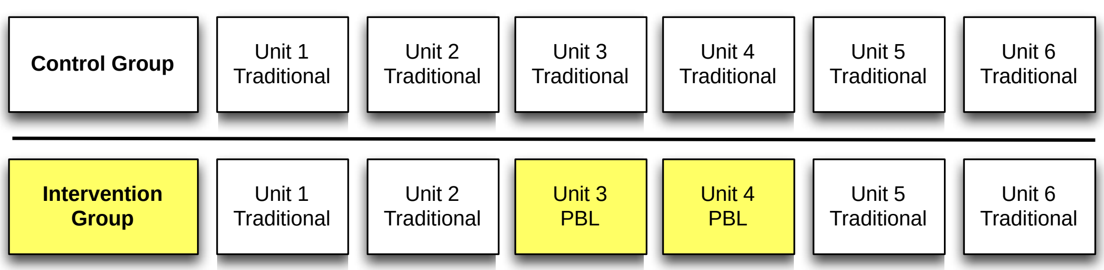

Figure 4-10. Contrasting units for the intervention group.

Interviewer: You did both kinds of units, the traditional instruction and the PBL instruction. So, when you look at the traditional and look at the [PBL approach], in your mind which one represents kind of the real work you are headed into?

Bill: Definitely the ones we did in the [PBL approach], definitely when compared to the original or a lab that we did before this class, uh, definitely those [PBL units]. Helped a lot more...I think we would come up with better engineers if we did those from the beginning…those kinds of labs from the start of the program.

Interviewer: Yeah, and why do you think that?

Bill: It's just real world, it's a... you're not focusing on just getting it done, you are focusing on how you get it done. And what you are doing exactly. And you are actually applying the equations and things that you have learned

Students perceived that the problem situations presented in the PBL units were more realistic and relevant to their imagined future. The students indicated that the PBL approach made a positive contribution to their vision of a future career as engineers. The content provided much-needed context that motivated the students to engage with hard studies. In addition, in their analysis reports, PBL students included contextual descriptions of the problem environment including addressing confirmation letters to simulated participants, a description of the terrain, and concerns they had for the inhabitants or customers included in the story.

Implicit reasoning processes in PBL and FTP. Another contribution of PBL that helped students make connections between instruction and their future was in the implicit reasoning processes associated with the PBL software. PBL, especially in K-12 environments, often focuses on problem solving without explicitly introducing reasoning frameworks (Brush & Saye, 2017). However, Barrows suggested implicit reasoning frameworks for medical students that provided both classroom structure and a model for diagnostic reasoning processes (Barrows, 1985). Bill commented about the rigor of the reasoning process:

> It took a lot more thinking…because you've got to think, even more than the original ones in the lab, you have to think...what do I need to measure, how can I solve this problem? Like for the HVAC one, we had to think like what equations do we use to get this humidity down or you know, it was a lot more learning, I think I learned a lot more from those two labs compared to just a regular one.

David also commented about the PBL process:

> David: I think it wasn't as obvious what we needed to do. And so it required more thinking… thinking through the process more rather than being just fed the problem
>
> Researcher: And is that good or bad?
>
> David: As far as solving it in a quick amount of time? It's not good. But I think as far as benefitting me it was better… it helped me understand the problem more, I think, understand some of the small little, facts.
>
> Researcher: Which of those two cases was interesting to you?
>
> David: The pump performance one, I thought was really fun to do. It just seemed like something that I would do in the future some time.

Students experiencing the PBL instruction seemed to be motivated to go beyond calculating equations, as they do in many of their other classes. Instead, they found themselves actually applying theory to a simulated problem that they perceived to be real and relevant.

Motivational context created by PBL and FTP. Instruction that is perceived by students to be hard for them, often presents a motivational obstacle to engagement and completion (Belland, Kim, & Hannafin, 2013; Simons & Klein, 2007). Students engaging with PBL instruction admitted that it required more of them, especially with respect to time during their senior year.

> Bill: [The PBL approach] was different I mean, you put more input on that. You actually have to go through and uh it's kind of helpful. You can go in and log things [in the software]. It was more work, it seems like, it is hard to get yourself to do it. It's like it is a little more work. But it does help you go through, and you feel like you have to think more because you are actually going through and putting like notes on it, and I think it is helpful but it is more work and…
>
> Interviewer: So what kind of work.
>
> Bill: Uh, the work to actually go through it and put in the time. To actually think through it and not just mindlessly ...
>
> Interviewer: (Interrupted Bill) So what is the alternative? How would you think through these problems if you hadn't used the [PBL software]?
>
> Bill: Oooh, that's a tough one. I don't know. It's almost like at least for me, I have to be forced to do it, otherwise, it doesn't… I don't really put as much thought into it… [the PBL approach] feels better, to feel like you are actually using the stuff rather than just going through the motions.

Students recognized that being asked to make separate software entries invited them to think harder about the details of each case, making the PBL approach more complete but also more time consuming. Trace data from the software illustrated the level of detail in their analysis process differed for each unit. Some students were more detailed in the first unit and less in the second. Others were equally detailed in both units. Also, students concluded that traditional engineering instructional approaches often engage them with endless calculations, that without relevance or context become "mindless" almost busy-work activities. Field note entries resulting from classroom observations corroborated these student perceptions of traditional classroom activities. However, despite requiring more detailed analysis activities in the PBL approach, students acknowledged value in the harder work required. When students saw the problem exercises in a context that contributed to a perception of their future career as engineers, they concluded that the extra work was worth the effort.

Discussion

This study confirmed what De Bilde, Vansteenkiste, and Lens (2011) found with respect to motivation and future time perspective. De Bilde et al. determined that students with strong FTP regulated their study habits based on feelings of guilt, shame, conviction and interest. For example, students may compare their current study activities with their perception of a career in the future, perceive a dissonance between the two, and experience guilt or shame that provides motivation to act. Other students entered their engineering studies with the assumption that, over time, a specialty within the broader degree will make itself known. In one student interview "waiting for clarity" often was associated with guilt and shame, wondering why they cannot decide on a career path when others already have. Some students began their pursuit of an engineering career with clarity about their specific career course and therefore advanced down their degree path with conviction and interest.

Miller and Brickman (2004) posited how Bandura's (1986) social cognitive perspective and future time perspective (Nuttin, 2014) reflect self-defined future goals as part of the identity development process associated with self-determination theory (Ryan & Deci, 2000). It is one thing to practice engineering work as a student and another to develop and possess an identity as an engineer. Long-term goals, when supported by the setting and striving for short-term goals, provide incentive for personal exertion and self-efficacy beliefs that contribute to identify formation (Komarraju & Nadler, 2013). Students who possessed a clear vision of the future found classes and activities connected and relevant contributors to their engineering identity. Students lacking a clear definition of their career future, completed student activities with less enthusiasm, requiring extrinsic motivational strategies to keep moving forward.

