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Exploring the Relationship between Epistemological Beliefs and Self-Determination

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Abstract

The present study investigated whether epistemological beliefs (i.e. learners’ beliefs in acquiring knowledge and knowledge itself) can significantly predict self-determination (i.e. drive that comes primarily from the self which pushes an individual to engage in a task) among Filipino preservice teachers. Specifically, the study aimed to determine whether each subscale of epistemological belief (i.e. Complexity of Learning and Structure of Learning) was correlated and would significantly predict self-determination (i.e. Perceived Choice and Awareness of Self). There were 310 preservice teachers in the undergraduate level from different colleges and universities in the Greater Metro Manila area who were asked to complete two measures: Schommer Epistemological Beliefs Questionnaire derived by Bernardo (2008) and Self-Determination Scale. The average age of the participants was 19.16 years (SD = 1.63). Correlation and multiple regressions conducted in the study revealed that only complexity of learning significantly increased with each subscale of self-determination.

Keywords: Epistemological beliefs, self-determination

Introduction

Our beliefs influence our performance and engagement in a task. These beliefs are important in the processes involved as well as how an individual views and creates sense of the information. Epistemological belief is defined as the learner’s system of beliefs about the nature of knowledge and learning (Schommer, 1990). A learner’s epistemological belief can affect the learner’s cognitive processes, performance, feelings of competence, liking for school, metacognition, monitoring, learning strategies, persistence, confidence, and achievement as shown by different studies (Schommer 1990, 1993; Schommer, Mau, Brookhart, & Hutter, 2000; Qian & Alvermann, 2000; Schommer, Calvert, Gariglietti, & Bajaj, 1997; Yoon, Yang, & Choi, 2000). Moreover, epistemological beliefs also influence our motivational beliefs, such as our effective use of learning strategies, academic performance, engagement, and persistence behaviors in self-regulatory and achievement-oriented processes (Shell & Husman, 2008). For instance, if the learners believe that learning is a fixed ability, that is, being smart or intelligent is an inborn trait, hard work does not lead to success, and learning occurs immediately, then the learners would tend to display behaviors of helplessness and lack of persistence when faced with challenging tasks. Seeing hard work as unrelated to success may also hinder them from performing well and exerting effort to achieve on a task. In another instance,
if the learner sees knowledge directly coming from knowledgeable sources and authorities such as parents and teachers, they would be more likely to depend on these “sources” as information-givers and refer themselves as merely “information-receivers”. For this type of learner, his/ her beliefs may lead to a lack of initiative to discover and explore independently, and develop passivity in taking in information. Questioning may also be thwarted because of the belief that the sources and authorities are always right and should not be questioned or contradicted. With these, learners may develop passive, dependent, unreflective, close-minded behaviors, lack of critical thinking, and may tend to reject new ideas. By being aware of how we view the nature of knowledge and learning, we also deepen our understanding of how we become driven to seek knowledge.

The present study also focused on self-determination. By the term self-determination, it emphasizes the learner's role in the learning process. The initiative to acquire knowledge and explore should originate from the learner and the intent is triggered primarily from their beliefs, rather than brought about by external factors like rewards and punishment (Reeve, Nix, & Hamm, 2003; Ryan & Deci, 2000). Further, how the learner perceives control in learning, autonomy-support from the environment, and self-competence to do the task plays an important role in self-determination in the learning process. Learners who seem to feel in control and receive adequate autonomy-support from the environment are more likely to display greater levels of self-determination, and internalize the learning process (Ryan & Deci, 2000). Thus, self-determination in learning becomes more evident through active engagement and commitment to acquire knowledge.

The connection of self-determination with epistemological beliefs is rooted on the impact of motivational beliefs on the learner's self-regulatory strategies, which involves metacognition, effective plan in learning, and drive to learn (Paulsen & Feldman, 1999). Learner's perceptions on the nature of knowledge and learning also relates as to how they maintain the use of cognitive strategies and learning outcomes (Schommer, 1990; Hofer & Pintrich, 1997). Studies of epistemological beliefs generally emphasize that learners who have complicated view on learning and knowledge are more effective to plan, reflect, and persist through challenges, and engage actively in the learning process. These outcomes hint that one's epistemological beliefs influence self-determination.

The present study used the two-factor model of Bernardo (2008) involving complexity of learning and structure of learning as subscales of epistemological beliefs. In addition, the study attempted to explore if these two subscales of epistemological beliefs significantly predicts self-determination among Filipino preservice teachers.
Epistemological Beliefs

An individual’s epistemological belief is shaped by surroundings and experiences, such as educational and personal experiences, as well as culture and age (Schommer, 1990; Youn, Yang, & Choi, 2001; Chan & Elliot, 2000). The early beginnings of investigating epistemological beliefs started from the developmental conception of Perry (Schommer, 1990). He posits that an individual goes through a series of sequential “positions” in developing epistemological beliefs, from being dualist, recognizing multiplicity, relativist, to commitment within relativism. He suggested that individuals see knowledge in a dualistic and absolutist perspective in the early phase. Being dualistic, knowledge is perceived as either right or wrong. In this stage, authorities are also seen as the omniscient information-giver. From a dualist perspective, the individual emerges to multiplicity stage wherein knowledge is seen as diverse and uncertain, yet can still be discerned. Eventually, learners will develop relative perspective in their beliefs, whereby knowledge becomes contextual and utilized in varying and novel situations. Lastly, learners are able to expand the relativist viewpoint of their knowledge towards different life contexts, such as career, interpersonal relationships, and identity. Although according to Schommer (1990), Perry did not explore the relationship of his epistemological theory with student learning, he however suggested that his theory is fundamental to learner's cognition, learning strategies and development (Hofer & Pintrich, 1997). Ryan (1984) further explored on epistemological theory and used the scale of Perry to assess the stage of epistemological belief that they learner is experiencing. In addition, learners who portray dualist perspectives use knowledge standards in learning, specifically in monitoring text comprehension (Ryan, 1984). Dualist learners tend to memorize specific details and facts, focus more on surface learning and lower level of thinking skills such as remembering details from the text. More so, dualist learners were also noted to have poorer grades. On the other hand, relativists applied their prior knowledge to match a new set of information or context. They implemented comprehension and application standard, wherein deeper learning and higher level of cognitive thinking is exhibited through paraphrasing, knowledge integration, and reflection and assessment of performance and effort. Not surprisingly, their performance was better showed by gaining higher course grades than dualist learners. By observing the differences from these two groups of learners, we can consider epistemological beliefs as a factor for developing standards for cognitive processes, evaluating effective learning strategies, academic performance, and achievement. These findings by Ryan (1984) also suggest that superficial perspective on knowledge and learning brings about a
negative impact on how the learner structures, organizes and understands the information, as well as how the learner performs and evaluates the learning. Thus, we can say that as the learner gains deeper and broader view of what knowledge and learning is all about, awareness and appreciation in the course and system of learning is also heightened. This better understanding of knowledge and learning results in more effective learning process, more structured and meaningful organization of knowledge, keener observation and evaluation of the learner's cognition and performance of the tasks.

Schommer (1990) restructured this one-dimensional perspective of epistemological beliefs and realized the great extent of its scope. She further defined epistemological beliefs as a “system of more or less independent dimensions” (Schommer, 1990, p. 498). Considering it as a system points to the continuum or various domains of beliefs which are involved. While the dimensions are characterized as relatively independent suggesting that beliefs in knowledge and learning among learners do not follow a developmental stage or a pattern, and that individuals can hold multiple and varying degrees of the epistemological domains. Furthermore, epistemological beliefs about knowledge are categorized into its structure, stability, and source. In these domains of epistemological beliefs, knowledge may be seen in the naive perspective as unrelated and individual pieces of information, absolute, and directly based from an omniscient source. Meanwhile, perceptions of learning can be classified according to learner’s malleability and speed. In these domains, learner from an immature phase see learning as genetically set, and processed quickly.

The study of Schommer (1990) enumerated and characterized five dimensions of belief:

1. Epistemological Beliefs on Knowledge:
   1.1) Structure of Knowledge. Knowledge is seen to be simple or complex. Subset dimension includes seek single answers, and avoid integration.
   1.2) Stability of Knowledge. Knowledge is viewed as either permanent or tentative. Subset dimension includes avoid ambiguity, and knowledge is certain.
   1.3) Source of Knowledge. Knowledge may be perceived as handed down by authority versus learner’s construction of knowledge through reason. Subset dimension includes don’t criticize authority and depend on authority.

2. Epistemological Beliefs on Learning:
   2.1) Malleability of Learning. Learning is believed to be innate or gradually develops with experience. Can’t learn how to learn, success is unrelated to hard work, ability to learn is innate.
(2.2) Speed of Learning. Learning may be thought of as quick or not-at-all. The first three domains refer to the nature of knowledge while the last two relates to the nature of knowing. Subset dimension includes Learning is quick, learn first time, concentrated effort is a waste of time.

Beliefs about knowledge and learning have a great deal of influence with the learner’s approach in dealing with and constructing information. The domains of epistemological beliefs were classified by Schommer (1990) as either involving naïve or mature, sophisticated approach. In the naïve perspective, knowledge is seen to be simple, isolated pieces of information, absolute, inborn, quickly learned, and unchangeable “truth” from the authority. Learners who have these beliefs towards knowledge and learning tend to be close-minded, hesitant to new ideas, passive, and uncritical to information. Furthermore, they are more likely to develop maladaptive patterns portrayed by sense of helplessness and quick withdrawal from challenges and complex information, oversimplification of conclusions and poor metacognition. (Qian & Alvermann, 2000; Dweck, 1986; Youn, Yang, & Choi, 2001). Furthermore, performance-goal oriented learners, base their success on positive judgments from other people. Performance-goal oriented learners usually deem exertion of effort as a sign of lack of ability and intelligence, as well as failure (Dweck, 1986). On the other hand, a more complex view on learning is related to adaptive motivation patterns and learning-goal orientation, in which effort expended, is perceived to accumulate towards success, and is a sign of high ability (Dweck, 1986). Individuals who are learning-goal oriented tend to have more effective and higher learning processes, and a wide array of positive attitudes towards learning (e.g. critical thinking, activeness, independence, persistence, flexibility, and open-mindedness) (Chan & Elliot, 2000; Qian & Alvermann, 2000; Youn, Yang & Choi, 2001).

Models of Epistemological Beliefs

Several studies have further investigated the components of epistemological beliefs. Although there are multiple domains composing epistemological beliefs, not all seem to be apparent. Therefore, it is necessary to consider the weight of each domain or subscale in relation to other variables and in varying contexts. The Structural Equation Modeling (SEM) technique is often utilized in establishing factors of epistemological beliefs. In addition, factor analysis is also used to determine the subscales included in the structured model (Schommer et al., 2000; Bernardo, 2008). Confirmatory Factor Analysis (CFA) is used to verify the domains of epistemological beliefs included in the hypothesized and preconceived model, as well as analyzing the significant factor loadings and fit indexes computed (Bernardo, 2008; Schommer 1993, 1998; Schommer et al., 1997; Schommer et al., 2000). Discussing the treatment of epistemological domains in studies, some were
added, extracted, simplified, altered or renamed. In most studies involving secondary and college students, only four subscales were found to be evident (Schommer 1990, 1993, 1998; Schommer et al., 1997). That is structure of knowledge, ability to learn, speed of learning, and stability of knowledge. In the initial study, Schommer (1990) used exploratory factor analysis in determining which among the subscales displayed significant loadings. The four-factor model was then replicated, analyzed, and developed through confirmatory factor analysis in several subsequent studies (Schommer 1993, 1998; Schommer et al., 1997; Schommer et al., 2000; Bernardo, 2008). Further, Schommer (2000) included only three subsets of epistemological beliefs: ability to learn, speed of learning, and stability of knowledge. Structure of knowledge was eliminated, since it did not show substantial loading values. The explanation given for this was that middle students’ domain of knowledge belief is not yet fully formed. As compared to high school and college students, middle school students’ epistemological beliefs in general appear to be simpler, yet their conceptions about knowledge are more abstract (Schommer 1990, 1993, 1998; Schommer et al., 2000). Moreover, a three-factor model was also used in the study of Chan and Elliot (2000) wherein multiple domains were merged and made complex. Bernardo (2008) and Youn, Yang and Choi (2001) found only two but different factors of the epistemological beliefs to be explicit.

Youn, Yang and Choi (2001) employed a two-factor model, where integrated items from epistemological beliefs subscales of innate ability and quick learning were loaded. Again, items from various domains were incorporated. Although this model primarily showed two factors, it basically used all the five factors of epistemological beliefs. The five domains were only synthesized into two main subscales: (1) Innate ability, fused with certainty of knowledge, omniscient authority, orderly process (i.e. simple knowledge), and (2) Quick learning.

**Two-Factor Model of Epistemological Beliefs on Learning**

In Bernardo's (2008) study, only items from simple learning and structured learning subscales were included on the two-factor structure in examining Filipino preservice teachers’ epistemological beliefs. This model was found to have suitable goodness-of-fit. However, some items from other excluded domains were integrated and utilized. In his study, Filipino preservice teachers’ epistemological beliefs were investigated using two versions (i.e. Filipino and English version) of the Schommer Epistemological Questionnaire. Findings show that although Filipino preservice teachers are bilingual, their fluency and proficiency in both languages did not hold a significant difference in their epistemological beliefs. This signifies that multilingual people remain consistent in their epistemological beliefs whether tested from their native language or foreign language. Moreover, his
study found that Filipino preservice teachers are different in terms of how they see learning as a process. Some view learning as a simple yet unsystematic process; while some also believe that learning as a complicated yet orderly process wherein it involves creating a well-formed plan or structure. Bernardo (2008) explained that latter conception of learning process implies that although learning seems to involve complicated aspects, it could still be effectively deciphered by having an organized and systematic way of understanding one's knowledge and learning process.

On a follow-up study of Bernardo (2009) which dealt with the links of social axioms and epistemological beliefs, he used the two similar epistemological subscales, simple learning and structured learning. However, the first measure of epistemological belief was changed from simple learning to complex learning since most of the items express agreement towards learning as a complicated process. The finding that complex learning and structured learning were significantly correlated remained. The result suggests that Filipino preservice teachers believe that learning is a continually developing and a complicated process, and similarly they were less likely to believe that organization and accuracy is necessary in the learning process. Thus, both complexity and structure of learning are essential in the learning process.

The variation in the model structures and number of factors and items loaded in each study may be attributed to the diverse contexts, cultures, and age ranges that it involved. Also, the models that are used in the studies should prove to be a good fit according to the statistical index, and the variables should be significant or must have a heavy factor loading.

Epistemological beliefs were also explored though cross-cultural studies. Beliefs on the nature of knowledge and learning were argued to be culturally-specific, particularly comparing Western and Asian educational systems (Youn, Yang, & Choi, 2001; Bernardo, 2008; Chan & Elliot, 2004). Among Asian culture (i.e. South Korean and Chinese), omniscient were found to have significant influence in learning (Chan & Elliot, 2000). In cross-cultural comparisons based from study done by Youn, Yang, & Choi (2001) differences in deemed omniscient authorities, teaching methods influenced learner’s development for beliefs. In America, for example, utilizing student-centered approach encourages students to question and criticize the information given by the teacher. As teacher-student relationship is more distant, students feel more comfortable giving criticisms, considering that their teachers take it constructively and as a part of stimulated learning. In this case, the learners develop open-mindedness, critical thinking, and involvement. On the other hand, Korea’s teacher-centered setting inhibits questioning from the learners since teachers are considered all-knowing authority. This type of classroom setting tends to promote students to become passive and uncrictical learners.
Self-Determination

Self-determination is basically a self-initiated drive or force that pushes a person to do or engage in a task (Reeve, Nix, & Hamm, 2003; Ryan & Deci, 2000). Differentiated from the broader concept of motivation, self-determination emphasizes that the self mainly instigates the action or task, rather than triggered by external factors. There might be a number of reasons why an individual wishes to perform a certain task. Tasks may be initiated out of a liking for an instant reward, or doing the action leads to another more gratifying result, or simply because the person finds enjoyment or interest in engaging in an activity. Reeve, Nix, and Hamm (2003) mentioned three characteristics that define self-determination, namely, perceived locus of causality, volition, and perceived choice. First, self-determination entails oneself as the source of action, thus reflecting internal locus of causality. However, external pressures may hinder the individual from maintaining engagement in the task. Second, self-determined actions portray volition, wherein the person intends to act freely and performing a task based on one’s integrated sense of self (Reeve, Nix, & Hamm, 2003; Deci & Ryan, 2000). Lastly, the person should have the opportunity to choose and freely decide to demonstrate perceived choice. Perceived choice is not only contained with the individual having options over actions, but it also pays essential attention that the person has the preference whether to do or not to do a particular task. These three qualities of self-determination are joined up into a single concept referred to as autonomy (Reeve, Nix, and Hamm, 2003). By having autonomy, it means that the person acts within his/her full consent and that the choice is decided upon according his/her own values and beliefs, and not necessarily disengaging or being absolutely independent from external factors (Ricoeur, 1966, as cited in Ryan and Deci, 2006). Moreover, autonomy should not be opposed to the idea of relatedness since self-determination theory expresses that “the issue of autonomy concerns the extent to which one fully accepts, endorses, or stands behind one’s actions” (Chirkov, Ryan, Kim, & Kaplan, 2003, p. 99, as cited in Bao & Lam, 2008). An individual’s sense of autonomy would still be preserved as long as the person freely agrees to follow the choice; the decision is in congruence with one’s values, and that the act is fully endorsed by the self, thus enforcing self-determination (Ricoeur, 1966, as cited in Ryan & Deci, 2006). This also provides explanation that the three psychological needs can be fulfilled harmoniously without one opposing the significance of the other.

