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Motivation and Learning in Mathematics Pre-service Teachers

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Table of Contents

Abstract

Based on a review of literature of conceptual and procedural knowledge in relation to intrinsic and extrinsic motivation, the purpose of this study was to test the relationship between conceptual and procedural knowledge and intrinsic and extrinsic motivation. Thirty-eight education students with a mathematics focus (elementary or secondary) in their junior, senior, or fifth year completed a survey with a Likert scale measuring their preference to learning (conceptual or procedural) and their motivation type (intrinsic or extrinsic). Findings showed that secondary mathematics focused students were more likely to prefer learning mathematics conceptually than elementary mathematics focused students. However, secondary and elementary mathematics focused students showed an equal preference for learning mathematics procedurally and sequentially. Elementary and secondary students reported similar intrinsic and extrinsic motivation. Extrinsically motivated students preferred procedural learning more than conceptual learning. While there was no statistically significant preference with intrinsically motivated students, there was a trend favoring preference of conceptual learning over procedural learning. These results tend to support the hypothesis that mathematics focused students who prefer conceptual learning are more intrinsically motivated, and mathematics focused students who prefer procedural learning are more extrinsically motivated.

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CHAPTER 1
INTRODUCTION

Students are motivated to learn for a variety of reasons. Some students are motivated to learn for its own sake, to gain knowledge and understanding, or to become competent, intelligent people with the skills to do a future job effectively. Others are motivated to learn in order to please their parents, to earn good grades in school, or to earn some other reward. Students also like to learn in a variety of ways. Some students like to learn step by step instructions or through procedures and directions. Other students like to understand the concepts behind the content, learn about similarities and differences between topics, discover concepts through their own inquiry and discussion, or reason and problem solve to find answers to questions.

As an education and mathematics major, I noticed that as classes became less relevant to teaching, mathematics education students seemed less motivated to learn the concepts and became more extrinsically motivated to simply pass the class. I found through my student teaching that many students asked, “Why do I need to know this?” which made me hypothesize that students want to know concepts and deeper meanings behind mathematical topics. On the other hand, many students I taught were also very focused on the grade they were receiving in their mathematics class, which would indicate that they were more extrinsically motivated in their mathematics class. At the college level, I noticed that when students had a higher level of vested interest in the mathematics course, for a variety of reasons, they were more intrinsically motivated to learn the details behind the concepts versus learning only the procedures.

These observations led me to this thesis, which explores the relationship between types of motivation and types of learner. Motivation type is defined as either intrinsic (self) or extrinsic (outside sources). Learner type is defined as conceptual learner (learning concepts and connections) and procedural learner (learning the skills). Knowing relationships exist among these variables with pre-service teachers at the University of Connecticut will help teacher educators better prepare future mathematics educators. Pre-service teachers who are intrinsically motivated may favor conceptual learning more than extrinsically motivated pre-service teachers. Since students asked, “Why do we need to know this?” future teachers should also understand the concepts behind the content, if they are going to be able to teach most effectively. For the pre-service teacher who is extrinsically motivated, teacher educators need to find a way to make concepts more meaningful and motivating.

CHAPTER 2
REVIEW OF LITERATURE

Introduction

This review of literature will explore the relationships among conceptual and procedural knowledge and intrinsic and extrinsic motivation. Conceptual and procedural knowledge will be defined, the relationship between the two will be discovered, as well as their relation to mathematics topics will be discussed. Intrinsic and extrinsic motivation will be defined and explored in relation to how they combine to form students' total motivation and how they relate to students in mathematics classroom settings. This review of literature will also investigate the relationships between the knowledge types as one element, with the motivation of students as another element. Studies that have previously addressed these topics will be cited and comparisons will be made in order to offer depth and clarity for the literature topics.

Conceptual and Procedural Knowledge

Defining conceptual and procedural knowledge. Rittle-Johnson, Siegler, and Alibali (2001) defined conceptual knowledge as "implicit or explicit understanding of the principles" (p. 1) that guides certain areas of learning and of the relationships between different topics of a similar area. This type of knowledge can be useful for various applications in mathematics, such as knowing why the quadratic formula works when solving for the roots of a polynomial equation or being able to give a non-example for an obtuse angle and being able to explain why it is a non-example. Berenson (1998) described conceptual knowledge as knowledge that conveys the significance of the ideas related to a given set of procedures; for instance, when students learn the scientific method, it is important they know why it is arranged in the order that it is. Kulm (1994) explained that conceptual learning cannot be based solely on definitions and examples. Rather, students should be capable of showing non-examples, of comparing concepts, of understanding why processes work, and of reasoning and problem solving.

Procedural knowledge is not as adaptable to other applications as conceptual knowledge. According to Rittle-Johnson et al. (2001), procedural knowledge consists of knowing the sequences of steps to solve a problem, such as when students follow the order of operations steps to solve arithmetic problems (parentheses, exponents, multiply/divide, and add/subtract, all starting from the left). Kulm (1994) stated that procedural knowledge is most often associated with skills.

Generally, conceptual knowledge is identifying why, whereas procedural knowledge is recognizing how. For example, a student might know how to solve a mathematics problem related to triangles using the Pythagorean Theorem, $a^2 + b^2 = c^2$, which means the student possesses procedural knowledge for this topic. If that same student knows why the Pythagorean Theorem works and can apply it to other areas of geometry to solve other problems, then this student also possesses conceptual knowledge related to this topic in mathematics. As this example showed, conceptual and procedural knowledge are interrelated, but there is some disagreement in the research on how the interrelationship works.