Similar to the prior knowledge that medical students bring to PBL, engineering students also bring prior knowledge to their engineering studies (Dolmans & Schmidt, 1996). All students in this study reported that they had benefited from hands on mechanical experiences in their youth, which contributed to a perception of their future. Those who engaged with the PBL version of the engineering instruction also acknowledged that the simulations associated with the PBL problem descriptions contributed materially to a picture of their future as engineers. Further, Mentzer, Becker, and Sutton (2015) determined in their research that students tended to spend less time in the information gathering process associated with design of solutions. This is consistent with the experience of the PBL students who admitted that the PBL process in this course of recording facts, hypotheses, and learning gaps during the information gathering sequence was more detailed and demanding than traditional instruction. However, the contribution of the perceived authenticity of the PBL units was supportive of their view of the future, and therefore provided needed motivation to complete hard tasks that would otherwise be considered difficult for them (Tabachnick, Miller, & Relyea, 2008).

Future time perspective is a motivational construct that contributes to an understanding of how present-day activities connect to an individual's concept of their future (Husman & Lens, 1999; Lens, Paixão, Herrera, & Grobler, 2012; Nelson, Shell, Husman, Fishman, & Soh, 2015). In this study, element contributed to FTP provided a self-regulative effect as students set goals, made plans and initiated actions in the present to make a vision of the future reality. It has been argued that future activities have not happened yet and therefore cannot impact individual motivation to do something (Avci, 2013; Bembenutty & Karabenick, 2004; de Bilde et al., 2011; Nuttin, 2014). However, this study confirmed that a present anticipation of future events can strengthen future time perspective and therefore individual motivation to act (Husman & Lens, 1999). Students in this class who participated in PBL instruction commented how the problem situations created a realistic anticipation of engineering activities they could see themselves doing in the future. In addition, ill-formed nature of the problems added to the perception that the problems were both difficult yet authentic and therefore worth pursuing.

Reinforcing theoretical understanding of engineering principles is a priority among engineering educators (Ayar, 2015). Engineering educators sense an obligation to cover a significant amount of theory, so much so that for some instructors dedicating more time to application-based activities in the classroom seems unreasonable. At the same time, however, students desire to solidify both their engineering understanding and their vision of the future through more applied instruction. The problem-based learning approach is one way to bridge the theory/application gap (Elshorbagy & Schonwetter, 2002). In this study, PBL attempted to narrow this gap through technology-enhanced teacher scaffolding. Among other facilitative priorities, the teacher could ensure that students consider theoretical concepts by generating prompts pre-loaded into the software, the response to which emphasized theoretical understanding (Chng, Yew, & Schmidt, 2011; Donnelly, 2013). The problem selection and presentation element of PBL provided the material with which students developed deep learning as they were aided by their teacher (Donnelly, 2013; Kaufman & Holmes, 1998). The PBL approach connects theoretical understanding to problem triggers that students are likely to encounter in the future, prompting at some future date knowledge recall and application of theory to problems (C. Hmelo, 2004).

Students in this course confessed that traditional instruction approaches in their classes often led them to remember information just long enough to pass exams. With too much to recall beyond test taking, many students placed a value on "knowing where to find information" rather than remembering it or using it, as if remembering was perceived as almost futile. Barrows and Wee (2010) expressed a similar concern from an instructor's perspective, when third year medical students could not pass exams they had already taken first and second year of medical school. Based on a problems-first and knowledge building second approach, PBL instruction contributed to learning and recall that more accurately modeled a student's future career experience. The students in this study acknowledged that the problem-first approach was more true-to-life. The problem-first approach in Barrow's version of PBL is important because engineers are unlikely to have a customer tell them to brush up on a certain theory or concept before meeting together to discuss the problem situation. Perhaps the problem first approach is one reason these students perceived that engaging with the PBL approach much earlier in their career would, in their words “produce better engineers.”

This study also sheds new light on how future time perspective may be a means by which students can perceive problem authenticity. Problems in PBL should be ill-structured, realistic, part of student experience, promote student curiosity and inquiry, and often require interdisciplinary solutions (C. Hmelo, 2004; Hmelo-Silver, 2013). However, PBL students in this study identified the HVAC and pump performance simulations as both authentic and contributors to their vision of a future occupation as engineers. Further, the connection between the instructional activity and their perspective of the future was strong enough that it provided additional motivation to engage with instruction they admitted was harder, but more valuable than traditional approaches they had experienced. The connection between future time perspective and problem authenticity may provide guidance for problem selection and presentation that enhances the motivational design component of PBL instruction.

When designing PBL courses, evaluating problem selection and presentation for elements contributing to a students’ perception of problem authenticity has been identified as foundational to effective PBL (Mok & Lai, 2003). Problem situations presented in this course were designed so that students experienced a strong connection between the problem and their perception of the future, resulting in motivation to persist in their learning efforts. Future time perspective becomes, then, an important contributor to problem authenticity and should be considered as an essential identifier of effective PBL problem situations and presentations. A designer might ask, “Does this problem situation contribute to my students' future time perspective?" When it does, students will perceive the instruction as being more authentic, resulting in greater motivation to persist in their studies.

Limitations and Suggestions for Future Research

The research design attempted to limit influences on future time perspective to only the PBL intervention and the traditional instructional approach. However, through the interviews it became apparent that other student experiences acted as compounding variables that limited the value of the quantitative research. One of the benefits, then, of mixed methods research is that the integration of quantitative and qualitative results provides a more complete picture by which a deeper understanding is possible. However, this study cannot be generalized. In addition, the version of PBL in this study, while attempting to be faithful to Barrows' original ideas about PBL, was not a perfect reproduction of the method. For example, instructors did not provide tutor prompts as frequently as one would hope due to time constraints on the part of the instructor and inadequate rehearsal of tutor skills as part of the PL prior to students engaging with the PBL units. One impact of an inadequate number and quality of tutor prompts was the lack of explicit student connections between theory and application. Future research might focus more rigorously on how anticipating and loading prompting statements into the software influences student analysis, reasoning and perceptions of authenticity. Additionally, peer-to-peer group learning discussions associated with PBL were not easily integrated by instructors with the normal processes students followed when using the lab equipment to validate their problem solutions. Groups processes that are normally a part of PBL were limited. Woods (1994), described how students new to PBL experienced a transition period from the traditional instruction they experienced prior to the PBL approach they would be using going forward. Over time, students become more familiar with PBL, resulting in a decrease of the time necessary to complete instructional units. PBL instruction over an entire semester would provide an opportunity to understand how students became acclimatized to PBL developing deeper habits associated with reasoning, analysis, and problem solving. Finally, Barrow's version of PBL includes a group dynamics inventory at the conclusion of the unit serving to improve group collaboration processes. While student review of their PBL processes was included in the case write-ups, students were unclear how a self-evaluation should proceed. Further, improvements of group dynamics are best negotiated in a face-to-face group setting that occurs on a repeated basis.