Characteristics demonstrated by a highly self-determined individual are similarly exhibited by a person who has a high level of autonomy, basically holding an internal locus of control, a high sense of volition and perceived choice. From here, we can take note that autonomy takes in a central role in the definition of self-determination, where both highlights one’s initiative and willingness to perform or engage in a task. Thus, the
present research takes self-determination as equivalent with human autonomy, as did Ryan and Deci (2006). But then throughout the research, self-determination will be maintained to refer to autonomy.

According to the self-determination theory, there are three significant psychological needs (i.e. autonomy, competence, and relatedness) that should be maintained to continually exhibit motivation. Autonomy is the need for sense of volition and willingness to do the task. External distractions such as pressures, demands, deadlines, and threats can reduce the sense of learner’s autonomy (Deci, Vallerand, Pelletier, & Ryan, 1991). Competence is the sense the learner feels that the activity is challenging and that the learner is capable of accomplishing the task. Lastly, relatedness is represented by the learner’s sense of belongingness and connectedness. It is asserted from the theory that the degree of motivation gets closer to intrinsic when the learner’s sense of autonomy and level of engagement is heightened. The theory generally emphasizes that satisfaction of the three psychological needs is essential in stimulating one’s self-determination (Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan & Deci, 2000). However, among these three psychological needs, autonomy seems to have the greatest need for fulfillment to encompass self-determination. While fulfillment for competency and relatedness may lead one to be motivated, satisfaction for autonomy is essential in directing the individual to willingly set off the task and be intrinsically-driven all throughout the activity (Deci and Ryan, 2000; Deci, Vallerand, Pelletier, & Ryan, 1991). For example, a basketball player may feel competent to play in the finals game or a teacher feels related to his/her class. But without the sense of autonomy, the basketball player might feel pressured to play hard by his coach or teammates, and the teacher might feel that being warm to her students will earn her the endorsement of the principal. From these instances, we can note that a satisfied sense of competence, or for the other case, one’s fulfilled sense relatedness may facilitate action; however an individual takes absolute preference and intent of the action or simply said characterizes self-determination, when there is autonomy. Not only does autonomy instigate action, self-determination also results to one’s optimal engagement, including high performance, persistence, and psychological well-being as seen in contentment and pleasing affects (Sheldon, Ryan, & Reis, 1996; Deci & Ryan, 2000; Ryan and Deci, 2000, Guay Ratelle, & Chanall, 2008).

Maintaining the contention to essentially meet the three psychological needs, a self-determined individual primarily exhibits self-initiation or intrinsically driven interest (autonomy), incorporated with a sense of capability to accomplish (competence), and a sense of security in relationships (relatedness) (Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan & Deci, 2006, 2000; Deci and Ryan, 2000).

Having autonomy as the central aspect of self-determination, the research focused on the subscales, perceived choice and awareness of self.
These two are measures of autonomy, wherein Shedon and Deci (1993) defined perceived choice as the individual’s preference for and over the action or behavior, and awareness of self as an individual’s familiarity over his/her feelings or sense of self. “Providing choice and acknowledging feeling can enhance the sense of self-initiation – of being an origin (De Charms, 1968), thus providing satisfaction for the need for autonomy and resulting in more positive outcomes, including enhanced intrinsic motivation and increased self-confidence” (Deci & Ryan, 2000, p. 234). From here we can see that answering one’s needs for autonomy, through providing choices and knowing oneself, facilitate initiative to perform a task but also lead to a more holistic personal development.

**Perceived Choice**

Perceived choice is characterized by the individual’s sense of choice with regards to his/her behavior (Sheldon & Deci, 1993). It is one of the mentioned characteristics of self-determination (Reeve, Nix, & Hamm, 2003). As an element of autonomy, having the sense to freely choose, or choice in itself reciprocally strengthens autonomy, as autonomy allows one to choose and likewise, being able to choose indicates autonomy, which basically autonomy is joint with choice (Dan-Cohen, 1992). This implies that as one perceives the existence of alternatives and the capacity to choose, then the action is more likely to be initiated by oneself since the choice is freely decided upon and endorsed by one’s sense of self. The presence of alternatives and having the opportunity to select among these options mainly supports an individual’s sense of choice, and consequently self-determination (Reeve, Nix, & Hamm, 2003). One’s capability to freely decide among pleasant options, and not experiencing pressure and demand, assists the individual to exhibit better performance and progressive well-being (Deci and Ryan, 2000). Although an individual may not always have the opportunity to lead in choosing, instead following a choice, one’s autonomy would still remain if the person willingly concurs with the choice, and decides according to his/her values and interests (Ricoeur, 1966, as cited in Ryan and Deci, 2006). This suggest that perceived choice does not merely focus on availability of choices and capability to choose, but more importantly being able to integrate one’s beliefs, values, and interests with the choices made.

**Awareness of Self**

Awareness of self refers to the individual’s sense of awareness with regard to his/her feelings and sense of self. In particular, self-awareness means that a person becomes of his/her personhood or characteristics such as values, attitudes, beliefs, feelings, personal motives and needs, competencies, skills and limitation (Cook, 1999). In the self-determination, the three
psychological needs involve feelings or sense: feeling of autonomy, sense of competence, and feeling of relatedness, wherein the fulfillment of these needs of senses or feelings are essential for a person to be self-driven and remain persistent in a task. Awareness of self is an important function of autonomy since the individual’s action should emanate from one’s sense of self (Ryan and Deci, 2000) which involves consideration of one’s values, beliefs, and interests.

In relation to perceived choice and autonomy, awareness of self is important when the person decides to concur or not with other people’s choice. Although decision-making entails choices, values and beliefs are taken into consideration in evaluating available options.

Relating Epistemological Beliefs and Self-determination

Learner’s epistemological beliefs and self-determination play an important role in the learning process. This study explored on the relationships of epistemological beliefs and self-determination. In addition, it dealt with how the beliefs of learners on the nature of knowledge and learning were connected with their self-determination in the learning process.

Schommer’s theory of epistemology served as a foundation in assessing the learner’s beliefs about nature of knowledge and learning. However, Bernardo’s (2009) two-factor model was utilized for the present study. From his previous study (Bernardo, 2008), he developed the structure by evaluating the goodness of fit and the weight of the two subscales (i.e. Complex learning and structured learning) loaded. This meant that the two factors in the model of epistemological beliefs were more appropriate for the Filipino context since the level of goodness of fit was found sufficient. Also, the previous study (Bernardo, 2008) and the present study similarly involved Filipino preservice teachers. For this reason, the two-model factor derived by Bernardo (2008) was more apt to use than including all the five domains listed by Schommer (1991).

Complex learning is the individual’s belief that learning is a complex process. Specifically, learning can be evaluated and developed. Complexity of learning is combined from the subscales of fixed ability (i.e. can't learn how to learn, ability to learn is innate, success is unrelated to hard work, and learn the first time) and quick learning domains (i.e. don't criticize authority, and learning is quick).

Meanwhile, structure of learning is the learner's belief that organization and accuracy are important in the learning process. Structure of learning is a combination from the subscales of simple learning domain (i.e. seek single answers, avoid integration, and concentrated effort is waste of time).
Bernardo’s (2009) two-factor model will be used primarily because of its statistical significance and because similar sample is investigated, which is Filipino preservice teachers.

Another theory for the foundation of the present research is self-determination theory. This theory asserts that an act should be initiated by oneself’s volition and interest to act and not merely by external factors such as demands, pressures, and reinforcements (Reeve, Nix, & Hamm, 2003; Ryan & Deci, 2000). The concept of self-determination highlights one’s autonomy or having the self-initiative, choice, and volition to do a particular task. In measuring autonomy, perceived choice and awareness of self will be employed as autonomy requires deciding over and among options inner values and beliefs as primary considerations.

In the conceptual framework, the general hypothesis was that the two factors of epistemological beliefs (complex learning and structure of learning) were significantly related and serve as predictors for the learner’s self-determination. Specifically, when the learner believes in complex learning, the first specific hypothesis states that the individual’s self-determination also increases. With this kind of belief, the learner think that understanding one’s way of learning can develop how he/she is able to form and absorb knowledge. And that learning can be improved gradually through self-initiated exploration, increased effort and persistence. Similarly, if the learner believes in structure of learning, the second specific hypothesis asserts that the individual’s self-determination also increases. Learners who believe that organization and accuracy is important in the learning process stress the necessity to meticulously follow procedures, and ensure the accuracy of information and methods used. By having a belief that structure of knowledge contributes to effective learning process, the learner strives for accuracy and organization of information.

**Purpose of the Study**

The present study aims to explore on the relationship of epistemological beliefs with self-determination. This is in response to a number of studies which discuss the two factors separately. Discussing how these two factors are linked will contribute to further understanding how one’s beliefs on the nature of learning and knowledge can influence one’s drive to learn and understand how to learn.

**Method**

**Participants**

The research involved 310 (61 males and 249 females) preservice teachers in the undergraduate level from different colleges and universities in the Greater Metro Manila area in the Philippines. All participants were
students from the college of education, with ages ranging from 16-24 years with a mean age of 19.16 years ($SD = 1.63$). All participants were asked to complete the survey as part of a class requirement.

The participants were decided to be preservice teachers since programs for education students mainly employ and instruct using different techniques, and entail several class immersions which serve as preparation for teaching in real classroom set-up. With this formation for professional practice, it was anticipated that preservice teachers have been acquainted with complex views on learning and utilize the experience in their own learning process and teaching practice (Ravindran, Green, & DeBacker, 2005).

**Instruments**

**Epistemological Beliefs.** The study utilized the questionnaire used by Bernardo (2008), which was derived from Schommer's Epistemological Questionnaire (SEQ). The instrument is a 17-item Likert type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The items in the first subscale, Complex learning, constitutes items from fixed ability (i.e. can't learn how to learn, ability to learn is innate, success is unrelated to hard work, and learn the first time) and quick learning domains (i.e. don't criticize authority, and learning is quick). Meanwhile, the second subscale involves items from the structured learning subscale (i.e. seek single answers, avoid integration, and concentrated effort is waste of time). These items were found to have significant weight in the factor loading and suitable goodness-of-fit (Bernardo, 2008). Inter-item reliabilities for each factor ranges from .63 to .85 (Schommer, 1993). The two-factor model displayed a good fit based on Confirmatory Factor Analysis (CFA): $\chi^2/df = 1.67$; RNI = .90, TLI = .90, RMSEA = .04. Test-retest reliability is .74. In scoring the scale, a higher score in the complexity of learning denotes a belief for learning as a complex process, while a lower score denotes a belief for learning as simple or uncomplicated process. For scoring structure of learning, a higher score implies a belief for organized and accurate learning while a lower score implies a belief for unpredictable and irregular system of learning (Bernardo, 2009).

**Self-Determination.** For assessing self-determination, the Self-Determination Scale (Sheldon & Deci, 1993) was utilized. There were 10 items to be answered with a 5-point Likert Scale ranging from 1 (Only statement A feels true) to 5 (Only statement B feels true). There were two subscales measured: Perception of Choice (the individual’s sense of choice with regards to his/her behavior: “I always feel like I choose the things I do”) and awareness of self (the individual’s sense of awareness with regards to their feelings and sense of self: “When I accomplish something, I often feel it
wasn’t really me who did it). Sheldon and Ryan (1996) reported that the scale’s internal consistency is considered good, having alphas ranging from .85 to .93 in numerous samples. Also the test-retest reliability is sufficient having $r = .77$, over an 8-week period.

**Procedure**

During the administration of the questionnaire, the participants were instructed to answer the two questionnaires. They were reminded to maintain an orderly environment while answering the scale. The questionnaires were administered collectively during one of their classes. Participants were given around 45 minutes to answer the two questionnaires. They were also informed that there was no right or wrong answers. Participants were assured that their responses were kept within strict confidentiality and solely used for the purpose of the study. Clarifications were also entertained if there are vague parts in the questionnaire or in the instructions. Debriefing also took place at the end, after all participants were finished answering the questionnaires.

**Data Analysis**

The mean and standard deviation for each of the subscales of epistemological beliefs (i.e. complexity of learning and structure of learning) and self-determination (i.e. perception of choice and awareness of self) were obtained. The computed Pearson ($r$) correlation coefficient were used to determine whether there is a significant relationship among the subscales of epistemological beliefs and the self-determination. Further, two sets of multiple regression were conducted to analyze if the two measures of epistemological beliefs, particularly complexity of learning and structure of learning can significantly predict self-determination. Beta weight ($\beta$), multiple correlation coefficient (R), Squared correlation coefficient ($R^2$) and Adjusted $R^2$ were also computed in the multiple regression.

**Results**

The descriptive statistics, intercorrelations, and regression analysis of the epistemological beliefs and self-determination factors were obtained. There are two sets of multiple regression conducted to determine which between the two epistemological beliefs (complexity of learning and structure of learning) can significantly predict each self-determination (perceived choice and self-awareness).
Table 1

*Descriptive Statistics for the Factors of Epistemological Beliefs and Self-Determination*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>Minimum</th>
<th>Maximum</th>
<th>SD</th>
<th>Cronbach Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity of Learning</td>
<td>310</td>
<td>4.13</td>
<td>1.40</td>
<td>5.00</td>
<td>0.39</td>
<td>.63</td>
</tr>
<tr>
<td>Structure of Learning</td>
<td>310</td>
<td>3.43</td>
<td>1.29</td>
<td>4.43</td>
<td>0.46</td>
<td>.50</td>
</tr>
<tr>
<td>Perceived Choice</td>
<td>310</td>
<td>3.43</td>
<td>1.40</td>
<td>5.00</td>
<td>0.73</td>
<td>.66</td>
</tr>
<tr>
<td>Self-Awareness</td>
<td>310</td>
<td>3.66</td>
<td>1.00</td>
<td>5.00</td>
<td>0.78</td>
<td>.67</td>
</tr>
</tbody>
</table>

Table 1 presents the mean scores of the 310 preservice teachers on their epistemological beliefs and self-determination. The dispersion of the scores on the epistemological beliefs is considerably close. The highest possible score for all the variables was five, indicating that the mean for complexity was higher than the rest of the factors. Meanwhile, the scores on both measures of self-determination, perceived choice and self-awareness were also relatively close ($M = 3.43$ and $M = 3.66$, respectively). Comparing the values of standard deviation of the two factors shows that the epistemological beliefs scores ($SD = 0.39$ and $SD = 0.46$) are less scattered than self-determination scores ($SD = 0.73$ and $SD = 0.78$).

Table 2

*Intercorrelations of the Factors of Epistemological Beliefs and Self-Determination*

<table>
<thead>
<tr>
<th></th>
<th>Complexity of Learning</th>
<th>Structure of Learning</th>
<th>Perceived Choice</th>
<th>Self-Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity of Learning</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure of Learning</td>
<td>.27*</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Choice</td>
<td>.15*</td>
<td>.02</td>
<td>.29*</td>
<td>---</td>
</tr>
<tr>
<td>Self-Awareness</td>
<td>.13*</td>
<td>.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $p < .05$

Table 2 displays the intercorrelations of each of the factors of epistemological beliefs and self-determination. Complexity of learning resulted to a significant correlation among all the other three factors. The link between complexity of learning and structure of learning shows a significantly positive pattern ($r = .27$, $p < .05$). Meanwhile, there are significantly positive correlations between complexity of learning and the two measures of self-determination, perceived choice ($r = .15$, $p < .05$) and self-
awareness \((r=.13, \ p<.05)\). Structure of learning did not show any significant correlation with both measures of self-determination. In addition, there is also a significant link between the two measures of self-determination \((r=.29, \ p<.05)\).

In analyzing the two measures of epistemological beliefs as predictors for self-determination, two sets of multiple regression were conducted. The first multiple regression used perceived choice as the dependent variable predicted by complexity of learning and structure of learning. While the second multiple regression used awareness of self as the dependent variable predicted by complexity of learning and structure of learning.

### Table 3
**Multiple Regression Model Predicting Perceived Choice**

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>SE Unstandardized</th>
<th>B</th>
<th>SE Standardized</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity of Learning</td>
<td>0.16*</td>
<td>0.06*</td>
<td>0.30*</td>
<td>0.11*</td>
<td>2.69*</td>
<td>0.00*</td>
</tr>
<tr>
<td>Structure of Learning</td>
<td>-0.02</td>
<td>0.06</td>
<td>-0.04</td>
<td>0.09</td>
<td>-0.42</td>
<td>0.67</td>
</tr>
</tbody>
</table>

* \(p<.05\)

*Note. \(R^2 = .15 \quad R^2_{adj} = .02 \quad Adjusted R^2 = .017 \quad F(2,307) = 3.68 \quad p=0.02\)*

The data was analyzed using multiple regression, using complexity of learning and structure of learning as regressors. The regression was a rather poor fit \((R^2_{adj} = 1.70\%)\), but the overall relationship was significant, \(F(2,307) = 3.68, \ p < 0.05\). With other variables held constant, complexity of learning scores were positively related to perceived choice, increasing by 0.15 for every extra complexity. Only the complexity of learning was significant, \(t (307) = 2.70, \ p < 0.05\).

### Table 4
**Multiple Regression Model Predicting for Awareness of Self**

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>SE Unstandardized</th>
<th>B</th>
<th>SE Standardized</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity of Learning</td>
<td>0.12*</td>
<td>0.06*</td>
<td>0.25*</td>
<td>0.12*</td>
<td>2.11*</td>
<td>0.04*</td>
</tr>
<tr>
<td>Structure of Learning</td>
<td>0.03</td>
<td>0.06</td>
<td>0.06</td>
<td>0.10</td>
<td>0.58</td>
<td>0.56</td>
</tr>
</tbody>
</table>

* \(p<.05\)

*Note. \(R^2 = .14 \quad R^2_{adj} = .019 \quad Adjusted R^2 = .012 \quad F(2,307) = 2.93 \quad p=0.05\)*

The data were analyzed by multiple regression, using complexity of learning and structure of learning as regressors. The regression was a rather poor fit \((R^2_{adj} = 1.23\%)\), but the overall relationship was significant, \(F(2,307) = 2.93, \ p < 0.05\).
=2.93, \( p < 0.05 \). With other variables held constant, complexity of learning scores were positively related to awareness of self, increasing by 0.12 for every extra complexity. Only the complexity of learning was significant, \( t(307) = 2.10, p < 0.05 \).