Studies of conceptual and procedural knowledge in mathematics. The following two studies both proposed that conceptual and procedural knowledge influence one another. In fact, the two iteratively relate. Rittle-Johnson and Alibali (1999) examined the relationship between conceptual and procedural knowledge in 60 fourth-grade students and 29 fifth-grade students' understanding of mathematical equivalence. More specifically, the study examined the iterative effect that conceptual and procedural learning have on one another. Rittle-Johnson et al. (2001) studied the relationship between procedural and conceptual knowledge in 74 fifth graders' understanding of decimal fractions and how to graph them on a number line. Before and after both studies, students were assessed on their conceptual and procedural knowledge to see if instruction in one or the other had reciprocal gains in both. Both studies involved conceptual knowledge assessments, such as questions related to identifying concepts and meanings. The participants also were given procedural knowledge assessments. In the equivalence study, they were asked to solve standard equivalence problems and transfer equivalence problems where the operation used (addition or multiplication) was changed or the position of the blank was moved. In the decimal fractions study, students were asked to mark decimal fractions on a number line.

In the equivalence study by Rittle-Johnson and Alibali (1999), a classroom screening asked children to solve two equivalence problems, so the researchers could identify the children who solved the problem correctly and those who did not prior to intervention. All students completed the conceptual assessments in the first experimental session. Later, the instruction treatment group received instruction about equivalence problems. The children in the instruction group were divided into two groups: conceptual-instruction and procedural-instruction. In the conceptual-instruction group, students were taught the principle related to the problems. Instruction took place by spoken word and appropriate gestures. Students were not instructed on the procedure for solving the problems and no solutions were given. The procedural-instruction group, on the other hand, was shown the problem, and the students were taught that “there is more than one way to solve these problems, but one way is [the grouping procedure]” (p. 7). Children were given a problem to solve, and then, with no feedback, instruction was repeated on only the grouping procedure, and the students were given another problem. A second experimental session occurred the same way. At the end of the study, all students, including a control group that had received no treatment instruction, were taught by both methods so they benefited from their participation.

In the decimal fraction study (Rittle-Johnson et al., 2001), students were given procedural and conceptual pretests. Individual intervention was given in the form of one of four types of instruction: conceptual knowledge relevant to the problem, procedural knowledge relevant to solving the problem, both, or neither. All participants were given procedural, conceptual, and transfer posttests. The transfer posttests assessed how well the students were able to use the knowledge gained from instruction for one type of problem by applying it to slightly varied problems.

In both studies, the researchers found that students in the instruction groups, whether it was conceptual, procedural, or both, showed improvements in their conceptual and procedural knowledge. In the equivalence study (Rittle-Johnson & Alibali, 1999), results showed that students solved a similar number of problems whether they were conceptually instructed or procedurally instructed. In the decimal study (Rittle-Johnson et al., 2001), the children learned correct procedures for solving number line problems as long as they were instructed in some form. Both studies found evidence that there is an iterative interconnection between procedural and conceptual knowledge. Children who received conceptual instruction produced several correct procedures for solving equivalence or decimal fraction problems, which in turn, increased their conceptual knowledge of the topic, as seen in transfer scores. Students who received procedural instruction learned a new procedural method and increased their conceptual understanding.

These two studies explored the iterative model approach with conceptual and procedural knowledge in two different mathematical concentrations. However, there are other views of the relationship between conceptual and procedural knowledge.

Development of conceptual and procedural knowledge. Researchers and theorists have not clearly resolved the question as to whether conceptual or procedural knowledge develops first. Some researchers have shown that in certain topics of mathematics, such as proportional reasoning and multidigit arithmetic, conceptual knowledge is learned before procedural; thus, these researchers have advocated teaching conceptual before procedural (e.g., Dixon & Moore, cited in Rittle-Johnson & Alibali, 1999; Hiebert & Wearne, cited in Rittle-Johnson & Alibali, 1999). Others have claimed, for mathematical topics like counting, that procedural is learned before conceptual since students learn the steps to a problem and then why the procedure works (e.g., Wynn, cited in Rittle-Johnson & Alibali, 1999). There are also instances in which researchers have discovered gains in one type of knowledge do not necessarily mean gains in the other type of knowledge at all; for instance, in domains like fraction multiplication and multidigit subtraction, procedures are learned but not usually conceptual knowledge (e.g., Byrnes & Wasik, cited in Rittle-Johnson & Alibali, 1999). Some researchers have shown that there appears to be an iterative relationship between the two types of knowledge in relation to mathematics topics, as shown in the previous heading (e.g., Rittle-Johnson & Alibali, 1999; Rittle-Johnson et al. 2001). The iterative model indicates that gains in one type of knowledge lead to increased knowledge of the second, which in turn leads to more knowledge of the first. According to Kulm (1994), procedural knowledge is grounded in conceptual knowledge, because application is only possible with understanding the underlying reasoning behind the procedures. “Without a sound understanding of concepts, skills may be used mechanically and easily forgotten. At the same time, strong mathematical skills and computation can help students build understanding of new concepts. So it is not an either-or situation" (p. 18). Yet, there are cases in which students learn a procedure and develop an understanding of the underlying concepts later, such as in the studies discussed in the previous section, where students who were instructed procedurally only later showed improvements in conceptual knowledge (Rittle-Johnson & Alibali, 1999; Rittle-Johnson et al. 2001).

Because there is inconsistency in research results over the relationship between conceptual and procedural knowledge, there could be instances in which procedural knowledge leads to conceptual gains, conceptual knowledge leads to procedural gains, or an increase in both occurs due to knowledge gains of one type. This is important since there seems to be a continuum of knowledge that people can possess. Whether there are any gains in a certain type of knowledge can depend on the instruction type and perhaps the motivation or learning preferences of the student.

Intrinsic and Extrinsic Motivations

Defining intrinsic and extrinsic motivations. Intrinsic motivation refers to taking part in an activity for itself and the enjoyment and satisfaction that comes from participating in the activity. Extrinsic motivation is related to behaviors that are engaged in as "means to an end and not for their own sake" (Vallerand, et al., 1992, p. 1006). Lowman (1990) defined intrinsic as "largely internal and self-defined" and extrinsic as "largely externally defined and tangible" in examining research on student motivation in the college classroom (p. 1). Husman and Lens (1999) described students as intrinsically motivated when they learn or perform at school as a goal in itself and as extrinsically motivated when they execute activities for the sake of tangible rewards that are not related to learning for its own sake. Ryan and Deci (2000) referred to intrinsic motivation as doing something for the inherent interest and delight and to extrinsic motivation as doing something for a separable result. They also discussed how students can actually fall under different types of extrinsic motivation. For instance, a student could execute a task with antipathy and resistance, which means he is externally driven into action. On the other hand, a student could execute a task with enthusiasm that demonstrates an inner acceptance of the value for the task, which is self-endorsed and with a degree of self-decision.