While this research indicates some preliminary evidence of the potential of PBL in an engineering education setting, additional research is needed. This study was conducted in a lab setting, where unanticipated blurring occurred between lab activities and PBL instruction. Further research in traditional learning settings would eliminate that conflict and shed further light on the effect and student perception of PBL instruction on future time perspective. Further, this research was conducted among senior engineering students. Research among students exposed to PBL in the second and third years of their engineering degree could also provide additional data about the contribution of PBL to future time perspective at that point. The software provided an opportunity for one teacher to prompt many groups of students, largely mitigating to some degree the concern some have about PBL in larger class sizes. However, the professional learning that supported the instructor to function as a facilitator was inadequate preparation to perform this tutor function. Future research with larger class sizes and improved preparation to use a software-based tutor prompting approach is needed.

Conclusion

The PBL instructional approach provided much-needed context that motivated engineering students to apply theory in a lower stakes environment than they will likely experience as career engineers. Senior engineering students engaging with PBL instruction admitted that it required more effort than they were used to. However, the extra work was worth the effort when students engaged with problem exercises in a context that contributed to a perception of their future career as engineers. Instruction that was perceived by students to be hard, presented a motivational obstacle to engagement and completion. Relevant real problems in this PBL setting also motivated students to rehearse the application of theory and think harder about the details of each case, contributing to a more comprehensive problem analysis and picture of a future engineering career. Student descriptions about the contribution PBL made to their perception of a career as an engineer provide reasons to engage in further research.

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CHAPTER 5

THE PURPOSE OF THE MULTIPLE PAPER DISSERTATION

Introduction

The business of educating students involves addressing the needs and concerns of a number of stakeholders, including government leaders, administrators, teachers and parents (Darling-Hammond & McLaughlin, 2011; Law, 2000). Students are better prepared for the future when their educational experience helps them develop skills such as critical thinking, problem-solving, cooperative learning and technology mastery (Sandoval & Bell, 2004). In pursuit of these goals, educational researchers often propose interventions (e.g., problem-based learning [PBL]) that they believe will promote the development of these skills. Researchers who develop new classroom interventions hope to engage with classroom teachers who will agree to explore new instructional boundaries (Barab & Squire, 2004). Research in the classroom provides first hand feedback about how proposed interventions are delivered by teachers and received by students (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). This multiple paper dissertation describes the journey of a researcher and a classroom instructor as they (a) agreed on implementing a problem-based learning approach in a senior engineering lab course at a higher education institution, (b) co-developed a professional learning course to support using PBL in the thermo-fluids lab class, and (c) applied PBL in the senior lab class. The research is presented in three papers from researcher concept to application in an engineering classroom (see Figure 1-1 in Chapter 1).

Professional Learning for In-situ Research

The literature is clear about the potential benefits of professional learning, including enhancing (a) content and pedagogical knowledge, (b) willingness to engage in new instructional practices, and (c) understanding of institutional priorities (Bolt, 2012). A variety of approaches to professional learning have been proposed, some concentrating on improving content knowledge, some on development of pedagogical understanding or the application of certain teaching methods. Recent research has suggested that a top-down approach to PL design be abandoned for a more learner-centered approach (Polly & Hannafin, 2011). A learner-centered approach to PL is possible when the PL designer becomes sensitive to the preferences and problems that PL participants face as they engage with the PL instruction. Chapter 2 proposed a professional development approach that is at once consistent with many learner-centered PL best practices (Hawley & Valli, 2000), but also unique in that it invites researchers and instructors to co-develop the PL approach. However, the approach recommended in Chapter 2 suggested that the researcher and the classroom teacher actually co-develop PL using the main constructs of Moore's transactional distance theory (TDT) as a co-development framework. The ensuing co-development discussion using this framework led to a PL design with which the classroom teacher then engaged as a PL participant. The TDT discussion framework that grounded the co-development discussion was useful as it introduced the three main topics of a co-development discussion (i.e., autonomy, dialog and course structure), which allowed student preferences for content and course delivery to be discussed, agreed upon and applied in the development and delivery of the PL course.

The discussion about autonomy in TDT centered around the degree to which a student desired and was capable of planning and conducting his own path through the PL content or would prefer a structure where he was directed step by step through the instruction (Moore, 1972). Chapter 3 illustrated that addressing this topic with Russ, the graduate research assistant, allowed him to highlight a preference that might not have been part of the researchers' PL design plan. Russ bought into the use of the discussion framework and was comfortable disclosing his preferences and ideas respecting both content and learning preferences. For example, a discussion about autonomy preferences suggested that Russ desired a step-by-step approach that, at first, reflected less learner autonomy and more teacher direction (Fukuda, Sakata, & Takeuchi, 2011). However, Russ also disclosed that he desired to experience a presentation of the material in a way that allowed him to navigate material on his terms, suggesting a preference for a more autonomous approach to his learning. A preference for more *and* less autonomy in the same course is unusual, but knowing that the instructor had such preferences allowed me the opportunity to clarify them and determine a PL design that met his needs in the most effective manner possible. Following up with questions about this apparent contradiction, I learned that Russ preferred that content in the learning management system be presented in a "topics and executive summary" format, allowing him to make his own value judgments quickly about each topic, and then decide for himself which topics he would give time to. My findings suggested that Russ' input on autonomy and PL design provided a lens into self-identified learning constraints and preferences that were key to the design of the PL course.

A discussion about dialog as a TDT construct illustrated that, consistent with Ekwunife-Ora and Tian-Lih (2014), dialog can take many forms. However, when dialog preferences are combined with learner autonomy preferences, dialogic choices can also reflect the value a PL participant places on how much time that a form of dialog can represent. Chapter 3 included a description that Russ offered as to dialogic preference. Russ preferred a monologic approach where material was presented in story or case format, preferring reading to discussion as he worked through material. Russ' preference was consistent with Schank (1995) who suggested that some learners store information in a story format. However, where Saba and Shearer (1994) identified dialog as a mediating factor in online instruction between autonomy and course structure, Russ preferred that the discussion about the material occur in a face-to-face setting rather than part of the online course. The face-to-face dialog that Russ described is a learning preference regarding the TDT "course structure" elements of responsiveness and flexibility (Garrison & Baynton, 1987) and is additional evidence of the interactive nature of TDT.