Discussion

It was hypothesized in the study that epistemological beliefs can significantly predict self-determination among Filipino preservice teachers. However, findings show that only one measure of epistemological belief, which is complexity of learning, significantly predicted the two subscales of self-determination: Perceived choice and awareness of self. Meanwhile, structure of learning did not show any significance in predicting self-determination. The difference in the effects of complex and structure of learning is attributed to the fact that educational system, which influences learner's epistemological beliefs, varies from culture to culture (Bernardo, 2009). For instance, the cross-cultural study of Youn, Yang, and Choi (2001) found that Americans implement student-centered learning where they appreciate and entertain criticisms from students, and consider these as part of interactive and stimulated learning. In contrast, South Koreans and Chinese observe teacher-centered practices where teachers are considered incontestable masters of the subject. Studies on epistemological beliefs of Chinese also denote that Chinese students were also found to strongly believe in omniscient authorities because Chinese culture emphasizes respect for the elderly and the authority (Chan & Elliot, 2000, 2004). With these disparities in culture and educational systems, American students develop active and open-mindedness, while Koreans and Chinese learners tend to be more passive learners (Youn, Yang, & Choi, 2001; Chan & Elliot, 2000, 2004). By noting the differences in educational system among the three cultures, we can see how a particular classroom setting can affect the learner's behavior and participation in the learning process.

The findings from the present study indicates that Filipino preservice teachers believe that learning can be reviewed, further developed, and expanded because their educational system is patterned from the Americans (Agbayani-Siewert, 2004). They have acquired this belief the over the years because the teacher education curriculum has focused on contemporary perspectives and more liberal ideals on teaching and learning. Education systems in the Philippines practice constructivism where learners are encourage being active and learning by doing. In the Korean setting though, they still follow the traditional teacher-centered approach wherein, learning and knowledge is controlled by the teacher, and the teacher is seen as all-knowing and unquestionable. South Korean educational system remains parallel with traditional teacher-centered setting since they have limited access on studies regarding teaching and learning. Also, most research
studies are written in the English language, which is different from their native language.

The epistemology of learning is basically guided by how educators teach subjects in school. Filipino instructors were said to create simple lesson plans and teach with minimal effort by employing simple, light forms of classroom discussion and activities (Bernardo, Limjap, Roleda, & Prudente, 2005, as cited in Bernardo, 2008). For example, science subjects involve scientific method and evaluation of theories and phenomena. It also requires reflective inquiry wherein students should be capable of accepting new ideas or knowledge which may be contradictory to what they already know. Students who believe that science is merely about facts and fixed knowledge are more likely to experience more difficulty in conceptual learning (Qian & Alvermann, 2000). In the Philippine education system, most teachers teach science concepts and principles based on book, and mostly discuss about terminologies and its definition. Activities for science usually consist of manual-guided laboratory experiments and field trips. Meanwhile, a study exploring epistemological beliefs in math reveals that most students hold a belief that mathematics is merely about memorizing facts and formula, following procedures from the book, rather than a collectively theoretical discipline, as well as being good in math is an inborn trait (Garofalo, 1989 and Schoenfield, 1989, as cited in Muis, 2004). As most students think of math as a subject understood by only “mathematically-gifted” individuals and a subject which does not require higher cognitive engagement, the more they experience difficulty grasping over mathematically abstract concepts. More so, they are more likely to withdraw from solving complicated math problems. When solving problems for math and science, Filipino teachers typically introduce only one standard formula and strategy for answering. And most of the time, topic integration and applications of the lesson are rarely tackled. That is why most students do not see the relevance of solving math and science problems in the practical context, which also affects how they push themselves to learn more and strive for solving challenging math and science problems.

While teachers are said to be more effective in simple-thinking tasks (Wong-Fernandez, & Reyes, 2003, as cited in Bernardo, 2008), findings in this study reveal that they still regard learning as a complicated process. This may due to the fact that Filipino preservice teachers acknowledge that learning involves constant development, and that learning is a lifelong process. On the other hand, preservice teachers experience difficulty in shifting to and implementing complex learning in their classroom practices since they have always been exposed to Philippine educational system concentrating on simple learning (Bernardo, 2008). In addition, they have been more familiar with tasks which mostly are cognitively-undemanding that is why they also assign simple tasks to their students.
Furthermore, the results of this study show that Filipino preservice teachers’ scores on complex learning consistently increases their self-determination on both perceived choice and self-awareness. This may be attributed to the fact that learners who seem to feel in control with their learning environment are more likely to demonstrate higher levels of self-determination (Ryan and Deci, 2000). Individuals who perceive learning as a complicated system recognize that learning continually develops, and needs to be further understood and improved. This belief encourages individual to gain deeper appreciation on how to learn effectively and understand the practice of the knowledge-seeking process. The finding might be due to the fact that Filipino preservice teachers recognize activities which require more complex tasks and effortful thinking, however, the delivery of complex learning inside the classroom remains a challenge since they have been taught and used to creating traditionally low-order thinking based lesson plans and classroom activities (Bernardo, Limjap, Roleda, & Prudente, 2005, as cited in Bernardo, 2008). This finding also implies that preservice teachers remain highly self-determined as they realize that learning is a complex process. While complexity of learning laid emphasis on the learners’ initiative to engage in tasks, self-determination similarly underscores individuals’ interest to engage and pursue in the task. For instance, when teachers have difficulty introducing a problematic topic or lesson to the students, the teacher stays earnest to teach them and is able to understand that some students may also encounter difficulty in comprehending the lesson. Also, the teacher is able to handle criticisms and is willing to improve on his/her manner of teaching. By this finding, it implies that teachers are able to create their choices freely and decide upon their learning environments since they believe that learning entails a lot of facets to be considered. By having a sense of control, Filipino preservice teachers are able to perceive choices and experience volition in the classroom activities that they set for their students, such as exploring and examining their knowledge, capabilities, and learning.

Complexity of learning also responds to another essential psychological need of self determination which is competence. As a preservice teacher appreciates that learning can be improved and explored, the individual take a lead in understanding more about how to find knowledge and answers, not merely depending on books and authorities but through observing and dealing with the environment. The individual takes the risks of facing challenges to better his/ her learning and knowledge. As preservice teachers, they understand that they are instrumental in developing a learner’s discovery of knowledge and learning. Likewise, the manner by which they teach and set tasks and activities for their class reflects how they see the nature of knowledge and learning.

Contrastingly, structure of learning did not significantly predict the two measures of self-determination. Learner’s belief on the necessity for organization and precision in learning process does not necessarily influence
their self-determination. Comparing the questionnaire items in the two measures of epistemological beliefs, one can note that items from the complexity of learning emphasize self-determination because it addresses autonomy and pursuance of action regardless of challenges. For example the statement, “If a person can’t understand something within a short amount of time, they should keep on trying.” suggests that a learner should remain motivated even if time is limited. It also encourages the learner to persist and not to lose hope despite troubles in learning. The statement further establishes that learning does not happen in a quick or constricted span of time, instead learning happens gradually. Meanwhile, questionnaire items from the structure of learning only stresses on following standards and procedures, precision, and details. For example, the statement, “The best thing about science courses is that most problems have only one right answer.” means that the learner should be contented with finding a single answer to a problem or question, and that after obtaining a single resolution, the learner does not need to further probe. The statement also promotes that science can be learned through rote memorization, and requires less effort. Science subject actually intends the learner to explore and discover, instead of sticking to information by the book. Also, studying science concepts, theories and principles involves reasoning and sometimes needs conceptual change (Qian & Alvermann, 2000). Like before, Pluto was considered to be a planet in the solar system. However, further investigations have verified that Pluto does not meet the criteria of a planet. With these comparisons from the statements of two epistemological beliefs, we can say that self-determination is evident or related to complexity of learning and not in structure of learning. This is why high-scorers on complexity of learning uphold to increased level of self-determination, and structure of learning did not render association with self-determination.

Another finding of the present study revealed that as preservice teachers believe in complex learning, they are also more likely to believe in structured learning. It implied that as an individual highly believes that learning involves numerous phases and complicated process, his/ her belief of the importance of organization and structure in learning also follows. Complexity of learning and structure of learning may emphasize different aspects of learning; however, both are essential in appreciating the value of the learning process. By having a complex view of learning, the individual realizes that there are multiple considerations for learning, and structure of learning builds and organization and system to this wide array of aspects so that it may be fully understood and seen as a complete and orderly picture. In the context of the preservice teachers, although they appreciate complex and structured view of learning, the effects seem to be different as it dealt with their self-determination.

Another key finding depicted a positively connection between the two subscales of self-determination, wherein as preservice teachers perceive
opportunities for decision-making, it is also more likely that incorporate or check their ideals, emotions, and beliefs. As explained in the review of literature, autonomy both emphasizes availability of choice and one’s awareness of beliefs and personhood. With this in mind, it means that Filipino preservice teachers take into consideration their beliefs, values, and feelings as they see evaluate which option will bring an optimal outcome.

References


**About the Author**

Dr. Carlo Magno is presently a faculty of the Counseling and Educational Psychology Department of De La Salle University in Manila, Philippines. Most of his research is focused on assessment of learning strategies, epistemological beliefs, and learner-centeredness.
Enhancing Mathematics Skill and Self-Regulatory Competency through Observation and Emulation

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The Graduate School and University Center
City University of New York

Abstract
This experimental study examined the effects cognitive modeling and social feedback on the mathematics skill and self-regulatory development of 88 fifth-grade students. The students were assigned randomly to one of four conditions: modeling with feedback, modeling without feedback, feedback without modeling, and no modeling or feedback. In the modeling conditions, students observed a model verbalized, demonstrated, and explained procedures to solve fraction problems. In the feedback conditions, students received feedback on the accuracy of their answers and when they made an error the researcher circled it and prompted students to correct them. Multivariate analysis of covariance showed a main effect of modeling, but no effect of feedback. Subsequent univariate analyses of covariance revealed a significant main effect for modeling on each of the dependent measures and a significant cognitive modeling × feedback interaction on the mathematics posttest, self-efficacy bias, and self-evaluation bias. The implications of the findings are discussed.

Keywords: cognitive modeling, feedback, fifth graders, self-regulation, mathematics

Introduction

Mathematics literacy is a serious problem in United States, many Western, and third-world countries. According to Hetch, Vagi, and Torgeson (2007), students have difficulties with fractions in elementary grades and competency in fraction skills is essential for success in algebra and advanced mathematics courses. Mathematics may be the “new literacy” (Schoenfeld, 1995) because the workforce in the near future will have to handle quantitative skills more skillfully than at present (National Mathematics Advisory Panel, 2008). One widespread goal of education in mathematics at the elementary level is “students’ study and use of numbers should be extended to include larger numbers, fractions, and decimals” (National Council of Teachers of Mathematics, 2000). The Panel (2008) specifically suggests that by Grade 4, students should be proficient in whole number operations (i.e., addition, subtraction, multiplication, and division) and begin work on fractions and decimals.

Success in mathematics depends on knowledge of content skills; moreover, research suggests that cognitive (e.g., planning, goal setting), metacognitive (e.g., calibration), and motivational (e.g., self-efficacy, intrinsic interest) variables also play a critical role (Zimmerman & Bandura, 1994; Schunk & Zimmerman, 2007). Elementary school students have difficulty with basic mathematics skills such as whole number operations, which present problems when they have to solve more complex fraction problems.
(Labuhn, Zimmerman, & Hasselhorn, 2010; NMAP, 2008). Researchers suggest that learners can acquire new mathematical skills and develop self-regulatory competency through four sequential levels of skill acquisition (Zimmerman & Kitsantas, 2002). The present study focuses on the first two levels of skill acquisition. Specifically, the research explores the role of cognitive modeling and social feedback on students’ mathematics skills, self-efficacy, self-evaluation, and metacognitive judgments.

**Social Cognitive Perspective of Self-Regulation**

A social cognitive view on the development of self-regulatory competency postulates that novice learners acquire new skills and strategies through four sequential levels, (a) observational, (b) emulative, (c) self-controlled, and (d) self-regulated (Kitsantas & Zimmerman, 2000; Schunk & Zimmerman, 2007; Zimmerman, 2000). At the *observational level*, novice learners observe a model demonstrating and verbalizing the skills and strategies necessary to complete a specific task. *Cognitive modeling* occurs when models explain and demonstrate their thoughts and reasons while performing a cognitive task (Michembaum, 1977; Schunk, 1981). For example, cognitive modeling occurs when teachers demonstrate and explain various procedures while solving a fraction problem, which enhances students’ learning of various skills and strategies. When problem-solving or using computation tools (e.g., strategy, calculator, or pencil-paper algorithm), teachers can model the choices they make and think aloud about them, and observing students can learn to make good choices (NCTM, 2000). Learners attain skill at this level when the observations facilitate a clear image of the processes necessary to solve fraction problems, for example recognizing another student’s successful solution of a fraction problem. Learners become motivated at this level when they observe the model or another person attain success or receive praise after solving the problem. After observing the model, the next process is practicing the modeled behavior, which occurs at an *emulative level*.

At an *emulative level*, novice learners try to enact the model’s performance. For example, after observing a teacher model a solution strategy with fraction problems, learners would understand the order of operations and would find the common denominator first before solving the problem. It should be noted that emulation is different from imitation. Imitation is merely copying every aspect of a model’s behavior, whereas, emulation involves the abstraction and transfer of the underlying strategy to a new problem (Zimmerman, 2000). Guidance and feedback are essential during emulative experiences and can lead to higher levels of learning (Kitsantas & Zimmerman, 2000). The main source of motivation for learners at the emulative level is social feedback, often by the model regarding the student’s work. *Feedback* is providing information to learners so they may
improve their skills, and it is related to higher achievement and superior motivation (Shute, 2008). Social feedback during emulative experiences enables learners to refine their skills and develop self-regulatory competency for further learning (Kitsantas & Zimmerman, 2000). These two levels are primarily social because observation and emulation occurs in the model’s presence (Schunk & Zimmerman, 2007). Learning of the specific skill has begun but the process continues at the third and fourth levels where students require less assistance and gradually build skills for further learning.

At the self-control level, learners can use the skill or strategy independently when performing related tasks. For example, learners who have learned the order of operations in solving fraction problems would be able to use those skills to solve fraction problems with and without whole numbers. Students acquire competency at this level through independent practice. Learners attain this level proficiency when they compare their efforts with the standards obtained from the modeling experiences. Those who match or surpass those standards experience positive self-reaction, which is the primary source of motivation at this level (Kitsantas & Zimmerman, 2000). Researchers have measured self-reaction at this level by using a self-satisfaction scale (Zimmerman & Kitsantas, 2002; Ramdass & Zimmerman, 2011). However, this study will use a self-evaluation scale to measure self-reaction because students are evaluating their personal efforts with the standards obtained from the modeled experiences.

At the final level, self-regulation, learners are able to adapt their skills and strategies to various tasks, internal, and external conditions (Kitsantas & Zimmerman, 2000; Schunk & Zimmerman, 2007). For example, they would be able to solve fraction problems at a higher level of difficulty or decipher that a word problem involves fraction skills. In addition, learners self-monitor their performance and maintain their motivation through self-efficacy and intrinsic interest in completing the fraction problems. Self-efficacy is an individual’s perceived capability of performing a task at designated levels (Bandura, 1997). Social influences are not present in these final two levels, but their influence never wanes completely and learners may seek help if a problem arises while completing a task (Zimmerman, 2000). Students who are able to use their skills to solve more difficult math problems would experience enhanced perceptions of self-efficacy, self-reactions, and intrinsic interest in this particular task and become more self-regulated.

**Self-Efficacy**

Self-efficacy is learners’ perceived capabilities to learn and complete a task at designated levels (Bandura, 1997). Learners who have high self-efficacy for acquiring a skill or completing a task work harder and persist longer when they face difficulties compared to those who doubt their
capabilities (Bandura, 1997; Schunk & Zimmerman, 2007). Learners' develop self-efficacy through actual performances, modeled experiences, verbal persuasion, and physiological reactions (Bandura, 1986; 1997). Numerous studies indicate that mathematics self-efficacy influences the accuracy of mathematics performance, effort, and persistence (Hoffman & Schraw, 2009; Pajares, 1996; Ramdass & Zimmerman, 2008; Schunk & Ertmer, 2000). Experimental studies have shown that self-efficacy beliefs can be modified through effort and various self-regulatory processes, such as goal setting, modeling, self-monitoring, and self-evaluation of progress (Schunk & Ertmer, 2000; Schunk & Pajares, 2004). Although optimistic estimates of one’s competency may increase effort and persistence initially, misjudgments of one’s capabilities can be problematic if they lead to poor performance (Bandura, 1989).

Calibration and Achievement

Current research suggests that the accuracy of these self beliefs, calibration, is critical to academic success and motivation (Chen & Zimmerman, 2007; Klassen, 2006). Calibration is the accuracy of learners’ perceptions of their performance (Huff & Nietfeld, 2009; Pieschl, 2009; Schunk & Pajares, 2004). Researchers suggest that calibration is one component in the process of developing self-regulatory competency and is a metacognitive skill for monitoring one’s performance (Pieschl, 2009; Zimmerman, 2008). It refers to learners’ awareness of what they know or do not know about their success as learners (Butler & Winne, 1995; Stone, 2000), which only captures a limited fraction of the entire realm of self-regulated learning (Pieschl, 2009). Decades of research has shown that students generally tend to overestimate their capabilities, which can have a detrimental impact on their learning and performance. Low-achieving students are less accurate and more overconfident than their high-achieving counterparts who tend to underestimate (Hacker & Bol, 2004; Klassen, 2006; Schunk & Pajares, 2004). Stone (2000) suggests that feedback plays an important role in influencing academic achievement and calibration.