Total motivation in the classroom. Total motivation is a combination of both intrinsic and extrinsic motivation. An example of a student with a total motivation that combines extrinsic and intrinsic is a student highly motivated for a course in mathematics for various reasons. He wants to become better at the concepts and procedures and has enjoyed learning throughout his school career, which is an example of his intrinsic motivation. He also works hard to get good grades and impress his parents and girlfriend, which is an example of his extrinsic motivation. This example shows how students are not motivated solely by one force or another. There are many forces of motivation, both intrinsic and extrinsic, surrounding students. Harter, as cited in Lepper, Corpus, and Iyengar (2005), designed a scale placing intrinsic and extrinsic motivations as opposing ends. Her scale did not provide students the opportunity to evaluate themselves as concurrently extrinsically and intrinsically motivated. Yet there could be times when a student is both interested in learning a subject and wants to please her teacher, so she is both intrinsically and extrinsically motivated at that time. This gives evidence showing that intrinsic and extrinsic motivations are not necessarily separate, but in fact they seem to fall on a continuum whereby a student could be more extrinsically motivated while still displaying some intrinsic motivation, or vice versa. Lepper et al. (2005) used independent scales for intrinsic and extrinsic motivations in a study involving third to eighth graders. The use of independent scales was to examine the relationship between intrinsic and extrinsic motivation (i.e., do they really contrast, as studied by researchers like Harter). The two scales had a moderate correlation, which suggests intrinsic and extrinsic motivations are orthogonally related, in other words, they intersect. For a classroom setting, the results of this study seem to imply that intrinsic and extrinsic motivation can and do coexist. From a practical perspective, it makes perfect sense for students to search for activities that they find inherently gratifying while simultaneously being aware of the extrinsic consequences.

Perceived instrumentality. In a review of motivation literature, Husman and Lens (1999) reported that students who have future goals in mind see the implications of their present courses for the future, which increases their instrumental motivation. Perceived instrumentality, or motivation, is a person's understanding of the influential future significance of a current behavior. If a student has utility value for an activity, which is a form of extrinsic motivation (Eccles as cited in Husman and Lens, 1999), she sees the importance of a task for a future goal. On the other hand, a student who has interest value for a task, which is a form of intrinsic motivation according to Eccles, receives instant satisfaction from participating in an activity. Therefore, if a student is motivated toward doing schoolwork for its utility value for achieving future goals, then by definition, the student is extrinsically motivated. Ryan and Deci (2000) discussed in their review of intrinsic and extrinsic motivations that there are different orientations to motivation. They investigated the underlying force or outcome that gives rise to a behavior or action. A student might be motivated to gain knowledge of skills because he or she wants to earn a good grade and/or because he or she comprehends the potential utility or value of the skills.

Relationship between Motivation and Type of Learner

Skaalvik and Skaalvik (2004) explored gender differences in mathematics performance expectations, intrinsic motivation, and goal orientation in four samples of Norwegian students. They associated students' motivation with their goal orientation. When students were task oriented, they focused on "learning, understanding and developing new skills as ends in themselves" (p. 243). This can be related to being intrinsically motivated to learn conceptual knowledge. Being ego oriented means that a student has the aspiration to be seen as able, outperforming others, and exhibiting superior aptitude (p. 243). A student with this type of orientation could be seen as extrinsically motivated to learn procedures. A person who is task-oriented and focuses on the learning and task for itself or is intrinsically motivated for an activity seems to be totally pulled into the process at hand. Students who seek to accomplish mastery, or task goals, usually have positive attitudes toward learning and growing intrinsic curiosity toward learning (Husman & Lens, 1999).

Implications

Based on the review of literature of conceptual and procedural knowledge in relation to intrinsic and extrinsic motivation, the purpose of this current study is to test the correlation of the two types of knowledge and motivation. It is hypothesized that students in a mathematics education program who are focused on gaining conceptual knowledge to be better teachers are also intrinsically motivated in their mathematics college courses. On the other hand, students who are focused on learning procedures in order to only do well in the class are extrinsically motivated.

CHAPTER 3
METHODS

Introduction

In this chapter, the participants, procedures, and instruments for this research will be described. In the next chapter, an analysis of the research results will be discussed.

Participants

The participants were junior, senior, and fifth year students in the IB/M program in the NEAG School of Education at the University of Connecticut who were involved in a mathematics focus (secondary mathematics major or elementary mathematics major). There were a total of 60 mathematics focused students in the School of Education, and 38 of the mathematics junior, senior, and fifth year IB/M students agreed to participate in completing a survey. All of the students were over the age of 18. Three males and 35 females participated in the study, and all ethnicities were included provided they had a mathematics focus. Eighteen participants were elementary education majors with a mathematics focus, 2 were special education majors with a mathematics focus, and 18 were secondary mathematics majors. Nineteen participants reported that their average high school mathematics grades were all A's, 10 reported that their average high school mathematics grades were mostly A's, 6 reported that their average high school mathematics grades were more A's than B's, and 3 reported that their average high school mathematics grades were more B's than A's. When asked to indicate whether they preferred to be taught the sequence of steps to solve a mathematics problem or the concepts and reasoning behind solving mathematics problems when they learn mathematics, 22 indicated the former and 16 indicated the latter.

Procedure

The student researcher presented information about the study to the potential participants during one of their education courses. Participants had no questions for the student researcher. An information sheet was also provided to explain the context of the study to participants. Participants were asked to take a survey if they were willing to participate. Submission of this survey was used to indicate consent, as surveys were kept anonymous. The student researcher then collected the surveys from the individual instructors.