The TDT framework for a PL co-development discussion with this higher education instructor worked rather smoothly and promoted mutual trust, discussion and innovation in PL design that was individualized for Russ. Our face-to-face discussions provided a way for me to see that the PL approach described in Chapter 2 and experienced in Chapter 3 had resulted in a deep understanding of PBL, which was the main topic of the PL. Russ described the co-development process, as guided by the TDT framework, as time efficient while still resulting in deeper engagement with the material.

Connecting Professional Learning to Classroom Realities

One of the most challenging aspects of developing PBL instruction is how well an instructor who is new to PBL selects, designs, and presents the problem situation in his classroom. The impact of professional learning in the student classroom is often mixed at best (Desimone, 2009), which introduces a concern when a novice PBL instructor is expected to design and deliver PBL instruction to his class. When developing PBL for an engineering classroom, a balance must be struck between the understanding of theory and its application in the identification and proposed management of a problem (Bledsoe & Flick, 2012; Dunlap, 2005). In Chapter 4, Russ illustrated his mastery of the PBL material presented in the professional learning course, as he independently designed the problem situations given to engineering students in his class. Jonassen et al. (2006) argued that the perception of problem authenticity is enhanced when the topics are extracted from real world settings and include a description of a problem space where students can practice by engaging in real world activities germane to the field. Qualitative findings in Chapter 4 made it clear that students perceived the problem situations experienced in the PBL instruction to be highly authentic, even to the point of them considering alternative career paths based on their interaction with the problems. The PL instruction provided Russ with sufficient support that he was able to design problem situations that resulted in effective instruction.

Future Time Perspective and Problem Authenticity

The findings in this study also introduced another element contributing to student perception of problem authenticity, namely future time perspective (FTP). The literature on FTP makes it clear that strong connections between present day activities and a perceived picture of the future increases motivation to act (Husman & Lens, 1999) and the findings in this dissertation appear to partially support that. Problem situations presented in a PBL course are perceived by students to be authentic when there is a strong connection between the instruction they experience and the future a student envisions. Therefore, according to FTP, problems perceived as authentic contribute to student motivation to persist in addressing hard problems. In this study, the perceived authenticity of the problem presentations on the part of the students was so high, that though students admitted that PBL was a much harder process, they were also convinced that by completing the activities they would be better engineers. Their motivation was sufficient to complete the hard analysis associated with the problem situation presented in the PBL course. One reason for the perceived authenticity of problem simulations and the increase in motivation was the degree to which students connected the classroom problem situations to their future as engineers.

Chapter 4 also presented a second element of FTP and problem authenticity that has great promise. Frank (1939), in some of the earliest conceptions of time studies, posited that a vision of a person's future is developed over many years, through many experiences and diverse influences. Data from student interviews supported this idea. In this study, students experiencing PBL instruction made a connection between present day activities and a future that they had envisioned as engineers. Some classes that are part of an engineering curriculum do not connect well to a students' vision of the future. In this research, students who engaged with PBL instruction described experiencing a strong connection between the problem situations designed by their teacher and their vision of the future. In some cases, the perception of authenticity in the instructional sequence was so strong, that an engineering activity that students had not yet considered part of their vision of the future became real enough for them to consider as a new career possibility. In this sense, the PBL instruction designed by the classroom teacher enlarged student visions of the future, and therefore offered them a broader view of instructional topics that might be considered relevant to them (see Figure 5-1). This suggests that PBL instruction that promotes strong future time perspective may introduce students to new future possibilities and therefore have the potential to increase student motivation to act over a broader range of instructional topics as they pursue their engineering degrees.

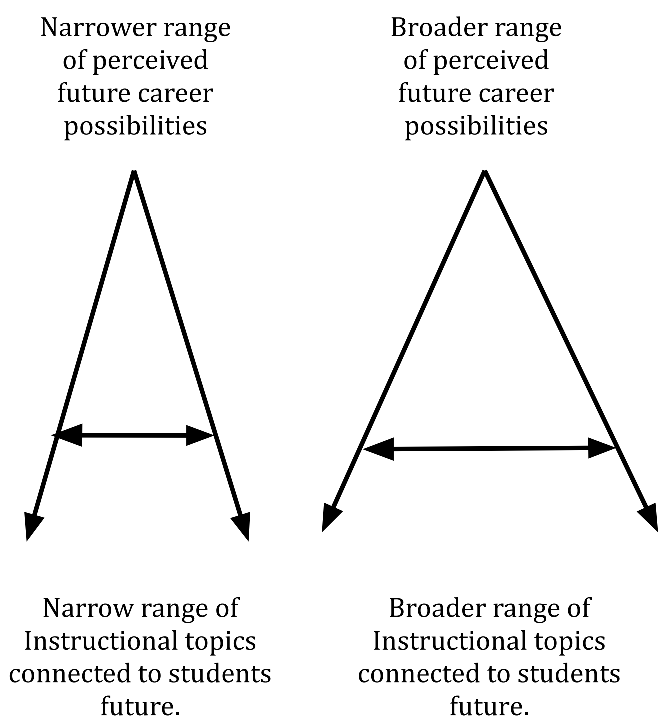

Figure 5-1. Future possibilities and connection to instruction.

Authenticity reflected in a PBL problem could also assist a student in deciding not to pursue a topic as a career option. In either case, problem authenticity in this study, as viewed through the lens of future time perspective, made a positive contribution to student learning and their perception of relevance represented in their daily instruction.

Implicit Reasoning Processes

While some instructional methods make learning memorable due to a story upon which the instruction is based, it is unlikely that students can memorize enough stories to reasonably address all the problems they might face in the future (Schank & Morson, 1995). Chapter 4 introduced the use of problem-solving frameworks embedded in the software. As emphasized by Barrows (1985), clinical reasoning frameworks are an essential part of PBL oriented instruction. The use of implicit reasoning frameworks in this study also provided students new to PBL a way to address not only the problems presented in the instruction, but also problem situations they may encounter in the future, enhancing their future time perspective. Reasoning frameworks teach them how to think through (problematize) the problem situation in a systematic way rather than memorize problem content (Reiser, 2004).