Measuring Calibration

Social cognitive and metacognitive researchers have used various methods to measure calibration. Schraw, Potenza, and Nebelsick-Gullet (1993) used mean bias, which refers to the difference between estimated and true performance (the direction of judgment error). Bias measures of over- or underconfidence on a test or task are computed by taking the mean differences between predicted and actual performance scores and can range from -1 to 1. Scores larger than zero signify overconfidence, and scores less than zero correspond to underconfidence. Mean accuracy is a second measure,
and it assesses the magnitude of judgment error. *Mean accuracy* is the absolute value of the bias score. Accuracy can be calculated by squaring the bias score or taking its absolute value and can range from 0 to 1.

Social cognitive researchers (Chen, 2003; Pajares & Graham, 1999; Zimmerman, 2008) and metacognitive researchers (Huff & Neitfeld, 2009) have used the above two measures of bias and accuracy over the past decade to measure self-efficacy calibration. This study employs only the bias measure and it would be calculated using both self-efficacy and self-evaluation scores. Self-efficacy ratings are done before the task, whereas, self-evaluation ratings are done after the task. The rationale for including both is that students may display more accurate metacognitive monitoring after performing the task compared to before doing it.

**Feedback**

Feedback from another person can influence learning outcomes (Hattie & Timperley, 2007) because students become aware of which strategies were effective when completing tasks, which should enhance performance and calibration (Butler & Winne, 1995). Meta-analytic studies show that the role of feedback in classroom learning has been very effective with a mean effect size of .79 (Hattie & Timperley, 2007). Feedback occurs in the emulation phase in Zimmerman’s (2000) model after students practice the modeled instructions on a new set of mathematics problems. Feedback at this stage is external because learners are still acquiring a skill, and it should enhance performance. Apart from improving performance, feedback may also enhance self-evaluative judgments, which occur after learners complete each problem. Recent experimental studies showed that feedback enhanced the accuracy of students’ self-evaluative judgments compared to students who received no feedback (Labuhn, Zimmerman, & Hasselhorn, 2010) and modeling with social feedback improved students’ math performance and metacognitive monitoring (Ramdass & Zimmerman, 2011). Feedback at the emulation level should enhance performance at the posttest level where students complete mathematics problems independently at the self-control level. One critical source of motivation at the self-control level is self-reaction. When students self-evaluate their work and find that they match or surpass the standards of the modeled experiences, they experience enhanced self-reactions, which motivate them to continue to acquire higher levels of mastery.

**Self-Evaluation**

Self-evaluation is judging one’s performance based on a set of standards or objective outcomes (Zimmerman, 2000). For example, learners can evaluate their performance based on the standards they acquired from the modeling experiences. Self-evaluation enables learners to assess their
performance and develop reflective skills. Positive self-evaluations of one's capabilities and progress are important for maintaining self-efficacy for learning (Schunk, 2003). Self-evaluation has played an important role in enhancing students' academic achievement in both correlational and experimental studies (Schunk & Ertmer, 2000). Self-evaluation is a key self-regulatory process, which enhances self-efficacy for performance in the fourth level, self-regulation.

Research Evidence

Zimmerman and Kitsantas (2002) have examined the first two levels of observation and emulation in writing tasks with 72 college students and found that modeling improved students' writing skills, self-efficacy, self-satisfaction, and intrinsic interest. They assigned students randomly to six conditions. These conditions were three types of modeling (i.e., no modeling, mastery, and coping) and two types of feedback (i.e., feedback vs. no feedback). They hypothesized that students who observed a coping model would surpass those who observed a mastery model. Second, students who observed a mastery model would perform better than students who observed no model. The findings showed that a coping model improved students' writing skill and self-efficacy compared with the other two conditions, and the mastery condition improved the outcomes better than the no-model condition. In addition, social feedback was significant in improving students' writing skill compared to the no-feedback condition in the posttest (Zimmerman & Kitsantas, 2002). Specifically, they found support for the first two levels of the multilevel view of skill acquisition. Students' degree of observation learning significantly influenced learning in the emulative phase of practicing the writing skill.

In another study with 84 high school girls, Zimmerman and Kitsantas (1999) investigated the effects of goals on the students' writing skills. They assigned students randomly to six experimental conditions and one control group. These were goal setting (i.e., process goal, outcome goal, and shifting process-outcome goal) and self-recording (i.e., self-recording vs. no self-recording). The students observed a model demonstrate how to combine multiple sentences into one sentence by removing redundancies and adding transitional phrases. Students in the process goal condition concentrated on performing key steps in the task. Students in the outcome goal condition rewrote the sentences using the least number of words. Students in the shifting goal condition first focused on performing the key steps, but after a few minutes they shifted to the outcome goal of using a minimal amount of words. Half of the students in each condition recorded the number of strategy steps (i.e., process goal) they did correctly or the number of words (i.e., outcome goal) in the sentence. This study addressed the four processes of self-regulatory acquisition and competence. Modeling with practice...
targeted the first two levels of observation and emulation. Process goals focused on the third level of self-control and outcome goals captured the fourth one, the self-regulated level.

The results indicate that students in the shifting goal condition evidenced higher self-efficacy and writing skill compared to the other conditions. In addition, students in the process goal were more effective than those in the outcome goal and no goal conditions. Students in the outcome goal group who skipped the third level of self-control had poorer writing skill and lower self-efficacy compared to those in the process and shifting goal conditions, implying that advancing through the stages may be beneficial in certain tasks (Schunk & Zimmerman, 2007; Zimmerman & Kitsantas, 1999).

Recently, Ramdass and Zimmerman (2011) examined the effects of coping and mastery modeling and social feedback on middle school students’ algebraic skills. The researchers randomly assigned students to one of four conditions, (a) coping model with feedback, (b) coping model without feedback, (c) mastery model with feedback, and (d) mastery model without feedback. Students in the coping model condition observed a model making errors and later correcting them. Students in the mastery condition observed a model solving algebraic equations without making any errors. Feedback focused on the accuracy of students’ responses. The results showed significant effects of modeling on students’ algebraic skills, self-efficacy, and self-satisfaction, and calibration bias. Feedback was significant only on the calibration bias measure, implying that modeling and feedback not only improved students’ algebraic skills and self-judgments, but also enhanced the accuracy of these self-judgments.

In an earlier study, Schunk (1981) evaluated the role of modeling on 56 elementary children arithmetic problem solving skills and self-efficacy judgments. The students were randomly to one of four treatment conditions, namely, (a) cognitive modeling with attribution, (b) cognitive modeling without attribution, (c) didactic instruction with attribution, (d) didactic without attribution, and (e) control group.

The first hypothesis explored whether modeling, guided performance, and self-directed mastery would facilitate development of arithmetic skills and self-efficacy. The second related to the effects of effort attribution on achievement during arithmetic training. Finally, the third set of hypotheses tested the relationship of self-efficacy to subsequent achievement. Students received either modeling of division problems or didactic instruction and then practiced on a new set of problems. During the practice phase, half of the students in each treatment condition received effort attribution for success and difficulty.

The results showed that cognitive modeling was more effective in promoting mathematical skill compared to didactic instruction, but modeling-attribution condition had no effect on persistence. Students in the modeling condition showed significant improvement in self-efficacy, solved more
problems, and persisted longer compared to the control group. Effort attribution had no effect on self-efficacy or mathematics performance. Self-efficacy was not significant, but there was a relationship between self-efficacy and persistence: students who judged they could solve more problems, persisted longer on solving them. In addition, students in the modeling and attribution condition had the highest congruence between self-efficacy and math performance compared to the didactic and control conditions.

**Present Study and Hypotheses**

To date, apart from writing, research on this model of sequential skill acquisition in other subject areas such as mathematics or reading is lacking. Although Schunk’s (1981) study focused on modeling, it was not based on Zimmerman’s (2000) model for acquiring skill through sequential instruction. In addition, the issue of the accuracy of students’ judgments was not fully explored. One primary goal of this study is to explore whether cognitive modeling would enhance fifth grade students’ mathematical skills, self-efficacy, self-evaluation, and metacognitive skills. The first hypothesis states that students in the cognitive modeling condition would surpass those in the no-cognitive modeling conditions on the above outcomes. A second goal is evaluating the effects of social feedback during emulative learning. The second hypothesis states that students in the social feedback condition would surpass those who practice math problems without receiving feedback. As a result, the effects of cognitive modeling and social feedback were expected to enhance students’ mathematics skill, self-efficacy, self-evaluation, and their metacognitive accuracy, which would provide support for the first two levels of sequential instruction of mathematics skills. In prior research with this model, Zimmerman and colleagues used a self-satisfaction scale to measure students’ self-reactions after performance. In this study, a self-evaluation scale is used to evaluate students’ self-judgments after the task. These goals are important for at least three reasons.

First, some researchers suggest that younger children have difficulty with metacognitive thinking, such as making a self-efficacy judgment (Berk, 2000); however, observing a model solve math problems students are currently studying should enhance their math skills, self-efficacy, self-evaluation, and metacognitive judgments. Students who observe an instructor model and verbalize how and why to use a strategy to solve a math problem can learn how to solve that problem (NCTM, 2000).

Second, the development of self-regulatory competency has been explored with students in higher grades. Research on younger children is lacking (Gaskill & Murphy, 2004). Self-regulation facilitates academic achievement (Zimmerman, 2008); therefore, it is important to study how younger children develop self-regulatory skills, which would shed more light on these processes from a developmental perspective.
Third, elementary students value and find mathematics important (NCTM, 2000), but in middle school their interest in mathematics, self-directedness, and intrinsic desire to learn begins to wane and this may affect mathematics performance (Fredericks, & Eccles, 2002; Pajares & Miller, 1994). Therefore, studying interventions that sustain younger children’s motivation and improve mathematics performance would provide researchers and educators with tools to understand how to address issues of self-regulatory development and self-directedness in later grades.

Method

Participants

The participants were 88 (49 girls, 39 boys) English-speaking fifth grade students from three urban private schools. Students’ mean age was 10 years 7 months (SD = 6 months). The ethnicity of the students was Caucasian (50%), South Asian Indian (22%), African American (14%), and Hispanic (14%). Participation in the study was voluntary, and required student assent and parental permission.

Task and Materials

The mathematics fraction problems were chosen from two math texts for elementary grades (Everyday Learning Corporation, 2004; Schwartz, 2008). The mathematical items were pilot tested on eight students, and a few problems were corrected to produce a range of problems from simple to difficult. The mathematics problems were presented in a stapled-worksheet containing 13 pages with ample space for students to display their work. In addition, students used pencils and erasers.

Measures

Mathematics skill. Each math problem was scored as correct 100 points, incorrect 0 points, or partial credit 50 points. Students received partial credit if they performed some steps toward solving the problem correctly, but did not complete the problem. The Cronbach’s alpha for these items was .72. The predictive validity and construct validity of the math posttest is supported by the significant correlation among the other dependent measures. These math items were taken from math texts books and represented the work the students were doing on fractions at that time.

Self-efficacy. This task-specific scale assessed students’ judgment of their capability during posttest before each of the six math problems (e.g., “How sure do you feel that you can solve this fraction problem correctly?”).
was developed based on the guidelines of Bandura (2006). The scale ranged from 0 (not at all sure), 40 (somewhat sure), 70 (pretty sure) to 100 (very sure). The Cronbach’s alpha for these six items was .90.

**Self-evaluation.** This scale assessed students’ performance after solving each math problem during the posttest. Students were asked, “After solving the problem, how sure are you that you have solved it correctly?” It was adapted from Chen (2003) and it ranged from 0 (not at all sure), 40 (somewhat sure), 70 (pretty sure) to 100 (very sure). The Cronbach’s alpha for these six items was .86.

**Self-efficacy bias.** Bias was calculated using procedures reported by Pajares and Graham (1999) and Schraw, Potenza, and Nebelsick-Gullet, (1993). Bias, the extent to which one is over- or underconfident in his/her judgement, is calculated at the item-level by subtracting each mathematics score from each self-efficacy score on the posttest (Chen, 2003). A student with a self-efficacy rating of 40 (somewhat sure) to solve the problem, but solved correctly (100) would have a bias score of -60 (40-100), indicating underconfidence. On the other hand, a student who rated his/her confidence to solve the problem as 70 (pretty sure) and solved it incorrectly (0) would receive a bias score of 70 (70-0), signifying overconfidence. As a result, self-efficacy bias scores could range from -100 to 100. The Cronbach’s alpha for these six items was .65.

**Self-evaluation bias.** This measure was calculated in the above manner using the self-evaluation scores instead of self-efficacy scores. The Cronbach’s alpha for these six items was .67.

**Research Design**

The researcher used a pretest-posttest group design. Students were randomly assigned to one of four conditions within each school, (1) cognitive modeling with social feedback, (2) cognitive modeling without social feedback, (3) social feedback without cognitive modeling, and (4) no cognitive modeling nor social feedback.

**Procedure**

The study was conducted with students individually in each school. All students returned the signed consent forms and provided demographic data (i.e., age, grade, gender, and ethnicity). Each session lasted roughly an hour and consisted of a pretest, a training phase, a practice phase, and a posttest. The researcher gave a brief overview of the study and told each student that participation was voluntary. Each student completed a set of six
fraction problems in the pretest phase, which lasted roughly 14 minutes and was identical for all students. Below is a description of the training phase according to each condition.

**Cognitive modeling with social feedback.** During the instruction phase students observed a model solve four fraction problems contained in the worksheet. The model demonstrated each step of the problem and verbalized aloud how to arrive at the correction solutions (see Appendix for sample problems). Training lasted for 14 minutes. In the practice phase, students solved four new math problems and received corrective feedback on each problem. If the solution was correct, the researcher told the student to proceed and solve the next problem. However, if the solution was incorrect, the researcher circled the error or errors and without giving the correct solution told the student, “This is the part you got wrong. What can you do to correct it?” This method of feedback was repeated for each of the four problems in the practice phase.

**Cognitive modeling without social feedback.** The treatment for this condition was similar to the one above except that in the practice phase students in this condition did not receive feedback. They were told to solve the four problems in the worksheet.

**No cognitive modeling with social feedback.** Students in this condition did not receive cognitive modeling instruction. After the pretest, they were advanced directly to the practice phase. After solving each problem, they received corrective feedback on their solutions. If the solution was correct, the researcher told the student to proceed and solve the next problem. However, if the solution was incorrect, the researcher circled the error or errors and without giving the correct solution told the student, “This is the part you got wrong. What can you do to correct it?” This feedback process was repeated for each of the four math problems in the practice phase.

**No cognitive modeling or social feedback.** In this condition, students did not receive cognitive modeling social or feedback. After the pretest, they were advanced directly to the practice phase where they solved the four problems, and then finally to the posttest.

The posttest phase occurred immediately after the practice phase. There were six problems in the posttest and each problem was shown briefly for students to make a self-efficacy judgment before solving it. After solving each problem, students rated their performance on the self-evaluation scale. This phase lasted roughly 20 minutes. For ethical reasons at the end of the study, students in the no-cognitive modeling with social feedback condition were taught cognitive modeling on problems in the training phase and students in the cognitive modeling condition without social feedback received
social feedback on the practice problems. Students in the no cognitive modeling and no social feedback condition were taught both cognitive modeling and got social feedback.

Results

The data were analyzed using multivariate analysis of covariance (MANCOVA) with pretest as the covariate, cognitive modeling and social feedback as independent measures, and posttest math, self-efficacy, self-evaluation, self-efficacy bias, and self-evaluation bias as dependent variables. This was followed by ANCOVA, and finally correlations between the dependent variables were calculated using Pearson correlation coefficient. To determine the effectiveness of random assignment, univariate analyses of variance of the pretest math fraction scores revealed no significant main effect or interaction effect, confirming that the groups were statistically comparable on math fraction skills before this study. Descriptive statistics are presented in Table 1.

Effects of Cognitive Modeling and Social Feedback on Practice Math

To assess the effects of cognitive modeling and social feedback on the practice mathematics data, ANCOVA results showed a main effect of cognitive modeling, $F(1, 83) = 58.21, p < .001$, partial $\eta^2 = .412$, implying that modeling at the observational level improved students’ math performance significantly in the emulative phase compared to students in the no-cognitive modeling condition. However, feedback was not significant.

Table 1
Descriptive Statistics for Each Group

<table>
<thead>
<tr>
<th>Measures</th>
<th>Modeling with Feedback</th>
<th>Modeling No Feedback</th>
<th>No Modeling with Feedback</th>
<th>No Modeling No Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics</strong></td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
</tr>
<tr>
<td>Pretest</td>
<td>35.98 (26.28)</td>
<td>20.45 (24.36)</td>
<td>25.00 (26.35)</td>
<td>25.00 (22.27)</td>
</tr>
<tr>
<td>Practice</td>
<td>71.59 (24.45)</td>
<td>66.48 (26.55)</td>
<td>34.10 (29.17)</td>
<td>29.55 (21.67)</td>
</tr>
<tr>
<td>Posttest</td>
<td>72.73 (19.78)</td>
<td>68.56 (19.40)</td>
<td>46.59 (29.51)</td>
<td>36.36 (20.66)</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>65.61 (21.77)</td>
<td>56.44 (21.78)</td>
<td>47.88 (22.89)</td>
<td>52.27 (24.38)</td>
</tr>
<tr>
<td>Self-evaluation</td>
<td>69.92 (20.93)</td>
<td>58.79 (23.45)</td>
<td>47.95 (22.43)</td>
<td>46.44 (29.53)</td>
</tr>
<tr>
<td><strong>Calibration Bias</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>-7.12 (19.18)</td>
<td>-12.12 (17.31)</td>
<td>1.29 (27.02)</td>
<td>15.91 (25.57)</td>
</tr>
<tr>
<td>Self-evaluation</td>
<td>-2.80 (14.15)</td>
<td>-9.77 (12.15)</td>
<td>1.36 (26.06)</td>
<td>10.08 (24.88)</td>
</tr>
</tbody>
</table>
Effects of Cognitive Modeling and Social Feedback on Posttest Measures

MANCOVA results showed a main effect of cognitive modeling, Wilk’s $\lambda = .58$, $F(3, 81) = 19.81$, $p < .001$, partial $\eta^2 = .423$, and a weak interaction of cognitive modeling and feedback, Wilk’s $\lambda = .92$, $F(3, 81) = 2.26$, $p < .088$, partial $\eta^2 = .077$.