Instrument

For the survey, the student researcher used 30 survey questions on intrinsic/extrinsic motivation from a previously published study administered by Lepper, Corpus, and Iyengar in 2005. She also created 17 conceptual/procedural survey questions and performed a content validity test for them. During the content validity phase, she provided her statements to 6 graduate students and asked them to read each of the statements and determine whether it represents conceptual or procedural learning by writing *C* for *Conceptual* and *P* for *Procedural* in front of each of the statements. She provided each of them with the following definitions of conceptual and procedural: *Conceptual learning* is being capable of showing non-examples, of comparing concepts, of understanding why processes work, and of reasoning and problem solving; *Procedural learning* is being capable of performing sequences of steps to solve a problem. Through the content validity test, the student researcher found that all the statements were correctly matched by all of the graduate students who examined them except for four statements. The four statements that did not match completely still had an 83% match rate, so the student researcher retained them in the survey. A copy of this content validity test is included in Appendix A.

Participants were asked to complete three parts of the survey. Section 1 was a Likert scale for intrinsic versus extrinsic motivation with 30 statements. Section 2 was a Likert scale for conceptual and procedural learning with 17 statements. There was also a section with demographic questions and open-ended questions that relate to both motivation and learning that was not used for the study. A copy of this survey is included in Appendix B. Since surveys were returned by students to their course instructors and then given to the student researcher, the researcher did not know which students had participated in the study. The survey was anonymous and students' names did not appear on it. All of the data was inputed into an Excel spreadsheet and then transferred to the SPSS statistics package.

From the statements for each Likert scale, the following five constructs were developed: Procedural, Conceptual, Sequence, Intrinsic, and Extrinsic. The reliabilities for each of the constructs are shown in the Tables 1-5. Each construct started with all the statements that related to the construct and statements were deleted based on the Cronbach's Alpha. Items were deleted in order to end with the most reliable set of statements to use for analysis. The procedural scale started with four items, and after deletion, the analysis depended on two items with a Cronbach's Alpha of .547. The conceptual scale started with 10 items, and after deletion, the analysis depended on seven items with a Cronbach's Alpha of .879. The sequence scale started with seven items, and after deletion, the analysis depended on two items with a Cronbach's Alpha of .860. The intrinsic scale started with 15 items, and after deletion, the analysis depended on 7 items with a Cronbach's Alpha of .888. The extrinsic scale started with 15 items, and after deletion, the analysis depended on 9 items with a Cronbach's Alpha of .828. Only the procedural scale had a reliability lower than .70, which is the minimal reliability recommended by Gable and Wolf (1993).

Table 1

Reliability for Procedural Scale

Item	Item Response Percentages 1	2	3	4	5	Mean	*SD*	Corrected Item-total *r*	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
CP1	0	10.5	7.9	50.0	31.6	4.03	.915	.378	.[a]	.547
CP13	0	15.8	15.8	44.7	23.7	3.76	.998	.378	.[a]	

Table 2

Reliability for Conceptual Scale

Item	Item Response Percentages 1	2	3	4	5	Mean	*SD*	Corrected Item-total *r*	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
CP4	0	5.3	15.8	47.4	31.6	4.05	.837	.756	.849	.879
CP5	0	0	13.2	55.3	31.6	4.18	.652	.698	.858	
CP7	0	7.9	26.3	44.7	21.1	3.79	.875	.656	.863	
CP11	0	2.6	26.3	42.1	28.9	3.97	.822	.581	.873	
CP12	0	2.6	13.2	60.5	23.7	4.05	.695	.698	.857	
CP14	0	2.7	18.9	54.1	24.3	4.00	.745	.643	.864	
CP15	0	2.7	16.2	54.1	27.0	4.05	.743	.635	.865	

Table 3

Reliability for Sequence Scale

Item	Item Response Percentages 1	2	3	4	5	Mean	*SD*	Corrected Item-total *r*	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
CP9	0	0	2.6	42.1	55.3	4.53	.557	.764	.[a]	.860
CP10	0	0	7.9	42.1	50.0	4.42	.642	.764	.[a]	

Table 4

Reliability for Intrinsic Scale

Item	Item Response Percentages 1	2	3	4	5	Mean	*SD*	Corrected Item-total *r*	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
IE1	0	2.6	21.1	60.5	15.8	3.89	.689	.691	.870	.888
IE3	0	0	18.4	50.0	31.6	4.13	.704	.640	.876	
IE13	0	10.5	23.7	52.6	13.2	3.68	.842	.772	.859	
IE14	0	5.3	18.4	63.2	13.2	3.84	.718	.712	.868	
IE19	0	5.3	21.1	60.5	13.2	3.82	.730	.615	.879	
IE22	0	10.8	32.4	51.4	5.4	3.51	.768	.744	.863	
IE29	0	13.2	18.4	57.9	10.5	3.66	.847	.605	.882	

Table 5

Reliability for Extrinsic Scale

Item	Item Response Percentages 1	2	3	4	5	Mean	*SD*	Corrected Item-total *r*	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
IE6	13.5	67.6	16.2	2.7	0	2.08	.640	.480	.818	.828
IE7	7.9	28.9	26.3	31.6	5.3	2.97	1.078	.545	.809	
IE10	0	36.8	39.5	23.7	0	2.87	.777	.499	.814	
IE11	10.5	31.6	13.2	34.2	10.5	3.03	1.241	.691	.789	
IE15	7.9	26.3	26.3	36.8	2.6	3.00	1.040	.620	.799	
IE16	44.7	36.8	7.9	10.5	0	1.84	.973	.448	.820	
IE17	15.8	71.1	13.2	0	0	1.97	.545	.579	.813	
IE25	0	47.4	26.3	21.1	5.3	2.84	.945	.586	.804	
IE28	10.5	55.3	18.4	13.2	2.6	2.42	.948	.446	.820	

Conclusion

In this chapter, the methods for this study were described: participants, instrument, and procedure. In the next chapter, the results of the study will be discussed based on three research questions.