Within a domain and its literature, there may be a variety of proposed problem-solving frameworks, each one having its own merits contributing to executive functioning (Zelazo, Carter, Steven, & Frye, 1997). The computer-based scaffold described in Chapter 4, provided the teacher the opportunity to attach a problem-solving framework of their choice to each lesson exposing students to a variety of problem solving frameworks. In Chapter 3, during the PL co-development process, we considered together several approaches found in engineering texts and decided that simplifying the reasoning process would best suit students new to PBL (Paul, Niewoehner, Elder, & Steyn, 2013). The framework applied by the instructor to the PBL situations presented to students in this study was simply (1) identify **facts**, (2) make **guesses** that describe problem and solution presented in the situation, and (3) identify **learning needs** where the student currently possesses insufficient information. Individual student entries for each of these framework topics were made in the software as the students read through the resources attached to each problem situation. As students made individual entries, each one was accumulated in the database and presented to both students and the instructor using a summary function in the software. Students examined their entries and the entries of group mates and drew conclusions that contributed to their analysis of the problem and their proposed solutions. The professional learning course resulting from the co-development process in Chapter 3, included a section on the role of a tutor in problem-based learning and how the scaffold was designed to facilitate tutor functions over multiple PBL groups. Similar to research about optimal functioning of a PBL tutor, the instructors view of the summary in the software made it possible to directly observe student reasoning and then respond accordingly with feedback or prompts in the software (Chng, Yew, & Schmidt, 2011; Leary, Walker, Shelton, & Harrison, 2013). As described in Chapter 4, students in this study reported that being required by the software to make explicit entries for each reasoning framework item made their analysis more detailed and therefore harder to complete than other instruction they had experienced. However, student interviews in Chapter 4 suggested that despite the increased difficulty associated with the PBL approach, consistent with Choi (2004), students admitted that their analysis process was deeper and that their understanding of the problem situation was more detailed than they experienced in traditional instruction. Further, consistent with Greening (1998), problem authenticity enhanced the fidelity of the student experience, so much so that students in this study were motivated to address tasks that were harder for them than they experienced in traditional instruction.

Limitations and Future Research

The TDT topics of autonomy, dialog and course structure as a discussion framework for co-developing professional learning, were not completely comprehensive as a discussion guide. For example, engaging in small talk to begin a discussion session, necessary to create mutual conversational rapport was not included in any of the elements of TDT. Also, both participants initiated the desire to learn more about PBL and apply it in their lab class. Not all PL participants are willing students of a given topic. The students were senior engineering students increasing the probability that they would value and appreciate the authentic representations of the problem in the PBL instruction as they were nearer to leaving school and seeking employment.

Both the co-development discussion group and the PBL class of 34 students lacked sufficient participants to make any attempt at generalization.

While I attempted to be true to the TDT framework, it was impossible for me to be completely attentive to my thought processes and undetected adjustments.

Relative to future time perspective quantitative results, the design of the research attempted to isolate variables so that students experiencing the PBL instruction would be compared to those experiencing traditional instruction. It was during the interviews it became apparent that broader influences beyond the instruction were contributing to students' perception of their future. Those influences played a large enough role in their perception of the future that the PBL course alone was not enough to differentiate PBL students from students engaging with traditional instruction.

While we attempted to be faithful to Barrows version of PBL, thinking its sophistication most appropriate for senior engineering students, we were not completely faithful to the method as he described it. The application of the technology-enhanced teacher scaffolding was not frequent enough, mostly due to time constraints on the part of the instructor. Additionally, Barrows' version of PBL includes a group dynamics inventory at the end of each unit, so that students not only benefit from the content of the unit but also are given the opportunity to improve at group process skills. We included this evaluation step in the student write-up for each unit but did not explain the purpose of the evaluation or give them an example, resulting in minimal contributions by the students.

Listening and responding to learner preferences created an individualized PL course design that may not be generalizable to larger groups.

While this research indicates some preliminary evidence that the co-development process was fruitful and that the PBL course created by the instructor had a positive influence on future time perspective, additional research is needed. Research about TDT as a co-development discussion framework with less enthusiastic participants could yield additional understanding how the framework succeeds at drawing out learning preferences and building mutual trust. If the TDT framework is found to be less comprehensive than in this study, key steps to using the framework could be identified. The application of PBL and the computer-based scaffold associated with this study in larger class settings would provide key insights into the potential of reducing teacher workload while increasing student responses to technologically enhanced teacher scaffolding.

Classroom research can present an interruption to the normal flow of instruction familiar to students. For example, students familiar with lecture-based instruction may find the transition to PBL to be more difficult at first (Woods, 1994). Therefore, a method of transition is needed to promote a successful shift from the instructional momentum that students are experiencing to a new method of instruction. The literature suggests the benefit of using a variety of teaching methods and techniques to engage students. However, the possible negative impact associated with imposing on students shifting approaches may include concerns about losing student interest, conflicts with existing classroom culture, as well as methods that lose the attention of higher performing students in order to improve the engagement of lower performing students, and vice-versa. In addition, changing methods creates greater work load for teachers as they seek to anticipate the impact of different approaches on students in the classroom (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010; Neville, 2012). More research is needed to address how students accustomed to traditional instruction may be successfully transitioned to the PBL method and back again.

Conclusion

Problem-based learning in engineering settings has the potential to enhance student learning as well as motivation to complete a rigorous course of study (Hays, 2008; Mantri, 2014). A key element necessary in problem-based instructional design is the inclusion of authentic problem situations. Problem-situations derived from a workplace context combined with a strong connection between instruction in the present and a student's perception of their future career as an engineer increases motivation to complete difficult instructional tasks. Professional learning is often envisioned as the development of training that can be delivered over time and to a variety teacher groups (Flint, Zisook, & Fisher, 2011). This study, however, specifically addressed professional learning in support of in-situ educational research where a small learning community is created and more individualized instruction is possible.

Roth and Lee, building on the work of Lave and Wenger, suggest that a sense of loyalty can be created when group members seek common goals (Lave & Wenger, 1991; Roth & Lee, 2006; Wenger, 1999; Wenger, McDermott, & Snyder, 2002). Communities of practice in higher education environments differ somewhat from K-12 settings; higher education environments include substantial flexibility in both method and content, while method and content in K-12 settings are driven by legislative and district requirements. Similar to PL that is organized around communities of practice, this study suggests that in a small group PL setting, teachers aspiring to include PBL in their instruction can benefit from co-developing with a PBL researcher, their own professional learning about the topic (Hadar & Brody, 2010). For example, the use of teacher assistants (TA) is frequent when engineering classes are large. As part of TA orientation at the beginning of the semester, TA learning preferences can be discovered using the TDT framework as discussed in Chapter 2. The TA pre-class orientation provided by the professor can then be informed by the PL participants' expressed learning preferences contributing to better prepared TA's and improved support of students. Professional learning, meant to support the application of new interventions for use in engineering classrooms, is likely to be more positively received when learning preferences of PL participants are discovered and incorporated into the PL design. In Chapter 3, the discovery of PL participants learning preferences made a valuable contribution to the design of the PL and the ultimate performance of the PBL units created by the teacher in Chapter 4.