Subsequent univariate analysis of covariance (ANCOVA) showed a main effect of cognitive modeling for each of the dependent variables. Math fraction skills, $F(1, 83) = 60.63$, $p < .001$, partial $\eta^2 = .42$. There was no main effect of social feedback. However, a significant interaction effect of cognitive modeling and social feedback, $F(1, 83) = 5.18$, $p < .025$, partial $\eta^2 = .059$, indicates that a combination of both variables improved students’ math performance significantly.

On self-efficacy, $F(1, 83) = 5.10$, $p < .027$, partial $\eta^2 = .058$, and self-evaluation $F(1, 83) = 12.39$, $p < .001$, partial $\eta^2 = .13$. There was no main effect of social feedback or interaction effect on these measures.

On the calibration bias measures, there was a main effect of cognitive modeling on both variables. On self-efficacy bias, $F(1, 83) = 13.65$, $p < .001$, partial $\eta^2 = .14$, and a significant interaction effect, $F(1, 83) = 5.25$, $p < .024$, partial $\eta^2 = .059$.

On self-evaluation bias, $F(1, 83) = 7.27$, $p < .001$, partial $\eta^2 = .081$, and a significant interaction effect, $F(1, 83) = 3.98$, $p < .049$, partial $\eta^2 = .046$. There was no main effect of feedback on both calibration measures.

Figures 1 shows significant interaction effects on self-efficacy bias, indicating that cognitive modeling and social feedback improved the accuracy judgments of students compared to students in the no modeling and no feedback conditions.
Correlation Analysis

Correlation among the variables is presented in Table 2. All the variables correlated positively and significantly with posttest math, except the calibration measures. The negative correlations between the calibration measures (i.e., self-efficacy bias, $r = -.60$; self-evaluation bias, $r = -.45$) and posttest math indicate that overconfidence diminished students’ math performance. Self-efficacy and self-evaluation correlated very high ($r = .85$), which extends a prior finding by Chen (2003). In addition, the two calibration measures also correlated positively ($r = .84$), implying that they both measured students’ metacognitive monitoring.

Table 2
Bivariate Intercorrelations among Dependent Measures

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Pretest</td>
<td>----</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Practice</td>
<td>.47**</td>
<td>----</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Posttest</td>
<td>.61**</td>
<td>.71**</td>
<td>----</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>.53**</td>
<td>.42**</td>
<td>.53**</td>
<td>----</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-evaluation</td>
<td>.55**</td>
<td>.47**</td>
<td>.86**</td>
<td>.85**</td>
<td>----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy Bias</td>
<td>-.12</td>
<td>-.34**</td>
<td>-.45**</td>
<td>.37**</td>
<td>-.07</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td>Self-evaluation Bias</td>
<td>-.12</td>
<td>-.34**</td>
<td>-.45**</td>
<td>.37**</td>
<td>.35**</td>
<td>.84**</td>
<td>----</td>
</tr>
<tr>
<td>Mean</td>
<td>26.61</td>
<td>50.43</td>
<td>56.06</td>
<td>55.55</td>
<td>55.78</td>
<td>-0.51</td>
<td>-0.28</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>25.11</td>
<td>31.45</td>
<td>27.00</td>
<td>23.29</td>
<td>25.71</td>
<td>24.68</td>
<td>21.20</td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
<td>.75</td>
<td>.75</td>
<td>.72</td>
<td>.90</td>
<td>.86</td>
<td>.65</td>
<td>.67</td>
</tr>
</tbody>
</table>

Note. ** p < .01

Discussion

Using a social cognitive model of self-regulatory development, the present study explored whether cognitive modeling and social feedback would improve fifth grade students’ mathematics skills, self-efficacy, self-evaluation, and calibration (i.e., the accuracy of these judgments). The results revealed a significant main effect of cognitive modeling on each dependent measure, implying that cognitive modeling led to superior math performance, enhanced self-efficacy, self-evaluation, and metacognitive monitoring compared to the no-cognitive modeling conditions. These findings provide support for the first hypothesis, which postulated a main effect of cognitive modeling.

Although students begin learning fraction skills in fourth grade, most students experience difficulty in this area. This study shows that modeling of strategies and skills to solve fraction problems enhanced students’ learning and skill acquisition. In a prior study, Schunk (1981) found that cognitive modeling improved the arithmetic skills and self-efficacy of children with low
arithmetic achievement. The sample in this study was normal achieving students and the results show that modeling exerted a significant influence in their learning of fraction skills, which was evident from both practice and posttest mathematics scores. During emulative practice, there was also a main effect of cognitive modeling on practice math, and practice math scores correlated significantly with posttest math scores ($r = .71$), implying that observing a model significantly improved the effectiveness of practice at the emulative phase. Significant effects of cognitive modeling on posttest mathematics imply that a combination of observational and emulative effects enabled students to solve the problems, signifying that they achieved some success in the third level of self-control. Moreover, significant self-evaluation findings confirm that students in the cognitive modeling condition experienced positive self-reactions compared to those in the no-cognitive modeling condition.

The second objective was whether social feedback would improve math performance, self-efficacy, self-evaluation, and calibration judgments. MANCOVA results showed marginal significance at the $p < .10$ level. Follow-up ANCOVA analysis showed no main effect of social feedback; however, there were significant interaction effects on posttest math and both calibration measures, implying that a combination of cognitive modeling and social feedback improved fifth grade students’ mathematics performance and also their metacognitive monitoring. This is an important finding because research on elementary students’ metacognitive skills is lacking. This study shows that a training protocol was effective in improving these students’ mathematics performance and calibration judgments. Although practice time was short to acquire proficiency in the fraction skill, the results indicate that practice is essential in acquiring knowledge of core arithmetical concepts.

In this study, feedback focused on performance, and it was corrective and highlighted errors. Feedback is more effective for novice learners when it is explanatory and provides details on how to improve task performance rather than indicating the accuracy of the answer or highlighting errors (Shute, 2008). Nevertheless, significant interaction effects on the math posttest, self-efficacy bias, and self-evaluation bias suggest that a combination of cognitive modeling and social feedback contributed to better math performance and lower self-efficacy and self-evaluation bias. This latter finding was an interesting one as it suggests that there was no difference in students’ awareness of what they knew before solving the problem (i.e., self-efficacy bias) or after solving it (i.e., self-evaluation bias). It implies that students in the cognitive modeling condition were confident in their metacognitive skills from the beginning of the task to the end. Finally, this study adds to the body of research on the social cognitive model of sequential skill acquisition that learners can acquire new mathematical skills through observation, emulation, self-control, and self-regulation (Ramdass & Zimmerman, 2011; Zimmerman & Kitsantas, 1999: 2002).
Educational Implications

The implications of this study are manifold. First, it shows that fraction skills can be taught in fifth grade, which is a recommendation by NCTM (2000). Classroom efforts should be dedicated at mastery of mathematical skills and the focus should not be solely on students’ successful performance on standardized tests. Second, cognitive modeling of strategies, verbalizing, and explaining the steps in the solution process are critical for students’ comprehension of novel concepts. In addition, students need ample time to practice new math skills until they acquire proficiency. Third, feedback on students’ work is important in enabling them to learn what they did correctly and improve on their mistakes. This also facilitates metacognitive awareness, which is a key component of self-regulatory development. Fourth, math tasks varied in this study from easy to difficult. It is important to have a range of tasks so students can develop competency to master more difficult problems. According to NMAP (2008), in the United States, elementary textbooks have easier arithmetic problems more often than difficult problems, whereas the opposite occurs in countries with higher mathematics achievement, such as Singapore and Hong Kong.

Limitations and Future Research

Like all research studies the present results should be interpreted with caution. First, students were tested individually and therefore, the findings may not be transferable to classroom settings. Future studies to test this model should be conducted with groups of students in classroom to determine how to promote self-regulated learning in actual classrooms.

Second, one weakness of this study is the type of feedback students’ received. Students received corrective feedback if their responses were correct. However, if it was incorrect, the researcher highlighted the errors without any further information. As a result, feedback exerted a weak effect on students’ math performance, and self-judgments. From a self-regulatory perspective, more elaborate feedback would enable students to learn how to correct their errors, which is important for skill development and metacognitive monitoring.

It is not clear how students develop internal feedback at the third level. The results seem to suggest that students in the cognitive modeling condition generated internal feedback, which enabled successful performance in the posttest phase. Instead of giving students feedback, it would be better to discover how students adjust their performance to the standards they derive from the modeled experiences. This type of feedback would be critical to success for transfer tasks, which should be explored in future studies. One may speculate that self-regulatory competency in a specific task would facilitate transfer of skills in solving a novel set of problems.
Conclusion

In conclusion, this study supports the social cognitive perspective of self-regulation that learning novel mathematics skills requires social guidance initially until students develop proficiency and self-efficacy in their capability. During observation, exposure to a model before practicing is critical for skill development and feedback is important during practice as it conveys important information that allows learners to gauge their skill development and monitoring their work.

References


Ramdass, D., & Zimmerman, B. J. (2008). Effects of self-correction strategy training on middle school students’ self-efficacy, self-evaluation, and


Appendix

Examples of Fraction Problems

1. From a 9 4/48 gallon container of milk, Sara used 6 11/12 gallons to make a cake. How much milk remained?
2. From 8/17 yard length of cloth, 37/85 yard was cut. How much yard remained?
3. In a math test, the three top students finished in 9 3/4 minutes, 9 5/6 minutes, and 9 7/9 minutes. How much minutes separated the first and third student?
4. A box had 72/81 pound of cookies. For breakfast, some children ate 60/72 pound of cookies. How much pound of cookies remained?

Acknowledgement

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A Motivational Analysis of Project Work in Singapore Using Self-Determination Theory

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Abstract
Our students today face a knowledge-based economy, which requires the ability to learn independently, to be innovative in using and synthesizing knowledge, and to adapt fast to the changing world. Project Work (PW) is introduced as one of the instructional models for a more student-centered approach of learning in Singapore. The purpose of this study was to examine the impact of project work (PW) and study the motivational processes of PW using a self-determination theory (SDT) framework. A total of 435 students from Normal Academic stream (NA) and Normal Technical stream (NT) were recruited from four secondary schools in Singapore. Students' perceptions of the values of PW, basic psychological needs, relative autonomy, enjoyment, and grades were measured across three time points. Results showed that students valued the PW experience. However, their enjoyment, needs, and relative autonomy decreased significantly in the 10 to 12 weeks of PW experience. Multiple regression analyses revealed that post-PW enjoyment negatively predicted PW grades, while psychological needs, relative autonomy and pre-PW enjoyment positively predicted post-PW enjoyment. After 6-month PW, post-PW enjoyment emerged as a stronger predictor than grades in predicting the perceived skills learned from PW. The study applies self-determination theory to the PW context and highlights the importance of facilitating the three psychological needs in the PW context to enhance students’ motivation and achievement in PW.

Keywords: Cooperative learning, groupwork, longitudinal study, psychological needs, self-determination theory.

Introduction
Our students today face a knowledge-based economy, which requires the ability to learn independently, to be innovative in using and synthesizing knowledge, and to adapt fast to the changing world. The educational focus needs to move away from teaching to learning where students have to be actively involved in the construction of knowledge (Liu, Wang, Koh, Tan, & Ee, 2007). This shift from the traditional teacher-centered approach to a more student-centered approach of learning has prompted many conceptual change in instructional models. One of the models proposed is project work (PW) or cooperative learning, where students work together in small groups on a project or a problem over a period of time that requires ideas and principles...
from different subject areas or disciplines (Goodrich, Hatch, Wiatrowski, & Unger, 1995). The proponents of PW suggest this approach enhances students’ intrinsic motivation towards the tasks. The purpose of this study was to examine the motivational processes involved in PW with a theoretical framework based on the Self-Determination Theory (SDT) and using a Singaporean sample.

The Ministry of Education (MOE) of Singapore has adopted the concept of ‘Thinking Schools, Learning Nation’ (TSLN) as its vision for educational reform (Goh, 1997). As part of the various strategies to promote innovative thinking and critical discussion in the classroom, the MOE made changes in its assessment procedures, moving away from traditional assessment methods towards alternative assessment. In the year 2000, PW was introduced in schools to improve standards of learning and achievement by fostering critical and creative thinking, self-directed inquiry, collaborative learning and communication skills (MOE, 1999).

There are three main academic streams in Singapore secondary schools: Express, Normal (Academic) and Normal (Technical). The Express stream is a four-year course leading to a Singapore-Cambridge General Certificate of Education Ordinary-Level (GCE-O Level) examination. The Normal stream is a four-year course leading to a Normal-Level exam, with the possibility of a fifth year to complete the GCE-O Level. The Normal Academic (NA) students take subjects similar to the Express students while the Normal Technical (NT) students take subjects that are more technical in nature, such as Design and Technology, and computer applications. Students are streamed based on their performance in the Primary School Leaving Examinations (PSLE).

PW is compulsory for all secondary schools and junior colleges in Singapore. PW is normally introduced at Secondary Two level (equivalent to Year 8 in the UK system or junior high schools in the US system) but the approaches vary from school to school. The variation is mainly due to the divergence in instructional framework, logistics and resources available. Most schools prefer an interdisciplinary approach to PW whereas some schools conduct PW within a subject. Curriculum time is allocated for the planning, implementation and assessment of the projects and lasts for at least 10 weeks (1 to 2 hours per week). Each school decides on its own theme for the PW and although the latter is considered as a non-examination subject, students are usually awarded a grade for their performance. However, at the junior college level, PW is a compulsory examination subject and a pre-requisite for admission to the local universities.

In a PW classroom, the students normally work in groups of four to six to select their own project idea, plan and execute their plan, and construct their own learning. The PW teachers’ role is to facilitate their students’ learning. Usually, the time frame and project deadlines are determined by the teacher. At the end of PW, students are expected to conduct an oral
presentation as a group, to showcase their final product, for example, an artefact, a report, a presentation or a performance (Liu et al., 2006). Table 1 shows an example of the time frame and project activity in a typical school.

<table>
<thead>
<tr>
<th>Week</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Orientation &amp; introduction to PW</td>
</tr>
<tr>
<td>Week 2</td>
<td>Teaching project work related skills (e.g., Good thinking habits, communication skills)</td>
</tr>
<tr>
<td></td>
<td>Organisation of groups</td>
</tr>
<tr>
<td></td>
<td>Group building</td>
</tr>
<tr>
<td>Week 3</td>
<td>Teaching project work related skills (e.g. Research skills and organisation, report writing)</td>
</tr>
<tr>
<td></td>
<td>Research for supporting materials</td>
</tr>
<tr>
<td></td>
<td>Consolidation of materials</td>
</tr>
<tr>
<td></td>
<td>Working out of draft for written report and IT component</td>
</tr>
<tr>
<td>Week 4 to 8</td>
<td>Teaching project work related skills (e.g. IT skills, oral presentation skills)</td>
</tr>
<tr>
<td></td>
<td>Individual and group work on project as allocated by group</td>
</tr>
<tr>
<td></td>
<td>Data collection and analysis</td>
</tr>
<tr>
<td></td>
<td>Keep research journal</td>
</tr>
<tr>
<td>Week 9</td>
<td>Work on IT presentation and final report</td>
</tr>
<tr>
<td>Week 10</td>
<td>Presentation of projects (IT presentation)</td>
</tr>
<tr>
<td></td>
<td>Marking of presentations and projects</td>
</tr>
</tbody>
</table>

A few studies have investigated the learning outcomes and students’ perceptions of PW in Singapore. Generally, studies on the effects of PW showed that it had a positive impact on students’ communication and teamwork (Tan, 2002), thinking and problem-solving skills (Chang & Chang, 2003), knowledge application and independent learning (Chua, 2004). A more recent study by Liu and her colleagues (Liu, Tan, Wang, Koh, & Ee, 2007) examined the impact of psychological needs based on the self-determination theory (SDT), on metacognition and enjoyment in a PW context. Specifically, they found that PW context is able to satisfy students’ basic psychological needs for relatedness and competence more than a conventional mathematics or science classroom environment. In addition, satisfaction of the three psychological needs is related to higher enjoyment and metacognition. However, most studies were cross-sectional and therefore the long term impact of PW is not known. Moreover, given the variations in PW delivery between schools, academic streams and gender, there is a need to take into consideration these independent variables in the analyses. This study aims to
explore further into the motivational processes of students in PW using the SDT framework.