CHAPTER 4
RESULTS

Introduction

In this chapter, the research questions will be answered through the analysis of the data from the surveys. For the research question, "*What are the relationships among procedural learning preference, conceptual learning preference, sequential learning ability, intrinsic motivation type, and extrinsic motivation type?*" a correlation test was conducted. Table 6 shows the results of the correlations among all of the constructs within the study. To answer the second research question, "*Is there a significant difference between mathematics focused pre-service teachers who indicate a preference for conceptual learning versus mathematics focused pre-service teachers who indicate a preference for procedural learning with regards to conceptual learning preference, procedural learning preference, sequential learning ability, intrinsic motivation type, and extrinsic motivation type*?" and the third research question, "*Is there a significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to conceptual learning preference, procedural learning preference, sequential learning ability, intrinsic motivation type, and extrinsic motivation type?*" *t* tests were conducted.

All of the variables are defined as follows in regards to the survey participants' answers. Procedural learning preference refers to favoring learning content through steps and directions. Conceptual learning preference refers to favoring learning the underlying concepts and connections within content. Sequential learning ability refers to the level of capability of being able to perform a sequence of steps to solve a problem. Intrinsic motivation type refers to people who are motivated to do a task for its own sake. Extrinsic motivation type refers to people who are motivated to do a task for outside rewards. Indicating a preference for conceptual learning or procedural learning refers to when participants were asked, "*Which of the following best applies to you? When I learn mathematics, I prefer to be taught the sequence of steps to solve a mathematics problem. When I learn mathematics, I prefer to be taught the concepts and reasoning behind solving the mathematics problem.*" This indication was a choice between these two statements, whereas procedural learning preference and conceptual learning preference were determined by the 17 statement Likert scale survey.

Research Question 1: What are the relationships among procedural learning preference, conceptual learning preference, sequential learning preference, intrinsic motivation type, and extrinsic motivation type?

There was not a significant relationship between the procedural and conceptual learning styles of pre-service teachers at the University of Connecticut, $r(36)=.121$, $p>.05$ (see Table 6). There was not a significant relationship between the extrinsic motivation and conceptual learning style of pre-service teachers at the University of Connecticut, $r(36)=-.214$, $p>.05$. There was not a significant relationship between the conceptual learning style and intrinsic motivation of pre-service teachers at the University of Connecticut, $r(36)=.095$, $p>.05$. There was not a significant relationship between the procedural learning style and extrinsic motivation of pre-service teachers at the University of Connecticut, $r(36)=.142$, $p>.05$. There was not a significant relationship between the procedural learning style and intrinsic motivation of pre-service teachers at the University of Connecticut, $r(36)=-.220$, $p>.05$. There was not a significant relationship between the extrinsic motivation and the ability to learn mathematics through steps of pre-service teachers at the University of Connecticut, $r(36)=-.174$, $p>.05$. There was not a significant relationship between the intrinsic motivation and the ability to learn mathematics through steps of pre-service teachers at the University of Connecticut, $r(36)=.259$, $p>.05$.

There was a significant relationship between the intrinsic and extrinsic motivation of pre-service teachers at the University of Connecticut, $r(36)=-.485$, $p<.01$. This negative relationship showed that a mathematics focused pre-service teacher who reported high scores on extrinsic type statements reported low scores on intrinsic type statements and vice versa. There was a significant relationship between the conceptual learning style and the ability to learn mathematics through steps of pre-service teachers at the University of Connecticut, $r(36)=.697$, $p<.001$. This strong relationship showed that students who prefer to learn mathematics conceptually also are able to learn mathematics sequentially. There was a significant relationship between the procedural learning style and the ability to learn mathematics through steps of pre-service teachers at the University of Connecticut, $r(36)=.340$, $p<.05$. This relationship showed that students who prefer to learn mathematics procedurally also are able to learn mathematics sequentially.

Table 6

Inter-correlations between Variables for Pre-Service Teachers (n = 38)

	Conceptual	Procedural	Sequence	Extrinsic	Intrinsic
Conceptual	1.000	.121	.697***	-.214	.095
Procedural		1.000	.340*	.142	-.220
Sequence			1.000	-.174	.259
Extrinsic				1.000	-.485**
Intrinsic					1.000

***Correlation is significant at the 0.001 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Research Question 2: Is there a significant difference between mathematics focused pre-service teachers who indicate a preference for conceptual learning versus mathematics focused pre-service teachers who indicate a preference for procedural learning with regards to conceptual learning preference, procedural learning preference, sequential learning ability, intrinsic motivation type, and extrinsic motivation type?

There was not a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to sequential learning ability, $t(36) = .538$, $p > .05$. Pre-service teachers reported similarly high scores for sequential learning preference regardless of their preference for conceptual or procedural learning (see Table 7). There was not a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to intrinsic motivation type, $t(36) = 1.161$, $p > .05$. Pre-service teachers who indicated a preference for conceptual learning reported similarly slightly above average scores for intrinsic motivation type with pre-service teachers who indicated a preference for procedural learning.

There was a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to conceptual learning preference, $t(36) = 2.408$, $p < .05$. Pre-service teachers who indicated a preference for conceptual learning reported higher scores for conceptual learning than procedural learning. There was a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to procedural learning preference, $t(36) = 3.685$, $p < .05$. Pre-service teachers who indicated a preference for procedural learning reported higher scores for procedural learning than conceptual learning. These indicate that the single dichotomous choice question, "*Which of the following best applies to you? When I learn mathematics, I prefer to be taught the sequence of steps to solve a mathematics problem. When I learn mathematics, I prefer to be taught the concepts and reasoning behind solving the mathematics problem*," accurately measured the participants preference for conceptual or procedural learning. There was a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to extrinsic motivation type, $t(36) = 2.368$, $p<.05$. Pre-service teachers who indicated a preference for procedural learning reported higher scores for extrinsic motivation type than pre-service teachers who indicated a preference for conceptual learning.

Table 7 shows the means and standard deviations for the *t* test conducted for this research question.