The professional learning co-development process is enhanced when the researcher and the classroom teacher are guided in their design decisions by a discussion framework that promotes mutual understanding about content and instructional preferences on the part of the PL participant. A discussion about learner autonomy, dialog and course structure, all elements of transactional distance theory, assists both the researcher and classroom teacher in finding common ground.

From the conception of the in-situ educational research project, through the professional learning experience and finally as the intervention is applied in the student classroom, a foundation is created upon which additional research can be conducted resulting in enhanced student learning outcomes.

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APPENDICES

Appendix A

Interview Questions for Department Leadership

Interview Questions for Semi-Structured Interviews of Engineering Department Leadership

1) Will you please share with me the history of the college of engineering at Utah State University?
2) How has engineering education changed over the years?
3) What are some of the current goals and points of emphasis for this department with respect to engineering education?
4) What are the strategies that this engineering department uses to prepare students for success upon graduation?

Follow Up Questions types:

Types of Interview Questions
Introductory Questions: "Can you tell me…?" , "Do you remember a time?". Meant to yield rich descriptions where the subject is themselves.
Follow-up Questions: A nod, or pause, repeating significant words asking for further elaboration.
Probing Questions: "Could you say something more about that?", "Can you give me some examples of that?" Probing is an attempt to verify understanding of the interviewees comments.
Specifying Questions: "When you did that, what was actually happening, going on?", "Have you experienced this yourself?"
Direct Questions: Introducing topics and dimensions that go beyond the spontaneous descriptions offered so far by the interviewee.
Indirect Questions: "How do you think others view this phenomenon?" Often interviewees will express their own opinion as the opinion of others.
Structuring Questions: "I have another topics I would like to explore." Often used to change topics when a particular topic has been exhausted and it is time to move on.
Silence: Simply being silent can encourage reflection and further comments.
Interpreting Questions: "You mean that…?", "Is it fair to say that you mean…?" Rephrasing a statement and asking for clarification and interpretation.

Appendix B

Negotiation Framework Questions for Design Group

Pre- PL Questions for Design Meetings Between the Researcher, the Assistant Engineering Professor and his Graduate Assistant

1) You have mentioned that you are already doing some very successful and innovative things to educate engineering students in fluid dynamics. Would you share with me a few of these approaches that are working well for you?

2) How did your interest for PBL get started? What positives do you see PBL offering to add to the great things you are already doing?

3) When you stop and think about it, what are some of the reasoning steps that your field of engineering employs to solve engineering problems? How do you expect your students to employ these processes once they graduate and are in the real world?

4) My current thoughts about the PD design to learn some basics about PBL had maybe three modules that each took about 30-45 minutes each to work through. How might that fit into your busy schedule? (Autonomy)

5) Some people who have taken PD to learn about PBL like to set their own goals and path through the PD topics, while others like to be led in a logical and structured fashion. Can you describe what your preference might be? (Autonomy)

6) What more about your students and classroom setting should I understand to help this intervention succeed? (Autonomy)

7) Some PD favors built-in flexibility reflecting learner choice, while other forms of PD are more step-by-step learning. Which approach do you think will work best for you? (Autonomy)

8) What has been your experience with online forms of PD as opposed to a one-to-one meeting where we get together and work through the issues in a face-to-face manner?" (Dialog)

9) Can you tell me about a time when hearing actual case studies was a helpful approach to learning for you? How would that be helpful in learning more about PBL (Dialog)

Appendix C

Post Professional Learning Interview Questions

Post PL Questions for Design Group

1) When we worked together to co-design the PL for PBL approach, one major theme was respecting your autonomy as a learner. How did the PL approach do that in your estimation?
2) Another major theme centered on the various forms of dialog. How the course might encourage conversation? How it might answer questions that would support you? What are your impressions about that discussion and how it played out?
3) Can you describe the return for invested time in taking this course?
4) We talked about setting your own path through the material vs being guided. You said…. How did that work out for you?
5) Some PD favors built-in flexibility reflecting learner choice, while other forms of PD are more step-by-step learning. We chose… How did that work out in reality?
6) We discussed online forms of PD as opposed to a one-to-one meeting where we get together and work through the issues in a face-to-face manner?" (Dialog). We chose… How was that the right choice?
7) Another topic had to do with using case studies as a helpful approach to learning PBL? We decided to do… ? How did that work? (Dialog)
8) Our PD could contain a number of different types of learning activities. We decided that… would be most effective for you. We did… how did that meet your needs? (Course Structure)
9) We discussed your preference when it came to setting your own learning goals and activities or have them set for you by the course? Your preference was.... How did that work out in this PL course (Course Structure)?
10) During PL, questions often arise about PBL during the PD We said we could simply exchange emails, we could use a discussion board kind of approach to record both questions and answers. There are lots of approaches. Which would be your preference when questions come up? We chose to communicate this way…. Describe how you felt supported during the course in terms of responsiveness to things that came up? (Course Structure)
11) There we some other preferences you mentioned, like… We tried to get them into the course. How did you feel those choices impacted the PL about PBL course?

Follow-up Questions:
1. Do you mean…?
2. How did that make you feel?
3. Could you say more about that?

What did you do then?

Appendix D

Future Time Perspective Survey

Speed

Note to Committee: Speed considers the perception of how fast time moves, specifically how fast the future is perceived to be approaching the present.