**Self-Determination Theory**

The central tenet of SDT (Deci & Ryan, 1985; 1991) is that human beings have three innate psychological needs: competence, relatedness and autonomy. Competence is the need to feel that one is effective in performing the requisite actions. Relatedness refers to the need to feel that one is connected to others and a sense of belonging to a social group. Autonomy refers to the need to express one’s authentic self and to feel that self is the source of action. These three needs are assumed to be innate and universal to all humans. It is therefore expected that the processes that lead to intrinsically motivated behavior will be universal across gender, age, and culture. Although much of the SDT literature is based on North American and Western European studies, a recent study by Wang and his colleagues (Wang, Hagger, & Liu, 2009) comparing samples from Singapore and the Great Britain supports the validity of the ‘universality hypothesis’. If the three needs are satisfied, an individual’s motivation, growth and well-being will be enhanced. In contrast, if the three needs are not supported, motivation, growth and well-being will be diminished (Deci & Ryan, 2000). In other words, the satisfaction of these psychological needs will result in the formation of different motives, which can range from intrinsic to extrinsic.

Intrinsically motivated behaviors are evident when an individual chooses to engage in an activity for its own sake, whether for interest, pure enjoyment of the experience or for the opportunity to learn (Vallerand et al., 1992). Extrinsic motivation refers to situations in which individuals perform an activity as a means to an end. Within SDT, extrinsic motivation is defined as a multidimensional construct, according to different degrees of self-determination or behavioral regulations. Each of these regulations reflects a qualitatively different ‘reason’ for acting out the behavior chosen. There are four types of extrinsic motivation commonly studied in the classroom context (Vallerand et al., 1992). They are external regulation, introjected regulation, identified regulation, and integrated regulation.

External regulation represents the least self-determined kind of extrinsically motivated behaviors. Such behaviors are controlled by external means (interpersonally controlled), such as rewards or threats, and avoidance of punishment. For example, “I do PW because it is a compulsory component of the school curriculum”. Introjected regulation refers to behaviors performed out of guilt avoidance or to attain ego enhancement. It is characterised by feelings of internalised pressure, for example, “I do PW because I want to show the teacher that I am a good student”. Identified regulation includes behaviors that are acted out in accordance with one’s choice or values and are more self-determined. For example, “I do PW
because I want to learn something useful”. Integrated regulation is the most autonomous form of extrinsic motivation. It occurs when identifications have been assessed and integrated into the self. Researchers have suggested that full integration of a behavioral regulation is very unlikely to occur during childhood or adolescence (Deci & Ryan, 1985; Vallerand, 1997), therefore, we have excluded this regulation in the current study.

The different types of motivated behaviors mentioned above can be categorized along a self-determination continuum. From lower to higher levels of self-determination, they are external regulation, introjected regulation, identified regulation, and intrinsic regulation. An overall relative autonomy index (RAI) can be calculated by weighting each subscale to indicate the level of autonomy in the following way: external regulation (-2) + introjected regulation (-1) + identified regulation (+1) + intrinsic regulation (+2) (see Goudas, Biddle, & Fox, 1994). The final RAI measure serves as an indicator of a person’s overall motivational orientation with positive scores representing more autonomous regulation and negative scores representing more controlled regulation.

Research indicates that more self-determined motivation was found to be associated with more engagement (e.g., Connell & Wellborn, 1991), better performance (e.g., Grolnick, Ryan, & Deci, 1991; Miserandino, 1996; Pintrich & De Groot, 1990), greater conceptual learning and better memory, (e.g., Grolnick & Ryan, 1987; Grolnick et al., 1991), as well as more positive emotions in the classroom, more enjoyment of academic work and school (e.g., Ryan & Connell, 1989; Vallerand, Blais, & Brière, 1989).

Vallerand and Losier (1999) propose that social factors, such as the PW classroom climate, teachers’ expectations, success and failure, have a profound impact on individuals’ thoughts, feelings, and behaviors. The effects of these social factors on motivation are mediated by perceptions of competence, autonomy, and relatedness (Blanchard & Vallerand, 1996; Vallerand & Reid, 1984: Whitehead & Corbin, 1991). The extent to which social factors foster perceptions of these three psychological needs will result in different types of behavioral regulation or motivation, or varying degrees of self-determination. Subsequently, this will lead to different cognitive, affective and behavioral consequences. For example, Ryan and Connell (1989) found that different types of extrinsic motivation did indeed produce different experiences and outcomes. Specifically, they found that externally regulated students tended to show less interest, value and effort toward achievement, and they were more inclined to disown responsibility for negative outcomes. Students with introjected regulation were willing to expend more effort but they tended to be anxious and coped poorly with failures. In contrast, students with identified regulation had more positive coping styles. They were more willing to expend effort, and they reported more interest and enjoyment of school. Other studies reiterated the findings, demonstrating the motivational benefit of more self-autonomous behavioral regulations in the
classroom (Grolnick & Ryan, 1987; Ryan & Connell, 1989; Vallerand & Bissonnette, 1992). Specifically, more self-determined extrinsic motivation (with greater internalisation) was found to be associated with more engagement (Connell & Wellborn, 1991), better performance (Miserandino, 1996), and higher quality learning (Grolnick & Ryan, 1987).

In the PW context, Liu and her colleagues (Liu, Wang et al., 2007) found that students’ enjoyment and metacognition were enhanced by the satisfaction of the three needs through intrinsic regulation. In fact, many researchers have argued that project-based learning designs, because of their emphasis on student choice, collaborative learning, and authentic assessment are designed to maximize students’ orientation toward learning and mastery (e.g., Thomas, 2000). Likewise, others have posited that project tasks that incorporate features such as student choice, variety and challenge should promote students’ interest and perceived value (Blumenfeld et al., 1991). Studies looking at motivation in PW or project-based learning have generally provided support for this contention (e.g., Beneke, 2000; Blumenfeld et al., 1991; K. Liu & Chien, 1998; Wolk, 1994). Although the usefulness of PW is well endorsed, no study has tracked the perceived value of PW in line with the desired outcomes of PW in Singapore. The first purpose of the present study was to examine the perceived value of PW in terms of development of metacognition, communication skills, collaboration skills, and problem-solving skills across the time frame of PW period and six months after PW.

Secondly, this study sought to understand the underlying motivational processes in PW using the SDT framework, that is, how the context of PW promotes students’ interest, needs satisfaction and autonomous regulation. Thirdly, the study examined the predictors of PW grades and students’ interest. We included PW grade because this is the only objective outcome from the PW experience. Fourthly, the study examined whether PW grades and post-PW enjoyment predicted students’ perceived value in PW six-month after. The final purpose of the present study was to examine academic stream, gender or school effects in the study variables. The findings might assist PW teachers in Singapore in providing positive experiences for students to maximize their learning in PW. In addition, the findings could be used to guide future interventions in motivating students in PW. Based on the findings of the previous studies, this study attempted to answer the following research questions:

1. Do the students value PW in terms of development of metacognition, communication skills, collaboration skills, and problem-solving skills at pre-PW, post-PW period and after 6-month PW period?? Are there any academic stream, gender or school effects?
2. How do students’ self-reported enjoyment (outcome measure) changed from pre- to post-PW? Are there any academic stream, gender or school effects?
(3) How do students’ perceived needs satisfaction change from pre- to post-PW? Are there any academic stream, gender or school effects?
(4) How do students’ behavioral regulation change from pre- to post-PW? Are there any academic stream, gender or school effects?
(5) What are the significant predictors of the PW grades? Are there any academic stream, gender or school effects?
(6) What are the significant predictors of post-PW enjoyment score? Are there any academic stream, gender or school effects?
(7) Would PW grades or post-PW enjoyment predict students’ perceived value of PW in terms of development of metacognition, communication skills, collaboration skills, and problem-solving skills six months after PW? Are there any academic stream, gender or school effects?

**Method**

**Participants and Procedures**

A total of 435 students were recruited from four typical government funded co-educational secondary schools in Singapore (we used School A, B, C and D to represent the four schools). The sample consisted of Secondary Two students aged 12 to 14 years ($M = 13.29, SD = .94$). There were 259 males and 176 females. 295 students were from the NA academic stream and 140 students were from the NT academic stream.

The school principals granted consent for data to be collected in their schools. After which, the PW teachers in the 4 participating schools were contacted to design common PW tasks to be used by their students during the study based on a common theme of ‘adaptation’ before the beginning of the study (two months before start of PW). A package developed by the Ministry of Education was used as a resource pack for PW. As mentioned, a typical PW program usually lasts for 10 weeks followed by a scheduled presentation. The pre-survey was conducted at the initial stage of PW, that is, after the PW groups had been formed, this was around week 2 to 3. The post-survey was conducted immediately after the end of PW presentation week (which ranged from the 10th to 14th weeks). After 6-month PW, we administered the post 6-month surveys.

Administration of the questionnaires took place in quiet classroom conditions under the supervision of a researcher. Students were told that there were no right or wrong answers, assured of the confidentiality of their responses, and encouraged to be honest and to ask questions if necessary. Normal informed consent and ethical procedures were followed and conformed to guidelines of the British Psychological Society.
Measures

The pre- and post-surveys contain all the measures listed below. The post 6-month survey only had items for metacognition and perceived skills learned from PW.

Basic Psychological Needs. We used the Basic Psychological Needs questionnaire from Liu, Wang et al. (2007) to measure the three needs. There were three items each for competence and relatedness. An example item for competence is ‘I think I am pretty good in PW’, and for relatedness, is ‘I feel close to my PW team-members’. There were 6 items for autonomy. An example item is ‘I am free to express my ideas and options in PW’. Answers for all the 12 items were given on a 7-point scale ranging from 1 (not true at all) to 7 (very true). Cronbach’s alphas for perceived competence ($\alpha = .72$ to .75), relatedness ($\alpha = .66$ to .72), and autonomy ($\alpha = .85$ to .88) for the present sample were satisfactory.

Enjoyment. We used the enjoyment subscale of the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989) to assess students’ enjoyment in PW. An example item is ‘When I do PW, I think about how much I enjoy it’. All the five items were measured on a 7-point scale ranging from 1 (not true at all) to 7 (very true). Internal consistency was satisfactory for the scale across two time point ($\alpha = .85$ to .87).

Behavioral Regulation. The Academic Self-Regulation Questionnaire (SRQ-A) developed by Ryan and Connell (1989) was used to assess four types of behavioral regulation in the project work context. The stem for all the items was ‘I take part in PW …’. Example items are “because I'll get into trouble if I don’t” (external regulation, four items), “because I'll feel bad about myself if I didn’t” (introjection, four items), “because it is important for me to do well in PW” (identification, three items), and “because PW is fun” (intrinsic regulation, three items). Answers for all the 14 items were given on a 7-point scale ranging from 1 (not at all true) to 7 (very true). Cronbach’s alphas for the pre- and post-surveys for external, introjected, identified, and intrinsic regulations were satisfactory (.73 to .75 for external, .61 to .74 for introjected, .74 to .80 for identified, and .80 to .83 for intrinsic). An overall relative autonomy index (RAI) was computed to indicate the level of relative autonomy.

Metacognition. There were seven items in the metacognitive strategies subscale of the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1993) to measure metacognitive strategies used in PW. One example item is ‘I always ask myself questions to understand the PW problem better’. Response was given on a 7-point scale anchored by (1)
‘Not at all true’ to (7) ‘Very true’. The scale was internally consistent (α ranged from .85 to .88).

**Perceived Skills Learned in PW.** Students’ perceived skills learned in PW were measured with a 15-item inventory (Liu, Wang et al., 2007), which was included in the pre- and post 6-month surveys. The stem for the inventory was ‘In doing PW, …’. The inventory included communication skills (e.g., ‘it teaches me negotiation skills in communication’, four items), collaborative skills (e.g., ‘I learn to share ideas and work with my peers’, five items), and problem-solving skills (e.g., ‘I develop research skills’, six items). Answers for all the items in the three scales were given on a 7-point scale ranging from 1 (not true at all) to 7 (very true). Cronbach’s alpha coefficients ranged between .78 to .82 for communication skills, .81 to .86 for collaboration skills, and .84 to .88 for problem-solving skills.

**PW grades.** At the end of the PW presentation, the students’ grades were collected from the PW teachers. Each student could receive a different grade from his/her peers since marks were awarded on the basis of a student’s contribution to the project task.

There was one school that failed to report the PW grades of the students and the post 6-month survey (School D). Therefore, the PW grades were only available for three schools.

**Data Analysis**

In the preliminary analyses, we computed the overall means, standard deviations and the zero-order correlations of the samples. In the primary analyses, we conducted two repeated-measures multivariate analysis of variance (MANOVA) to examine changes from pre- to post 6-month PW as well as the academic stream, gender, and school effects. The first MANOVA involved the PW skills (metacognition, communication, collaboration, and problem-solving skills) and the second MANOVA involved enjoyment, three psychological needs, and RAI. Follow-up ANOVAs were conducted if significant multivariate effects were found. We used post-hoc Tukey tests to determine the difference between schools. Next, we conducted hierarchical regressions to examine predictors of PW grades and post-PW enjoyment. Finally, a series of hierarchical regressions were conducted using PW grades and post-PW enjoyment as independent variables and metacognition and PW skills as dependent variables, while controlling for academic stream, gender and school effects.
Results

Values of PW in Developing Skills

Table 2 shows the means and standard deviations, and intercorrelations of the students’ perception of the value of PW in terms of the development of metacognition, communication, collaboration, and problem-solving skills. Table 3 presents the descriptive statistics and intercorrelations of the main study variables in pre- and post-PW.

Two repeated-measures Multivariate Analysis of Variance (MANOVA) were conducted to examine whether stream, gender and school effects were evident. The first MANOVA dealt with the value of PW. The results showed that there were no significant differences between the students perceptions of the value of PW in terms of development of metacognition, communication, collaboration, and problem-solving skills from pre- to post 6-month PW, Pillai’s Trace = 0.069, $F(8, 206) = 1.90$, $p = .06$, $\eta^2 = .07$. However, there were significant school effects [Pillai’s Trace = 0.075, $F(8, 422) = 2.07$, $p < .05$, $\eta^2 = .04$. No gender or stream effects or interaction effects were found. Follow-up ANOVA showed that one particular school (School C) reported significantly higher scores in all the four PW skills compared to other schools.

Self-Determination Theory Constructs

The results of the second repeated MANOVA showed that there were significant multivariate effects from pre- to post-PW in terms of the key study variables, Pillai’s Trace = .215, $F(5, 305) = 16.71$, $p < .01$, $\eta^2 = .22$. The interaction effects between time and academic stream and between time and school were significant (see Tables 4 and 5). The follow-up ANOVAs showed that enjoyment, competence, relatedness, and RAI decreased significantly from pre- to post-PW (all $p$s < .01). The change in autonomy was not significant. An analysis of the time by stream effect found that the decrease in enjoyment and RAI among the NT academic stream was steeper compared to the NA academic stream. In terms of autonomy, the NA academic stream reported higher autonomy at post-PW while the NT academic stream reported a decrease in autonomy at post-PW. In terms of time by school interaction effect, we found that School B was the only school that reported an increase in enjoyment and RAI at post-PW. The decrease in competence in School B was also among the least compared to all other three schools (see Table 5).
Table 2

Students’ Perception of the Values of PW

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Metacognition (Pre)</td>
<td>4.45</td>
<td>1.01</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>2. Metacognition (Post)</td>
<td>4.38</td>
<td>1.02</td>
<td>.48</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3. Metacognition (Followup)</td>
<td>4.61</td>
<td>1.32</td>
<td>.44</td>
<td>.46</td>
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<td></td>
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<tr>
<td>4. Communication (Pre)</td>
<td>4.33</td>
<td>1.06</td>
<td>.70</td>
<td>.38</td>
<td>.43</td>
<td>1.00</td>
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<tr>
<td>5. Communication (Post)</td>
<td>4.41</td>
<td>1.07</td>
<td>.35</td>
<td>.74</td>
<td>.39</td>
<td>.34</td>
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<td>6. Communication (Followup)</td>
<td>4.53</td>
<td>1.26</td>
<td>.44</td>
<td>.48</td>
<td>.84</td>
<td>.44</td>
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<td>1.00</td>
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<tr>
<td>7. Collaboration (Pre)</td>
<td>4.51</td>
<td>1.08</td>
<td>.67</td>
<td>.43</td>
<td>.39</td>
<td>.78</td>
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<td>.43</td>
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<tr>
<td>8. Collaboration (Post)</td>
<td>4.52</td>
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<td>.39</td>
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<td>9. Collaboration (Followup)</td>
<td>4.64</td>
<td>1.22</td>
<td>.43</td>
<td>.46</td>
<td>.81</td>
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<td>.50</td>
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<tr>
<td>10. Problem-Solving (Pre)</td>
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<tr>
<td>11. Problem-Solving (Post)</td>
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<td>.80</td>
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<tr>
<td>12. Problem-Solving (Followup)</td>
<td>4.52</td>
<td>1.22</td>
<td>.45</td>
<td>.47</td>
<td>.85</td>
<td>.44</td>
<td>.41</td>
<td>.91</td>
<td>.42</td>
<td>.41</td>
<td>.89</td>
<td>.34</td>
<td>.44</td>
</tr>
</tbody>
</table>

Note. **p < .01. M = 6 month**

Table 3

Means, Standard Deviations, and Intercorrelations of Major Study Variables

| Variables                  | Mean | SD  | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|---------------------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1. Competence (Pre-PW)    | 4.07 | 1.19 | 1.00 |
| 2. Competence (Post-PW)   | 3.69 | 1.20 | .21  | 1.00 |
| 3. Autonomy (Pre-PW)      | 3.94 | 1.22 | .24  | .31  | 1.00 |
| 4. Autonomy (Post-PW)     | 4.02 | 1.17 | .21  | .63  | .45  | 1.00 |
| 5. Relatedness (Pre-PW)   | 5.04 | 1.33 | .17  | .19  | .25  | .16  | 1.00 |
| 6. Relatedness (Post-PW)  | 4.64 | 1.32 | .10  | .26  | .20  | .40  | .39  | 1.00 |
| 7. RAI (Pre-PW)           | 1.61 | 5.33 | .30  | .46  | .61  | .38  | .25  | .17  | 1.00 |
| 8. RAI (Post-PW)          | .69  | 5.05 | .16  | .79  | .31  | .69  | .14  | .34  | .50  | 1.00 |
| 9. Enjoyment (Pre-PW)     | 3.88 | 1.44 | .17  | .24  | .32  | .22  | .15  | .10  | .62  | .33  | 1.00 |
| 10. Enjoyment (Post-PW)   | 3.70 | 1.38 | .14  | .56  | .24  | .44  | .14  | .28  | .40  | .64  | .51  | 1.00 |
| 11. Grade                 | 3.65 | 1.11 | .04  | .12  | .08  | .09  | .03  | .11  | .13  | .06  | .10  | .13  |

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Table 4
Descriptive Statistics of Enjoyment, Psychological Needs, and RAI by Gender and Academic Stream

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Post-PW</th>
<th>SD</th>
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Table 5
Descriptive Statistics of Enjoyment, Psychological Needs, and RAI by School

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In sum, all the students tended to agree that PW helped them in developing metacognition, communication, collaboration, and problem-solving skills (all scores were above the mid-point of the scales). This was consistent throughout the PW experience. The results were consistent for the two genders and two academic streams. Only one school (School A) reported
significant higher scores in metacognition and PW skills, compared to the other schools.