Table 7

Mean Table for Conceptual/Procedural Indication

	Procedural			Conceptual		
CP	*M*	*SD*	*n*	*M*	*SD*	*n*
Conceptual*	3.8366	.52031	22	4.2560	.54346	16
Procedural*	4.2500	.63151	22	3.4063	.77929	16
Sequence	4.4318	.60347	22	4.5313	.49896	16
Extrinsic*	2.7330	.67714	22	2.3194	.39310	16
Intrinsic	3.6981	.66054	22	3.9196	.44559	16

* *t* tests showed significant difference at $p < .05$.

Research Question 3: Is there a significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to conceptual learning preference, procedural learning preference, sequential learning ability, intrinsic motivation type, and extrinsic motivation type?

There was not a statistically significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to procedural learning preference, $t(36) = .420$, $p>.05$ (see Table 8). There was not a statistically significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to sequential learning ability, $t(36) = 1.516$, $p>.05$. There was not a statistically significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to intrinsic motivation type, $t(36) = .887$, $p>.05$, nor in regards to extrinsic motivation type, $t(36) = 1.055$, $p>.05$. This showed that elementary and secondary mathematics focused pre-service teachers reported similarly for these constructs. There was a significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to conceptual learning preference, $t(36) = 2.715$, $p<.05$. This shows that secondary mathematics focused pre-service teachers were more likely to prefer learning mathematics conceptually than elementary mathematics focused pre-service teachers.

Table 8 shows means and standard deviations for the *t* test conducted for this research question.

Table 8

Mean Table for Major

	Elementary			Secondary		
Major	*M*	*SD*	*n*	*M*	*SD*	*n*
Conceptual*	3.7698	.55250	18	4.2500	.50766	18
Procedural	3.8889	.60768	18	3.7778	.94281	18
Sequence	4.3333	.64169	18	4.6111	.43910	18
Extrinsic	2.4390	.52409	18	2.6358	.59263	18
Intrinsic	3.8929	.59219	18	3.7222	.56184	18

*t test showed significant difference at $p<.05$.

Conclusion

The data analysis showed the significant and non significant relationships and differences between the five constructs. The correlation test conducted showed there was a negative relationship between the intrinsic and extrinsic motivation of pre-service teachers at the University of Connecticut, which showed that a mathematics focused pre-service teacher who reported high scores on extrinsic type statements reported low scores on intrinsic type statements and vice versa. There was a significant positive relationship between the conceptual learning style and sequential learning style as well as the procedural learning style and sequential learning style of pre-service teachers at The University of Connecticut. This showed that from the students surveyed, both conceptual learners and procedural learners felt they have the ability to learn mathematics through steps.

The t test conducted for the major descriptor showed there was a significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to conceptual learning preference. This shows that secondary mathematics focused pre-service teachers were more likely to prefer learning mathematics conceptually than elementary mathematics focused pre-service teachers.

The *t* test conducted for the conceptual procedural indication descriptor showed there was a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to conceptual learning preference. If a pre-service teacher indicated a preference for conceptual learning, they reported higher scores for conceptual learning than procedural learning. If they indicated a preference for procedural learning, they reported higher scores for procedural learning than conceptual learning. This showed that the participants tended to prefer the learning style for which they reported higher scores.

There was not a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to intrinsic motivation type. Yet, pre-service teachers who indicated a preference for conceptual learning reported slightly higher scores for intrinsic motivation type than pre-service teachers who indicated a preference for procedural learning. There was a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to extrinsic motivation type. Pre-service teachers who indicated a preference for procedural learning reported higher scores for extrinsic motivation type than pre-service teachers who indicated a preference for conceptual learning. These results tend to support the hypothesis that mathematics focused pre-service teachers who prefer conceptual learning are more intrinsically motivated, and mathematics focused pre-service teachers who prefer procedural learning are more extrinsically motivated.

CHAPTER 5
DISCUSSION

Summary of Findings

The findings from this research showed that there was not a significant relationship between the procedural and conceptual learning styles of pre-service teachers at the University of Connecticut. This tells us that no matter how a participant scored (high, average, or low) for procedural learning preference, there is no way of knowing what the same participant scored for conceptual learning preference. There was not a significant relationship between either motivation type (intrinsic or extrinsic) and either learning style (conceptual or procedural) of pre-service teachers at the University of Connecticut. This tells us that based on the Likert scale surveys, if a participant scored a certain way for motivation type, then there is no way of connecting that score to what they scored for learning preference type. So if a participant scored high for intrinsic motivation, then we are unable to say how the participant scored for either conceptual learning preference or procedural learning preference.

There was a significant negative relationship between the intrinsic and extrinsic motivation of pre-service teachers at the University of Connecticut, which showed that a mathematics focused pre-service teacher who reported high scores on extrinsic type statements reported low scores on intrinsic type statements and vice versa. This showed that these participants tended to be either intrinsically or extrinsically motivated, but not both. This finding contradicts the review of literature that discussed the idea that people can be both extrinsically and intrinsically motivated.

There was a strong relationship between conceptual and sequential learning styles, which showed that students who prefer to learn mathematics conceptually also are able to learn mathematics sequentially. This finding supports the idea of the iterative model for learning styles, which indicated that gains in one type of knowledge (conceptual or procedural) lead to increased knowledge of the second, which in turn leads to more knowledge of the first. There was a significant relationship between the procedural learning style and the ability to learn mathematics through steps of pre-service teachers at the University of Connecticut, which showed that students who prefer to learn mathematics procedurally also are able to learn mathematics sequentially. Since learning a topic sequentially is a form of procedural learning, this finding affirms the meaning of procedural learning. Both of these findings make sense since mathematics is a sequential process whether it is learned conceptually or procedurally.

Through the *t* test results, we found there was not a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to sequential learning ability. This showed that no matter what the preference of learning, the participants of this study felt they were able to learn mathematics sequentially, which supports the findings from the correlation test.