1. I find it hard to get things done without a deadline.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree

2. I need to feel rushed before I can really get going.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree

3. I always seem to be doing things at the last moment.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree

Extension

Note to Committee: Extension is the amount of time that is contained within the students perceived time space

4. August seems like a long way off.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree

5. It often seems like the semester will never end.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree

6. Half a year seems like a long time to me.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree

7. In general, six months seems like a very short period of time. September seems very near.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree

Value

Note to Committee: Valence is the importance people place on goals attainable in the future

8. Given the choice, it is better to get something you want in the future than something you want today.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

9. Immediate pleasure is more important than what might happen in the future.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

10. It is better to be considered a success at the end of one's life than to be considered a success today

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

11. The most important thing in life is how one feels in the long run.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

12. It is more important to save for the future than to buy what one wants today.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

13. Long range goals are more important than short range goals.
What happens in the long run is more important than how one feels right now.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

Connectedness

Note to Committee: Connectedness is the tendency to make a connection between present activities and future goals

14. I don't think much about the future.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

15. I have been thinking a lot about what I am going to do in the future.

1. Strongly Disagree	2. Somewhat Disagree	3. Neutral/no opinion	4. Somewhat Agree	5. Strongly Agree
○	○	○	○	○

16. It’s really no use worrying about the future.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

17. What one does today will have little impact on what happens ten years from now.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

18. What will happen in the future is an important consideration in deciding what action to take now.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

19. I don’t like to plan for the future.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

20. It’s not really important to have future goals for where one wants to be in five or ten years.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

21. One shouldn’t think too much about the future.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

22. Planning for the future is a waste of time.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

23. It is important to have goals for where one wants to be in five or ten years.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

24. One should be taking steps today to help realize future goals.
What might happen in the long run should not be a big consideration in making decisions now.

1.	2.	3.	4.	5.
Strongly Disagree	Somewhat Disagree	Neutral/no opinion	Somewhat Agree	Strongly Agree

Appendix E

The Self-Regulation Scale: Reasons for Learning

Reasons for Learning Questionnaire

The following questions relate to your reasons for participating actively in your senior thermal dynamics engineering lab class. Different people have different reasons for their participation in such a class, and we want to know *how true* each of the reasons is for you. Please use the following scale to indicate how true each reason is for you:

A. I will participate actively the senior engineering thermal dynamics lab:

1. Because I feel like it's a good way to improve my understanding of the material.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

2. Because others might think badly of me if I didn't.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

3. Because I would feel proud of myself if I did well in the course.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

4. Because a solid understanding of thermal dynamics is important to my intellectual growth.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

B. I am likely to follow my instructor's suggestions for studying thermal dynamics:

5. Because I would get a bad grade if I didn't do what he/she suggests.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

6. Because I am worried that I am not going to perform well in the course.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

7. Because it’s easier to follow his/her suggestions than come up with my own study strategies.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

8. Because he/she seems to have insight about how best to learn the material.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

C. The reason that I will work to expand my knowledge of thermal dynamics is:

9. Because it’s interesting to learn more about the nature of thermal dynamics.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

10. Because it’s a challenge to really understand how to solve thermal dynamics problems.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

11. Because a good grade in chemistry will look positive on my record.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

12. Because I want others to see that I am intelligent.

1. Not at all true	2	3	4. Somewhat true	5	6	7. Very true
○	○	○	○	○	○	○

Scoring information for this SRQ-L (thermal dynamics).

Begin by calculating the two subscale scores by averaging the items on that subscale. They are:

Autonomous Regulation: 1, 4, 8, 9, 10 Controlled Regulation: 2, 3, 5, 6, 7,11,12
In past studies, the alpha reliabilities for these two subscales have been approximately 0.75 for controlled regulation and 0.80 for autonomous regulation. Analyses can be done with the two separate subscales, or a Relative Autonomy Index can be formed by subtracting the controlled subscale score from the autonomous subscale score.

Appendix F

Questions for Semi-structured Interview Future Time Perspective

Connectedness

Connectedness is the tendency to make a connection between present activities and future goals

- What are your goals for the future?
- What are your career goals for the future?
- What parts of your education do you see as relevant to your future?
- Describe how the classes you are taking this semester contribute to those goals
- In what ways do you plan on using what you are learning in your current major as part of your day-to-day work?
- What parts of your education do you see as relevant to your future?
- What skills are relevant to your ideal future self (who you would ideally like to be)?

Extension

Extension is the amount of time that is contained within the students perceived time space

- How long until you graduate?
- How long do you think it will take from today to become a competent engineer? Why?
- What are some of your personal career goals and how long will it take for you to get there?
- Describe where you see yourself in 5 years? 10 years?
- If you could pick one thing and it could happen, what would it be and when would it happen?
- If you could pick a professional goal to attain, what would it be and when would it happen?
- How did you develop these conceptions of your future?

Speed

Speed considers the perception of how fast time moves, specifically how fast the future is perceived to be approaching the present.

- How prepared to do professional engineering work do you feel you are today if you began your new job tomorrow? In a year? Why the difference?
- How fast is the future coming at you? Why do you feel that way?
- What role do deadlines play, if at all, in how you learn?
- How does your performance as a student relate to deadlines that are fast approaching?

Valence

Valence is the importance people place on goals attainable in the future

- What would you tell other students about what to do when they sit down to study during their study time?
- How do your future goals affect how you approach your engineering study skill use?
- How do you define success? What kinds of skills have you developed so far in your experience as an engineering student?
  What do you consider success in terms of using the skills you have?
  How important are grades? Why?
- What skills do you view as important for your profession?
- What do you consider success in terms of your studies as an engineering student?

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Paper 1: Professional Development Supporting In-Situ Educational Research
Paper 2: Co-Designing Professional Learning in Support of a Problem-Based Higher Education Engineering Class: A Qualitative Study
Paper 3: Future Time Perspective, Problem-Based Learning, and Engineering Education: A Mixed Methods Case Study

Research Interests: Problem-Based Learning, Professional Development, Online Learning Pedagogy, Computer-based Scaffolding

M.S. Instructional Technology and Learning Sciences 2009
Online Learning from concept to world-wide implementation
Instructional Technology and Learning Sciences Dept.
Utah State University, Logan UT

B.A. English 1976
Department of English
Brigham Young University

Professional Memberships

American Educational Research Association
Association for Educational Communications and Technology

Manuscripts Published

Weiss, D. M., & Belland, B. R. (2017). PBL Group Autonomy in a High School Environmental Science Class. *Technology, Knowledge and Learning*, 1–25. https://doi.org/10.1007/s10758-016-9297-5

Weiss, D. M., & Belland, B. (2016). Transforming Schools Using Project-Based Learning, Performance Assessment, and Common Core Standards. *Interdisciplinary Journal of Problem-Based Learning*, *10*(2). https://doi.org/10.7771/1541-5015.1663

Belland, B. R., Weiss, D. M., Kim, N. J., Piland, J., & Gu, J. (In press). An examination of credit recovery students' use of computer-based scaffolding in a problem-based, scientific inquiry unit. *International Journal of Science and Mathematics Education*

Manuscripts in Progress

Belland, B. R., Gu, J., Weiss, D. M., Kim, N.J. & Piland, J. (In Press) An Examination of Credit Recovery Students' Use of Computer-based Scaffolding in a Problem-based, Scientific Inquiry Unit

Randy C. Hurd, D. Mark Weiss, Jackson J. Graham, Tadd T. Truscott. Future time perspective and problem-based learning in a senior thermo-fluids engineering lab class.