Regardless of gender or academic stream, students reported lower satisfaction of the needs for competence and relatedness, relative autonomy, and enjoyment in their 10 to 12 weeks of PW experiences. One school (School B) managed to increase the students’ enjoyment and RAI at post-PW and was able to minimise the drop in perceived competence, compared to the other three schools.

**Predictors of PW Grades**

A hierarchical regression was conducted to predict the overall PW grades. In the first step, all the pre-PW variables (basic need satisfaction, RAI, and enjoyment) were entered together with gender, academic stream and school. In the second step, all the post-PW variables were entered into the model. The first step of the analysis revealed that pre-PW enjoyment, gender, and school predicted PW grades ($F = 9.40, p < .01$). In the second step, post-PW enjoyment was a significant negative predictor of PW grades ($t (172) = -.332, p < .01 \beta = -.38$), after controlling for the effects of the pre-PW variables and demographic variables. The results showed that 36.5\% of the variance in PW grades was accounted for by the model. Girls tended to score higher grades in PW compared to boys. School B had significantly higher PW grades compared to Schools A and C.

**Predictors of Post-PW Enjoyment in PW**

The second hierarchical regression was conducted with post-enjoyment as the dependent variable. All the pre-PW variables (pre-PW enjoyment, basic need satisfaction, RAI) and demographic variables were entered together in the first step. In the second step, all the post-PW variables were entered into the model (need satisfaction and RAI). The first step of the analysis found that pre-PW enjoyment predicted post-PW enjoyment, and that there were stream and school effects. The second step revealed that the three needs satisfaction (competence, autonomy, and relatedness), as well as RAI, positively predicted post-PW enjoyment ($F = 73.39, p < .01$). A total of 72.8\% of the variance in post-enjoyment was accounted for by the model.

**Predictors of PW Skills 6-Month After PW**

We conducted four hierarchical regressions to predict perceptions of the values of PW 6-month after (metacognition, communication, collaboration, and problem-solving) using PW grades and post-PW enjoyment. We entered gender, stream and school in the first step, PW grade was
entered in the second step and post-PW enjoyment in the third step. Table 6 shows the results of the regressions.

The value of PW in developing metacognition after a 6-month completion of the PW experience was significantly predicted by post-PW enjoyment. The model explained 25.3% of the variance in metacognition. There was significant school effect ($t = -4.40, p < .01$). Communication skills after 6-month PW was positively predicted by post-PW enjoyment, PW grades and school, with an overall model explaining 27.0% of the variance in development of communication skills. Post-PW enjoyment, grades and school were all significant predictors of the development of collaborative skills six months after PW. The model explained a total of 27.7% in collaborative skills. Problem-solving was also predicted by post-PW enjoyment, grades, and school. The model explained 24.5% of the variance of developing this skill.

Table 6
Hierarchical Regression Analysis Examining Effects of Grades and Post Enjoyment on Values of PW 6-Month After (Standardized Coefficients)

<table>
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<tr>
<th>Metacognition</th>
<th>Communication</th>
<th>Collaboration</th>
<th>Problem-Solving</th>
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<td>.465**</td>
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Note. *p < .05, **p < .01

Additional Analyses

We conducted a series of exploratory regressions to test all potential two-way interactions among gender, academic stream and school, for the predictions of PW grades and post-PW enjoyment and PW skills. The results showed that none of the two-way interactions were significant.
Discussion

The Ministry of Education of Singapore is fully committed to PW in all schools. Currently, PW has been implemented in all primary and secondary schools at least at one level. PW is an integrated learning experience that aims to improve students’ communication skills, collaborative skills, metacognition, problem-solving skills, self-directed inquiry and life-long learning skills. However, a pedagogical approach will not automatically lead to the desired outcomes. There is a need to understand the underlying mechanisms underpinning the motivational processes and experience of students in PW. The purpose of this study was to examine the impact of PW and to study the motivational processes of PW using a SDT framework.

Has PW succeeded or failed in the Singapore context? The first research question may shed light on this. The results of this study found that students perceived PW to be useful in terms of development of metacognition, communication skills, collaboration and problem-solving skills. The responses were consistently above 4.20 (on a 7-point scale) at pre-, post-, and after 6-month PW period. This is great news for the Singapore Ministry of Education which has been doing more than any other country to advance 21st Century Skills through PW and technology (ICT; Borja, 2004). These findings add to the current literature (e.g., Chang & Chang, 2003; Liu, Tan et al., 2007; Liu, Wang et al., 2007; Tan, 2002) in that PW has a positive long term effect on students’ perceptions. Singaporean students do recognize the value of PW in developing metacognition skills and other lifeskills, even after 6-month PW. In fact, all the mean scores at after 6-month PW were much higher than the scores before- and after-PW. This is consistent across gender and academic stream. One exception is School C, which reported significantly higher scores in all four skills compared to other schools. School C was over-represented by NA academic stream students (112 NA students vs. 31 NT students) and this may have had an influence on the scores.

According to SDT, enjoyment in the target task is a form of intrinsic motivation (Deci & Ryan, 1985) and may lead to greater conceptual learning (Grolnick & Ryan, 1987) and more engagement (Connell & Wellborn, 1991). It is thus an important variable in motivation. The results of the present study over the two time points showed that the students reported a decrease in enjoyment level from pre-PW to post-PW. The students in the NT academic stream reported a steeper decrease in post-PW enjoyment compared to the NA students. In terms of school effects, one school reported an increase in post-PW enjoyment. The findings suggest that the PW experience of the students could be improved. Bearing in mind that enjoyment is an indicator of intrinsically motivated behaviors (Csikszentmihalyi & Nakamura, 1989; Deci & Ryan, 1985; Harter, 1978), it is important for students to gain interest and enjoyment in their first encounter with PW. Instead of increasing students’ enjoyment in PW, the 10 to 12 weeks of PW experience had a
negative impact on students’ enjoyment. It is thus imperative to examine the causes of this phenomenon.

According to the motivational sequence proposed by Vallerand and Losier (1999), the three psychological needs are important mediators of motivational regulations and enjoyment. Liu and her colleagues (Liu, Tan et al., 2007) revealed that perceived satisfaction of the three psychological needs positively predicted more autonomous regulation towards PW, which in turn positively predicted enjoyment and metacognition. A total of 87.9% of the variance in enjoyment and 36.2% of the variance in metacognition were accounted for by their model. The finding supports the SDT’s overarching proposition (Deci & Ryan, 2000). The present study extended the literature by examining the changes in the needs satisfaction over the two time points of PW experience. The results suggest that there were significant decreases in competence and relatedness from pre- to post-PW. For autonomy, there was an increase from pre- to post-PW in one school but not in the other three schools. In the light of these results, it seems that the PW context may satisfy students’ needs for autonomy, if implemented in an appropriate manner.

Within SDT, there is a sub-theory named Cognitive Evaluation Theory (CET) which states that any event that promotes autonomy and perceived competence will enhance intrinsic motivation (Deci & Ryan, 1985). In the PW context, although students may have a sense of autonomy, the increase in autonomy may not compensate for the decrease in competence. Therefore, enjoyment for the task decreased.

Although advocates of cooperative learning suggest that group work should enhance teamwork or friendship, our results showed otherwise. Again, this could be due to the decrease in the students’ perceived competence over time and their lack of a sense of achievement that could have affected the friendship among the group members.

Interestingly, the findings of this study show that the decrease in competence and relatedness among students in PW across the two time points coincided with the decrease in RAI, regardless of gender, stream and school. According to the meta-analysis done by Deci, Koestner and Ryan (1999), which examined the effects of extrinsic rewards on intrinsic motivation, it was found that externally set deadlines, surveillance, evaluations, directives, and competition pressure undermined intrinsic motivation. What could possibly have happened is that, as the students worked through their PW tasks, the pressure of deadlines and evaluation might increase and this undermined their feeling of self-determination. For example, the lower ability students might start to feel that they were not competent enough to complete the tasks well.

According to CET, significant others’ behaviors can also impact upon the intrinsic motivation of individuals (Deci & Ryan, 1985, 1991; Vallerand & Losier, 1999). In a classroom context, the teacher is probably the most influential person in the environment. The ways teachers interact with
students in the classroom can either facilitate or undermine the intrinsic motivation of the students. Specifically, the teacher can either communicate with a controlling style, such as giving directives, exerting pressures, controlling the students’ behaviors, or interacting in an autonomy-supportive way that enhances students’ autonomy and choice. If the teachers focus mainly on meeting deadlines or communicate to the students in a controlling manner, this will thwart the needs of the students and lead to a decrease in intrinsic motivation. One recent study by Koh and her colleagues (Koh, Wang, Tan, Liu, & Ee, 2008) found that PW teachers were more concerned about the performance of the students, namely in terms of the quality of the project deliverables such as presentations and reports. The findings suggest that PW teachers need to create an autonomy-supportive classroom climate in which students feel respected and cared for, and have a sense of choice and competence. They need to model their concern for their students and encourage them to care for each other, especially within their project group.

The speculation that the pressure of evaluation caused the decrease in enjoyment was supported by the results. Post-PW enjoyment emerged as a negative predictor of PW grades and accounted for 36.5% of the variance in PW grades. This shows that as the students worked hard towards achieving higher grades, the focus might have shifted to extrinsic ego goals. This has been shown to undermine intrinsic motivation (Rawsthorne & Elliot, 1999).

What are the factors that would increase post-PW enjoyment? If the aims of PW are to foster long term learning, critical thinking, and self-directed inquiry, there is a need for PW to move beyond assessment and look into cultivating the intrinsic interest for PW. In accordance to the SDT framework, the results suggest that pre-PW enjoyment, the three psychological needs, and relative autonomy positively predicted post-PW enjoyment. These findings may offer some guidance for practice. For example, the teachers may arouse students’ interest by showcasing previous PW products and video clips of the PW processes. In addition, teachers may allow students to make decisions such as grouping and choice of PW tasks. Teachers should be more autonomy-supportive in PW and provide positive feedback. The benefits of promoting enjoyment in PW beyond the grades are evident after 6 months of their PW experience. The results showed that post-PW enjoyment positively predicted metacognition, communication, collaboration, and problem-solving skills, in addition to PW grades. In fact, post-PW enjoyment was a stronger predictor of the perceived values in PW, as compared to PW grades. This shows that the focus on providing a positive PW experience may reap more benefits than the focus on performance outcomes. Reviews in the achievement goal theory literature (Biddle, Wang, Kavussanu, & Spray, 2003) have revealed that mastery goals encourage students to learn and acquire more effective and creative problem-solving skills, while the focus on performance may encourage student to rely on
familiar knowledge and strategies. Therefore, it is important to focus on the process, rather than the product in PW.

In sum, this study adds to the literature in that SDT is applicable to the PW context. By using a sound theoretical framework, a deeper understanding of the underlying motivational process has been achieved. The theory has also provided directions for interventions and improvement to the PW process. Overall, the cooperative learning environment in PW may be ideal for the satisfaction of the three psychological needs. However, more needs to be done in order for this to be achieved in the current practice of PW in Singapore. Future research should focus on other social factors, such as group dynamics, school culture, motivational climates or classroom structure affecting the needs satisfaction and behavioral regulations in the PW context.

References


Acknowledgements

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How Lesson Study Develops Pre-service Teacher’ Instructional Design Competency?

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Abstract
This paper aims to examine how Lesson Study of an initial teacher education course develops the instructional design competency of pre-service teachers in Hong Kong. Lesson Study is a collaborative action research approach for developing teacher professional competency. This study assesses the effectiveness of the Lesson Study course conducted in a teacher education institute that based on a quasi-experimental design. There were 341 pre-service teachers participated to a questionnaire survey. Confirmatory factor analysis and reliability test were used to confirm the constructed validity and reliability of the survey instrument. Canonical correlation was applied to explore the relationship between the approaches of their learning process and their learning outcomes. Results show that action research tutorials and collaborative practice are predictors of their instructional design skills and teaching competency. This paper discusses the critical success factors and the potential for using Lesson Study as a model to help pre-service teachers develop their teaching competency.

Keywords: Lesson Study, Instructional design, Pre-service Teacher Education

Introduction

Developing pre-service teachers’ teaching competency has always been regarded as a critical element of initial teacher education programmes. Darling-Hammond (2006) mentions that the core dilemma in initial teacher education is the gap between theory and practice. How to bridge the gap between theory and practice has been an eternal problem in teacher education and the subject of investigation by numerous scholars in the field (Stigler & Hiebert, 1999; Brouwer & Korthagen, 2005; McIntyre, 2005; Christianakis, 2010). Unsurprisingly therefore, existing empirical studies focus on using different approaches to bridge that gap. For example, using action research in an undergraduate teacher education programme (Smith & Sela, 2005; Zambo & Zambo, 2006); applying a lesson study approach in an elementary science methods course for pre-service teachers (Marble, 2006) These models were applied with the aim of bridging the gap and enhancing the teaching competency of pre-service teachers.

Recent literature reveals a growing interest in exploring the potential of lesson study, an action research-based approach of teacher development in which teachers work together collaboratively to plan and reflect on their teaching through lesson cycles, and which can be used as a pedagogical approach to bridging the gap in initial teaching education programmes (Marble, 2006; Fernandez & Robinson, 2006; Davies & Dunmill, 2008). Educators attempted to find out if this approach could better support the learning of pre-service teachers in terms of connecting theory and practice, and establish an inquiry lens for examining teaching. In Hong Kong, the practice of Lesson Study was applied into a Bachelor of
Education programme of a teacher education institution. The Lesson Study course aims to enhance pre-service teachers’ teaching competency by developing their instructional design skills. It provides a collaborative learning experience for pre-service teachers by a spiral learning activities including tutorials and try-out lessons. Pre-service teachers are expected to acquire the skills needed to implement Lesson Study as an action research method for improving teaching and learning by developing an understanding of how pupils learn and at the same time developing their own instructional design skills. With the purpose of providing teacher educators’ insight into practical methods of promoting initial teacher education, this study explores the predictive effective of the action research tutorials and its collaborative practice on participants’ instructional design skills and teaching competency by a quasi-experimental design from the participants’ perspective. It is expected the course learning outcomes could be empirically identified and could also be predicted from the action research tutorials and collaborative practice.

Literature Review

Teacher development should be viewed as an ongoing lifelong learning process as teachers strive to learn how to teach (Cochran-Smith & Lytle, 1999). Darling-Hammond (2006) has identified some distinctive features of initial teacher education programmes which enable pre-service teachers to confront the problems and challenges involved in teaching practice. These features include providing extended reflective and clinical experiences which are carefully developed to support the ideas and practices presented in simultaneous, closely interwoven coursework; using case study methods, teacher research, performance assessments and portfolio evaluation to apply learning to real problems of practices; and engaging in inquiries or research concerning teaching in the programme. Most of these features are related to the idea of action research or the lesson study approach to teaching. The use of action research or lesson study in teacher preparation could create strategies for equipping teachers with an inquiry lens and enhancing their professional competency.

Action research is a form of self-reflective enquiry undertaken by participants in educational situations in order to improve the rationality and justice of their own educational practices, their understanding of these practices and the situations in which the practices are carried out (Kemmis, 1988). The study of involving teachers in collaborative action research into their own practices can be traced back to John Elliott’s (1976) research work. As part of the action research process, teachers are expected to learn cooperatively and become reflective practitioners (Schon, 1983) by practising theories postulated from others. Research shows that incorporating action research approaches into initial teacher education programmes could encourage critical reflection on their beliefs and conceptions about the role of teachers, teaching and learning, therefore educates reflective teachers to deal with the complexity of practice (Gore & Zeichner, 1991; Price, 2001; Cochran-Smith, 2004; Mills, 2007).
Action research helps pre-service teachers to improve their professional growth and teaching efficacy (Zambo & Zambo, 2006), and to develop skills of careful observation and reasoned analysis (Zeichner & Liston, 1987), but that adequate resources and supports need to be provided for the programme implementation. Some researchers felt that prospective teachers should be given appropriate support to undertake the research needed to acquire better learning skills to help them to develop an inquiry-oriented perspective on teaching (Clift, Veal, Johnson, & Holland, 1990; Cochran-Smith, 1991). Providing appropriate clinical support to pre-service teachers undertaking action research is an essential part of helping them to develop a perspective on teaching. Although action research has been shown to be effective as a means of enhancing teachers’ professional development, its focus on improving educational practices (Kemmis, 1988) has been criticised as vague. The emerging lesson study approach was influenced by the book The Teaching Gap written by James Stigler and James Hiebert (1999). Lesson Study has adopted the mechanism of action research, but has shifted the focus to student learning (Wiburg & Brown, 2007).