Even though there was not a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to intrinsic motivation type, pre-service teachers who indicated a preference for conceptual learning reported slightly higher scores for intrinsic motivation type than pre-service teachers who indicated a preference for procedural learning. If the number of participants had been greater, this finding might have been significant. There was a significant difference between pre-service teachers who indicate a preference for conceptual learning versus ones who indicate a preference for procedural learning with regards to extrinsic motivation type, which implies that pre-service teachers who showed a preference to procedural learning were also extrinsically motivated.

There was not a statistically significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to procedural learning preference nor with regards to sequential learning ability. There was not a statistically significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to intrinsic motivation type, nor in regards to extrinsic motivation type. This showed that the expected teaching level of the participant did not affect their motivation type. There was a significant difference between secondary major mathematics focused pre-service teachers versus elementary major mathematics focused pre-service teachers with regards to conceptual learning preference. This shows that secondary mathematics focused pre-service teachers were more likely to prefer learning mathematics conceptually than elementary mathematics focused pre-service teachers.

Implications

Based on the review of literature of conceptual and procedural knowledge in relation to intrinsic and extrinsic motivation and the findings from this study, the research implies that students in a mathematics education program who are focused on gaining conceptual knowledge are also intrinsically motivated in their mathematics college courses. On the other hand, students who are focused on learning procedures in order to only do well in the courses are extrinsically motivated. Based on the results of this study, elementary mathematics pre-service teachers tend to prefer a procedural learning style, whereas secondary mathematics pre-service teachers prefer a conceptual learning style. This has an implication toward how these pre-service teachers will conduct their future classes. If students in K-6 learn mathematics more procedurally and then teachers in 7-12 expect them to understand mathematics conceptually, students may have difficulty making the transition. Elementary teachers should be encouraged to teach mathematics conceptually as well. Since expected teaching level did not relate to motivation type in this study and pre-service teachers who were intrinsically motivated also preferred conceptual learning, elementary pre-service teachers who are intrinsically motivated could prefer conceptual learning. If this were taken advantage of, more elementary teachers might teach mathematics with a combination of procedural and conceptual knowledge, which based on the review of literature, would be more beneficial for students acquiring mathematics knowledge.

Limitations

There were a few limitations to this study. First, the chosen population was based on convenience. Since the researcher is a student in the Neag School of Education at the University of Connecticut, the participants were easier to access since they were also students in the Neag School of Education. Another limitation to the study was the size of the participation pool. The researcher asked almost 100 mathematics focused pre-service teachers if they would be willing to participate and only 36 participants responded. If there had been a greater number of participants, some constructs might have had varied findings. Another limitation was the low reliability of the procedural scale. Variables with low reliability are less likely to correlate with other variables. A final limitation to the study was the elementary pre-service teachers asked to participate were limited to mathematics focused students. Most elementary school teachers teach every content area, including mathematics, so all elementary pre-service teachers could have been surveyed, but were not. Thus, results cannot be generalized beyond the students who completed the survey.

Suggestions for Future Research

One suggestion for future research would be to increase the participant population of the study. Instead of only limiting the study to elementary and secondary mathematics focus pre-service teachers, include all of the elementary pre-service teachers. This would give more information about the relationship between a pre-service teachers' major and preferences.

Another suggestion for future research would be to study high school mathematics students. This type of research would be beneficial to mathematics teachers because it would provide them with some insight into their students' learning preferences in relation to their motivation type. This in turn would help teachers differentiate their teaching to optimally assist all students at learning mathematics most effectively.

Another suggestion for future research would be to study in-service teachers. A study could look at an in-service teacher's preference to learning style in relation to the type of teaching style he or she uses.

A final suggestion for future research would be to study other subject areas. This might pose a challenge since not all other subject areas have distinct procedural and conceptual aspects. Yet, it would still be worth the benefits of discovering how students are motivated in different classes versus their learning preference. In fact, comparing findings across subject areas might even report different learning preferences and motivation types in the same student depending on the varied subjects.

Conclusion

Before conducting this study, we believed that pre-service mathematics teachers who were intrinsically motivated would favor conceptual learning more than extrinsically motivated pre-service mathematics teachers. Findings from the study showed pre-service teachers who indicated a preference for conceptual learning reported slightly higher scores for intrinsic motivation type than pre-service teachers who indicated a preference for procedural learning. In addition, the significant difference between pre-service teachers who indicated a preference for conceptual learning versus ones who indicated a preference for procedural learning with regards to extrinsic motivation type implies that pre-service teachers who showed a preference to procedural learning were also extrinsically motivated. These findings agreed with our initial hypothesis for this study. With a larger participant pool, these findings might have shown even more significant differences between the preferences.

Knowing this relationship exists with pre-service teachers at the University of Connecticut will help us better prepare future mathematics teachers. Educators of pre-service teachers need to take a note from the high school students and ask themselves, “Why will they need to know this concept in order to teach?” Considering this question would benefit the intrinsically motivated pre-service teacher who prefers the conceptual way of learning and would assist the extrinsically motivated pre-service teacher who prefers the procedural way of learning to possibly become more intrinsically motivated.

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APPENDIXES

Appendix A: Content Validity Test

Conceptual learning is being capable of showing non-examples, of comparing concepts, of understanding why processes work, and of reasoning and problem solving. *Procedural learning* is being capable of performing sequences of steps to solve a problem.

Please read each of the following statements and determine whether it represents conceptual or procedural learning. Write *C* for *Conceptual* and *P* for *Procedural* in front of each of the following statements.