Brian R. Belland, Nam Ju Kim, D. Mark Weiss, Jacob Piland. High School Students' Collaboration and Engagement with Scaffolding and Information as Predictors of Argumentation Skill During Problem-based Learning

Brian R. Belland, Nam Ju Kim, D. Mark Weiss, Jacob Piland. Impact of Using a Generic Argumentation Scaffold in Two Successive Problem-Based Learning Units on Different Topics

Weiss, D. M. & Belland, B. R. Professional Development Supporting In-situ Educational Research.

Weiss, D. M. & Belland, B. R. Professional development for novice PBL instructors.

Belland, B. R., Gu, J., Weiss, D. M., Kim, N.J. & Piland, J. An Examination of High School Students' use of computer-based scaffolding in a Problem-based, Scientific Inquiry Unit.

Belland, B. R., Gu, J., Kim, N. J., Turner, D. J., & Weiss, D. M. The relationship between problem-based learning, epistemic beliefs, and argumentation in middle school science: An exploratory, mixed method study.

Presentations

Randy C. Hurd, D. Mark Weiss, Jackson J. Graham, Tadd T. Truscott. (June 2017)

Future time perspective and problem-based learning in a senior thermo-fluids engineering lab class. (Regional ASEE Conference, Provo, Utah)

Weiss, D. M. & Belland, B. R. (2015, November). Promoting Group Process Autonomy in a High School Problem-based Learning Unit. Paper presented at the 2015 Association for Educational Communications and Technology International Convention, Indianapolis, IN.

Belland, B. R., Gu, J., Weiss, D. M., & Kim, N. J. An examination of credit recovery students' use of computer-based scaffolding in a problem-based, scientific inquiry unit. Paper presented at the 2016 Annual Meeting of the American Educational Research Association, Washington, DC, USA.

Weiss, D. M. & Belland, B. R. (2014, November). Professional development for novice PBL instructors. Paper presented at the 2014 Association for Educational Communications and Technology International Convention, Jacksonville, FL.

Gu, J., Belland, B. R., Weiss, D. M., & Kim, N. Middle School Students' Science Interests and Epistemic Beliefs in a Technology-Enhanced Problem-based Scientific Inquiry Unit. Paper accepted for presentation at the 2016 Annual Meeting of the American Educational Research Association, Washington D.C.

Belland, B. R., Gu, J., Kim, N. J., Turner, D. J., & Weiss, D. M. (2014, April). How middle school students investigated water quality, evaluated evidence, and constructed arguments: An ethno methodological study. Paper presented at the 2014 American Educational Research Association Annual Meeting, Philadelphia, PA.

Belland, B. R., Gu, J., Kim, N., Turner, D. J., & Weiss, D. M. The relationship between problem-based learning, epistemic beliefs, and argumentation in middle school science. Paper accepted for presentation at the 2015 Annual Meeting of the American Educational Research Association, Chicago, IL.

Gu, J., Belland, B. R., Weiss, D. M., & Kim, N. Middle school students' science interest and epistemic beliefs in a technology-enhanced, problem-based, scientific inquiry unit. Paper accepted for presentation at the 2015 Annual Meeting of the American Educational Research Association, Chicago, IL, 2015.

Invited Lectures and Presentations

Weiss, D.M. (2017, June) Problem-based and project-based learning in a home schooling environment. Utah State Home Educators Conference. Farmington, Utah

Weiss, D.M. (2012, March) Designing Online Instruction to reflect Lived Student Experience. An In-service Presentation given to Distance Learning Designers at

Brigham Young University.

Weiss, D.M. (2011, January). How Online Pedagogy Can Inform Classroom Teaching Strategies. An In-service Presentation given to the Religion Faculty at Brigham Young University. (Honorarium Received)

Weiss, D.M (2009) The Case Method: Expectations and Roles. Presentation at the Western Case Writers Association Convention, Midway, UT.

Academic Appointments

Member – Faculty Search Committee, Department of Instructional Technology and Learning Sciences (2017 – Present)

Department Student Recruiting - Department of Instructional Technology and Learning Sciences (2017 – Present)

Research Assistant – Dr. Brian Belland, Utah State University Department of Instructional Technology and Learning Sciences (2013 – Present)

- Research Collection
- Data Analysis
- Mentoring of Undergrad students
- Technical evaluation and design
- Professional Development Design

Academic Technologist, Product Manager – (2010-2014). Church of Jesus Christ of Latter-day Saints – Seminaries and Institutes Department - Responsible for International online high school seminary campus in five countries.

- Development of online Instruction
- Management of international beta test sites
- Management of curriculum development staff
- Product planning and design
- LMS administrator
- Interface with development team

Teaching

INST – 6570 Human Performance Systems – (Teacher of Record - Face to Face and Online Courses, MS, MLTID) Spring 2016, Spring 2018.

INST – ITLS 6310: Foundations of Instructional Technology and Learning Sciences (TA for Dr. Brian Belland)

Service

President – ITSA Student Association – (2017 to present)
Journal Reviewer – Technology, Knowledge and Learning (2016 to present)

Honors (Other than Research, Teaching and Service)

2010 - Outstanding Graduate – Instructional Technology and Learning Sciences Master's Degree recipients.

2010 - Outstanding Scholar – Instructional Technology and Learning Sciences Master's Degree recipients.

2016 - AERA Division C Graduate Student Seminar. Mentor - Greg Chung Assistant Director for Research Innovation – UCLA

2017 – President Instructional Technology Student Association

Professional Experience

Product Manager, Online Learning Technologies
Administered and published 150+ online courses, trained 20+ developers, 55+ adjuncts, Seminaries and Institutes, LDS Church. (2010-2013)

Vice President Marketing / Sales (Owner-Partner)
Administered nationwide sales and marketing, multiple market segments
Manufacturers Supply, Inc. - Vancouver, WA 1992-2006

President (Owner-Partner)
The Weiss Company - Portland, OR 1988-1992 (Resulted in merger)

Regional Vice President
A. L. Williams (Primerica) 1982-1988

Outside Sales
David S. Weiss Company, Inc. - Portland, OR 1975-1982

Language Skills

English: native speaker
German: fluent