Lesson Study can be defined as action research conducted by teachers, in which they work collaboratively to reflect on their lessons and improve their teaching. Lesson Study has a long history in Japan (Yoshida, 1999; Watanabe, 2002) and spread rapidly throughout the United States following the publication of The Teaching Gap (Stigler & Hiebert, 1999). Stigler and Hiebert (1999) examined in great detail a large number of eighth-grade mathematics lessons in the U.S., Japan, and Germany. They found that in most Japanese lessons, teachers were better equipped to cater for students’ individual needs and to teach conceptual rather than procedural knowledge, compared to their U.S. counterparts. Their explanation for this difference was that while U.S. teachers work in isolation, all Japanese teachers have to engage in Lesson Study and meet regularly over a long period of time to work on one or more ‘research lessons’. Their findings sparked interest in Lesson Study among U.S. teachers, researchers and educational policymakers. The lesson study model in Japan essentially consists of four steps: Plan-Do-Check-Action (PDCA) (Sarkar & Matoba, 2005), whereas in the United States it developed as a design-based action research cycle which works on repeated ‘cycles of design, enactment, analysis, and redesign’ of lesson study (Lewis et al, 2006). Recent years have seen a steady growth in lesson studies outside the United States in places such as Hong Kong, Singapore, Sweden, and Iran (Lewis, 2002; Fernandez, 2002; Lo, et al., 2005). More recently, some researchers have been interested in assessing the feasibility and effectiveness of introducing the lesson study approach in initial teacher education. Marble (2006) applies the lesson study approach to develop a critical lens through which pre-service teachers can view their practice. He reports that lesson study encourages practitioners to take a reflective and engaged approach to teaching, focus on student success in their classrooms and create knowledge for teaching.
Research Questions

Lesson Study course appears to conceptualise an effective way of enhancing pre-service teachers’ instructional design and teaching competency by helping them to gain clinical experience through a process that requires them to inquire, diagnose, observe and evaluate learning and teaching. How effective are the learning activities in achieving the learning outcomes? The effectiveness of the course can be evaluated by considering the following research question: What are the participants’ perceptions of the theory based tutorial and collaborative practices on their instructional design and teaching competency in the Lesson Study course?

Method

Lesson Study Course

A teacher education institute in Hong Kong has offered the Lesson Study course to all Year 2 study of the BEd programmes. During the Lesson Study course, pre-service teachers were taught the theories and practice of Lesson Study in tutorials, and then worked collaboratively together in small subject groups to implement the Lesson Study project. The tutors plan the lesson with the participants throughout the process and give them guidance. Clinical supports were provided for the participants in the tutorial to select learning objective, formulate pre-test and post-test papers, analyse data from test papers, formulate lesson plans, conduct micro-teaching and evaluate lesson effectiveness.

Learning Process

They have to take part in the Lesson Study groups, contributing to the planning and evaluation of the research lesson, as needed to implement the two research lessons. Each group works on the design of a lesson period and the teaching practicum takes the form of two cycles of teaching in schools conducted by two students chosen from their own groups. There are two rounds of teaching in each group. The lessons are observed by the group members, video-taped by their peer and taken back to the tutors for detailed analysis. They then continue with their study and complete the next cycle. They have chance to discuss issues relating to the design of their lesson plan and the effectiveness of their research lesson implementation. Obviously, action research approached tutorial and collaborative practices are the main feature of their learning process in the Lesson Study Course. Collaborative practices are deliberatively embedded in to the PIE tutorials. Through this collaborative practice the pre-service teacher are provided an opportunity to share their knowledge, to learn from the others and product collective lesson planning and practices that enhance students learning.
Learning Outcomes

Pre-service teacher of the Lesson Study course are expected to gain knowledge of instructional design experience. This study adopts ADDIE instructional design model to conceptualize instructional design as a multiple competencies that involves analysis, design, development, implementation, and evaluation of a lesson (Molenda, 2003; Strickland, 2006). The acronym ADDIE stands for the 5 phases contained in the model. These five phases are compatible with the delivery of the tutorials and the PIE of the Lesson Study course. Pre-service teachers’ learning on instructional design is conceptualized by the knowledge and experiences they come across in the 5 phases of ADDIE model including analysis, design, development, implementation and evaluation. The learning outcomes include know how to analyse learner characteristics and task to be learned and identify learner entry skills; to design learning objectives and choose an instructional approach; to develop instructional or training materials; implement the lesson and deliver the instructional materials; and to evaluate the lesson plan and recommend the materials achieved the desired goals. The teaching experience that they had gained include determining the current state and needs of the learner, defining the end goal of instruction, and creating some instructional and learning strategies to facilitate teaching and learning. The learning outcomes in the Lesson Study are conceptualized lesson planning and teaching experience for instructional design of a research lesson.

Research Design

The study explores the relationship between the learning processes and the learning outcomes of the Lesson Study course. A quasi-experimental research design was used in this study to evaluate the effectiveness of the Lesson Study course and to determine the relationship between their learning process and learning outcomes. The theoretical framework of the study is shown in Figure 1. The independent variables were the PIE tutorial and collaborative practice. The dependent variables were instructional design skills and teaching competency. A self-response quantitative questionnaire survey was prepared in order to obtain feedback from the all the students on the Lesson Study course. There were 341 pre-service teachers responded to the survey. Data was collected directly from them by means of the questionnaire.

The Instrument

The questionnaire was based on four scales that were constructed to measure the variables. In order to develop valid items for these scales, the researcher conducted a content analysis of the Lesson Study course outlines. The learning process and the learning outcomes of the course were then converted into statements for use in the questionnaire. The data was collected directly from the participants by means of the questionnaire.
The questionnaire contained 16 questions which were used to measure the independent and dependent variables (see Table 1). Participants were asked to answer questions on the effectiveness of the learning process and their learning outcomes from the Lesson Study course. Likert six-point scales were used in both sections to measure the variables. Likert scales are commonly used in attitudinal research. The Likert scale assumes that the difference between answering ‘agree strongly’ and ‘agree’ is the same as between answering ‘agree’ and ‘neither agree nor disagree’ (Likert, 1932).

Data Analysis

Exploratory factor analysis was done separately for the two sets of variables by principal factor axis analysis to confirm the constructed validity the instruments (see table 1). The study is interest in a theoretical solution uncontaminated by unique and error variability and it is designed with a framework on the basis of underlying constructs that are expected to produce sources on the observed variables. Principal axis factor (PAF) analysis, which aims to reveal the underlying factors which produce the correlation or correlation among a set of indicators with the assumption of an implicit underlying factor model, was applied to the items from the learning processes and learning outcomes separately. Promax rotation, a method of oblique rotation which assumes the resulting factors are correlated with one other, was applied to extract the factors. An eigenvalue greater than one was used to determine the appropriate number of factors for the factor solutions.

Canonical correlation analysis was applied to explore the correlation among a two sets of variables in the experimental context and analyse the latent variables that represent the two sets of variables. This study is interest in exploring how the planning-implementation-evaluation (PIE) tutorials and collaborative practice related to the instructional design skills and teaching competency. Canonical correlation coefficient that measures the strength of association between learning process and learning outcomes and the canonical variants that weight the sum of the variables in the analysis will be identified.

Findings

The results of exploratory factor analysis, presented in Table 1, clearly suggest two two-factor structures for both independent and dependent variables that are both empirically feasible and theoretically acceptable. An eigenvalue greater than one was used to determine the appropriate number of factors for the factor analysis solution. Items were extracted with factor loadings greater than 0.624 across and within factors. The numbers of factor solutions extracted from a Promax rotation afforded the most meaningful interpretation theoretically. The process employed to identify and to label the factors that emerged was based on examining the derivation of the highest loading items on each of the factors. The reliability coefficients of the scales ranged from 0.850-0.922, which was
judged adequate for this study. The result of the factor analysis and reliability shows that the theoretical concepts of instructional design, teaching competency, PIE tutorial and collaborative practice are empirically constructed with constructed validity and reliability. The results of descriptive statistic show that the scale means of all the variables are higher than 4.7 within the 6 point-scale, this reflects that the participants tend to agree with all the items. The results of the canonical correlation analysis are presented in Table 2 and Figure 1. Two pairs of canonical variates were constructed. 49.547% variance was extracted from the set of learning process variables and 81.970% variance was extracted from its set of learning outcome variables (see table 2). The canonical correlation (\(\rho\)) between the learning process and outcome is 0.801. These results reflect that both the learning process PIE tutorials and collaborative practices contribute significantly to the learning outcomes that include instructional design and teaching competency.

Table 1

Results of the Exploratory Factor Analysis and Reliability Test

<table>
<thead>
<tr>
<th>No of items</th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>0.919</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>0.882</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>0.840</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>0.780</td>
<td></td>
</tr>
<tr>
<td>Q5</td>
<td></td>
<td>0.882</td>
</tr>
<tr>
<td>Q6</td>
<td></td>
<td>0.858</td>
</tr>
<tr>
<td>Q7</td>
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<td>0.832</td>
</tr>
<tr>
<td>Q8</td>
<td></td>
<td>0.742</td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>5.077</td>
<td>1.308</td>
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<tr>
<td>Variance</td>
<td>63.409</td>
<td>16.344</td>
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<tr>
<td>Cronbach a</td>
<td>0.922</td>
<td>0.906</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>4.765</td>
<td>4.748</td>
</tr>
<tr>
<td>SD</td>
<td>0.73</td>
<td>0.73</td>
</tr>
<tr>
<td>No of items</td>
<td>Factor 3</td>
<td>Factor 4</td>
</tr>
<tr>
<td>Q13</td>
<td>0.849</td>
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<tr>
<td>Q14</td>
<td>0.807</td>
<td></td>
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<tr>
<td>Q15</td>
<td>0.792</td>
<td></td>
</tr>
<tr>
<td>Q16</td>
<td>0.683</td>
<td></td>
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<tr>
<td>Q9</td>
<td></td>
<td>0.825</td>
</tr>
<tr>
<td>Q10</td>
<td></td>
<td>0.803</td>
</tr>
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</table>
Cont. Table 1

<table>
<thead>
<tr>
<th>Q11</th>
<th>0.751</th>
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<tbody>
<tr>
<td>Q12</td>
<td>0.624</td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>4.725</td>
</tr>
<tr>
<td>Variance</td>
<td>59.063</td>
</tr>
<tr>
<td>Cronbach α</td>
<td>0.884</td>
</tr>
<tr>
<td>Coefficient</td>
<td>0.850</td>
</tr>
<tr>
<td>M</td>
<td>4.785</td>
</tr>
<tr>
<td>SD</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Table 2

**Result of Canonical Correlation**

<table>
<thead>
<tr>
<th>Canonical Variable χ</th>
<th>Canonical Variable η</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIE Tutorials</td>
<td>0.769</td>
</tr>
<tr>
<td>Collaborative Practice</td>
<td>0.330</td>
</tr>
<tr>
<td>Lesson Planning</td>
<td>0.929</td>
</tr>
<tr>
<td>Teaching Experience</td>
<td>0.881</td>
</tr>
<tr>
<td>Variance</td>
<td>49.547%</td>
</tr>
<tr>
<td>Canonical Correlation</td>
<td>ρ = 0.801</td>
</tr>
<tr>
<td></td>
<td>(ρ² = 0.641)</td>
</tr>
<tr>
<td></td>
<td>81.970%</td>
</tr>
</tbody>
</table>

![Path Diagram](image)

**Figure 1. Path Diagram for Canonical Correlation Analysis**

**Discussion**

In answering the research question “what are the participants’ perceptions of the theory based tutorial and collaborative practices on their instructional design and teaching competency in the Lesson Study course?” The scale means of all the four variables are greater than 4.7, these results reflect that the participants have a positive perception to the learning process and outcomes. They tend to agree that the Lesson Study course has an effect in terms of helping them develop their instructional design and teaching competency effectively through delivery of the PIE tutorials and
try out the lesson collaboratively. This claim is further supported by the canonical correlation analysis, at which the latent variables of learning process and learning outcomes of the Lesson Study course are empirically constructed and there exists a significant relationships (0.801) between them (see Figure 1). Pre-service teachers’ instructional design skills and teaching competency could be enhanced by the PIE tutorials and collaborative practice. These findings are consisted with those of studies on action research conducted by Price, (2001), Cochran-Smith, (2004), Zambo and Zambo, (2006) and Mills, (2007), as well as studies on Lesson Study by Marble (2006), which indicate that action research or a Lesson Study approach can improve the learning of pre-service teachers. It is interesting to explore how PIE tutorials and collaborative practice contributes to their instructional design skills and teaching competency.

**PIE Tutorials**

The Planning-Implementation-Evaluation tutorials are the main and critical learning activities of the Lesson Study course that help participants master the skills required for instructional design and improve their teaching competency. A systematic process of inquiry which involves planning, implementation and evaluating a research lesson is central to tutorials of the Lesson Study course. The process of ADDIE instructional design model is embedded in the PIE tutorials which provide opportunities for participants not only to learn the concepts of instructional design, but also to gain clinical experience through data analysis and teaching. The PIE tutorials touches on a variety of professional habits and intellectual activities that meet pre-service teachers’ learning opportunity for collaboration, reflection, and observation of teaching within the context of specific classroom and student needs, helping to nurture the teaching competency of the participants.

The planning stage includes the process of choosing the topic, defining the learning objectives. The steps involve collecting teachers’ and students’ conceptual understanding toward the learning objectives. The ideas obtained will help the pre-service teachers identify the learner needs for instructional designing. The planning stage of the Lesson Study course allows participants to select suitable approaches and teaching strategies for lesson planning. It is similar to the function of the analysis, design, development phases of the ADDIE instructional design model.

After the planning stage, the research lesson is then co-taught by two pre-service teachers in same group, and their teaching will be observed by peers in the same group. The lesson is videotaped for detailed analysis later. A post-lesson conference is conducted right after the lesson. They could reflect on the lesson itself and share their views and give suggestions on how to improve the lesson. Then another two pre-service teachers co-teach the revised lesson to another class. Again the lesson will be video-taped and thoroughly discussed and the plan revised. This process is repeated until all the pre-service teachers have taught the lesson to their
respective classes. The lesson implementation for the research lesson is central to the work of Lesson Study: it takes learning beyond talk about practice and into the realm of learning by doing. Engaging in the research lesson of Lesson study and then come together to share their opinion enable the group members to learn from one another’s inquiry. This also reflects that teaching practices make a difference. Teaching practices could provoke a higher order reflection of the teachers who implemented the lesson plan.

The evaluation stage, which involves powerful reflective practices of the teachers, occurs simultaneously with the implementation stage. Reflective evaluation on the research lesson is done throughout the process involving data triangulation among the test scores, student interview data and teaching enactment from the video clip. The teaching enactment is the analysis and interpretation obtained from the triangulation of the video records and the data from pre-lesson tests and post-lesson test. Participants are provided with the video record of the research lessons in the different cycles and the test scores that reflected student learning outcomes. By triangulating the way the teachers taught and the performance of the students, the teachers may come up with suggestions as to what can be done to further improve the lesson, revise the lesson design and implement it again. After completing the process of inquiry, the pre-service teachers are required to reflect on what they have learnt through the Lesson Study, and externalize personal knowledge in the presentations by codifying tacit knowledge to explicit knowledge (Nonaka & Takeuchi, 1995). Then, the whole experience is written up and a presentation prepared, including video clips of the research lessons. This PIE tutorial approach could definitely enhance the instructional design and teaching competency of pre-service teacher.

Collaborative Practice

Lesson Study offers the potential for pre-service teachers to intellectually engage what brought them into the learning through collaborative works. Pre-service teachers learn collaboratively with each other and they have equal status in knowledge sharing. They created a team to share a teaching topic, a set of problems on student learning difficulties and a passion about the topic, and deepen their knowledge and expertise in teaching. The collaborative practice did not merely support communications and interactions between teachers; it also transformed knowledge into tangible, sharable, durable and transferable resources. As a collective, participates create knowledge such as learning objectives and learning activities in the lesson plan and teaching aids. If the goal of learning is based on a growth and practice standpoint, assisting pre-service teachers to develop their teaching competence that enables them to improve their practice, then the interaction function of the collaborative practice is essential. Regarding the relationship between collaborative practice and learning, there is a need to link teacher learning with the practice of teaching. Lesson study supports the development of a
collaborative practice because of its connectedness to their social learning. If the collaborative practice is removed from the Lesson Study, their learning will be less effective.

As a collaborative action research, Lesson Study provides pre-service teachers with the opportunity to learn from evaluating what they have planned and done, by reflecting on the discrepancy between the intended and enacted learning objectives, as well as by examining the relationship between enacted learning objectives with what the students have actually learned. They had a successful experience in internalizing the theory via teaching practice. Through the lesson implementation, explicit knowledge is being internalized and become implicit knowledge and reconstructed through reflection and become personal knowledge (Kolb, 1984), in which, they teaching competency are enhanced.

Conclusion

This study presents findings on the evaluation of implementation of a Lesson Study course in initial teacher education at a teacher education institute in Hong Kong. It describes how PIE tutorials and collaborative practice for initial teacher training operates, and how this approach nurtures their instructional design skills and teaching competency. The Lesson Study course has provided pre-service teachers with the necessary professional development skills. Teacher competency can be enhanced by using Lesson Study to organise initial teacher programmes. This study provides suggestions on the use of collaborative action research approach as a guiding principle for conducting the Lesson Study course. If pre-service teachers are denied the opportunity for involvement in collaborative action research approach for tryout a lesson, the framework for organising their learning will only be of limited relevance. There is an innovative aspect to the study, given the limited use of the collaborative action research approach in initial teacher education, particularly in Hong Kong.

References


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