____ Being instructed by steps is a good way to learn mathematics.

____ Being shown nonexamples, in addition to examples, helps me understand mathematics concepts better.

____ I am capable of performing a sequence of steps to solve a mathematics problem.

____ I am capable of showing non examples in mathematics class.

____ I can compare mathematics concepts and find connections.

____ I can find the relationships between different topics in mathematics.

____ I can give counterexamples for mathematics concepts.

____ I can show reasoning for answers to mathematics problems.

____ I have learned the skills to solve numerous mathematics problems.

____ I know how a variety of mathematics problems are solved.

____ I know why certain mathematics problems are solved the way they are.

____ I prefer to learn algorithms for solving mathematics problems.

____ I prefer to solve mathematics problems by being given a set of step-by-step instructions.

____ I understand the principles that guide the learning that occurs in my mathematics classes.

____ I understand why certain processes work to solve mathematics problems.

____ Learning procedures to mimic is a good way to study mathematics.

____ Problem solving and reasoning are good ways to learn mathematics.

Appendix B: Survey

Attitudes about Mathematics

Instructions: This survey should take approximately 15 to 20 minutes to complete. Please rate how strongly you agree or disagree with the following statements regarding your attitudes toward mathematics. In answering each question, use a range from (**1**) to (**5**), where (**1**) stands for **strongly disagree** and (**5**) stands for **strongly agree**. Please circle only one response choice per statement. Please respond to every statement.

Part 1	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I like hard work because it is a challenge.	1	2	3	4	5
2. I like to learn as much as I can in school.	1	2	3	4	5
3. I like mathematics classes that make me think pretty hard and figure things out.	1	2	3	4	5
4. I ask questions in class because I want to learn new things.	1	2	3	4	5
5. When I do not understand something right away I want the teacher to tell me the answer.	1	2	3	4	5
6. I do not like to figure out difficult problems.	1	2	3	4	5
7. I do mathematics assignments because my teacher wants me to.	1	2	3	4	5
8. I do extra projects because I can learn about things that interest me.	1	2	3	4	5
9. I like to try to figure out how to do mathematics assignments on my own.	1	2	3	4	5
10. I like to learn just what I have to in mathematics classes.	1	2	3	4	5
11. I do my mathematics work because my teacher tells me to.	1	2	3	4	5
12. I like to have the teacher help me with my mathematics work.	1	2	3	4	5
13. I like difficult problems because I enjoy trying to figure them out.	1	2	3	4	5
14. When I do not understand something right away, I like to try to figure it out myself.	1	2	3	4	5
15. I work on problems because I am supposed to.	1	2	3	4	5
16. I ask questions because I want the teacher to notice me.	1	2	3	4	5
17. I do not like difficult mathematics work because I have to work too hard.	1	2	3	4	5

18. When I make a mistake, I like to ask the teacher how to get the right answer.	1	2	3	4	5
19. I like difficult mathematics problems because I find them more interesting.	1	2	3	4	5
20. I do mathematics problems because I am interested in the subject.	1	2	3	4	5
21. I work really hard because I really like to learn new things.	1	2	3	4	5
22. When I make a mistake, I like to figure out the right answer by myself.	1	2	3	4	5
23. I like easy work that I am sure I can do.	1	2	3	4	5
24. If I get stuck on a problem, I ask the teacher for help.	1	2	3	4	5
25. I like mathematics classes where it is pretty easy to just learn the answers.	1	2	3	4	5
26. I work on problems to learn how to solve them.	1	2	3	4	5
27. I like to ask the teacher how mathematics assignments should be done.	1	2	3	4	5
28. I like to stick to assignments which are pretty easy to just learn the answers.	1	2	3	4	5
29. If I get stuck on a problem, I keep trying to figure out the problem on my own.	1	2	3	4	5
30. I like to do my mathematics work without help.	1	2	3	4	5

Part 2	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Being instructed by steps is a good way to learn mathematics.	1	2	3	4	5
2. Being shown nonexamples, in addition to examples, helps me understand mathematics concepts better.	1	2	3	4	5
3. I am capable of performing a sequence of steps to solve a mathematics problem.	1	2	3	4	5
4. I can give counterexamples for mathematics concepts.	1	2	3	4	5
5. I can compare mathematics concepts and find connections.	1	2	3	4	5
6. I prefer to learn algorithms for solving mathematics problems.	1	2	3	4	5
7. I am capable of showing nonexamples in mathematics class.	1	2	3	4	5

8. I can show my reasoning for answers to mathematics problems.	1	2	3	4	5
9. I have learned the skills to solve numerous mathematics problems.	1	2	3	4	5
10. I know the process for solving many mathematics problems.	1	2	3	4	5
11. When I look at a mathematics problem, I know how to approach solving it.	1	2	3	4	5
12. I can find the relationships between different topics in mathematics.	1	2	3	4	5
13. I prefer to solve mathematics problems by being given a set of step-by-step instructions.	1	2	3	4	5
14. I understand the principles that guide the learning that occurs in my mathematics classes.	1	2	3	4	5
15. I understand why certain processes work to solve mathematics problems.	1	2	3	4	5
16. Learning procedures to imitate is a good way to study mathematics.	1	2	3	4	5
17. Problem solving and reasoning are good ways to learn mathematics.	1	2	3	4	5

Which of the following best applies to you? Select one.

____ When I learn mathematics, I prefer to be taught the sequence of steps to solve a mathematics problem.
____ When I learn mathematics, I prefer to be taught the concepts and reasoning behind solving the mathematics problem.

Additional Information: Please choose only one response choice per question.

1. Gender: ____ Male ____ Female

2. Major: ____ Elementary ____ Secondary

3. Average high school mathematics grade:
    ____ All A's
    ____ Mostly A's
    ____ More A's than B's
    ____ More B's than A's
    ____ Mostly B's, some A's and C's
    ____ More B's than C's
    ____ More C's than B's

Continue on the back →

Open ended Questions: Please write one or two sentences to answer the following questions.

1a. List several examples of mathematics concepts that are best learned through steps.

1b. List several examples of mathematics concepts that are best learned when deeper concepts are taught.

2a. In which mathematics courses at THE UNIVERSITY OF CONNECTICUT did you feel you focused mainly on steps and processes?

2b. In which mathematics courses at THE UNIVERSITY OF CONNECTICUT did you feel you focused mainly on concepts?

3a. In which classes were you motivated to learn only the procedures necessary to do the mathematics?

3b. In which classes were you more motivated to learn the concepts behind the mathematics?

4a. Which of your mathematics courses seemed most relevant to your future?

4b. Which seemed less relevant to your future?

Thank you for your participation.