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The Impact Of The Group Performance And Assessment Program (GPA Program) On Math Interest, Effort, Self-Efficacy, Peer Influence, And Performance In A University College Algebra Setting

Dewitt Lasalle Johnson

THE IMPACT OF THE GROUP PERFORMANCE and ASSESSMENT PROGRAM (GPA Program) ON MATH INTEREST, EFFORT, SELF-EFFICACY, PEER INFLUENCE, AND PERFORMANCE IN A UNIVERSITY COLLEGE ALGEBRA SETTING

by

Dewitt Lasalle Johnson
Bachelor of Science, North Carolina A&T University, 2002
Master of Science, LaSalle University, 2004

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This dissertation, submitted by Dewitt Lasalle Johnson in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

Dr. Steven LeMire, Chairperson

Dr. Mary Baker

Dr. Robert Stupnisky

Dr. Richard Millspaugh

This dissertation is being submitted by the appointed advisory committee as having met all of the requirements of the School of Graduate Studies at the University of North Dakota and is hereby approved.

Wayne Swisher
Dean of the School of Graduate Studies

April 28, 2014
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May, 2016

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ABSTRACT

College algebra courses, as important as they might be to the students that take them, continue to represent some of the most difficult of the pre-major courses in the required general education environment. Various pedagogies aimed at improving student performance have been explored through educational research with results generally mixed. Using a theoretical framework of Vygotsky's social learning theory (1962, 1978), this research compared the impact of the Group Performance and Assessment Program (GPA Program) versus the traditional lecture pedagogy on four psychosocial factors of student performance: math interest, effort, self-efficacy, and peer influence. Using a retrospective Likert-type survey, this work compared the effects of each pedagogical approach on each factor. Using a pre and posttest, this work also compared the effects of each pedagogical approach on student performance. Data was analyzed using a 2 X 2 between and within groups repeated measures factorial design. Results, for each factor, indicated evidence supporting a main effect of time within, but no evidence to support any significant interaction between groups in the sample; hence no evidence that the GPA Program was better than traditional methods of teaching. Implications suggest the need for considering non-traditional pedagogical approaches that incorporate social learning in College Algebra.

CHAPTER I

INTRODUCTION

Overview

Before successful completion of many major fields of study in most universities, evidence must exist of having successfully passed pre-major courses, also known as gatekeeper courses (Billing, 2007; Eagan & Jaeger, 2008; Kerrigan & Jhaj, 2007; Nelson-Laird, Niskodé-Dossett & Kuh, 2009). College algebra is the gatekeeper course for quantitative cognition because of the required mathematical cognitive skill it takes for students to be successful in that course (Eagan & Jaeger, 2008; Kendricks, 2011; McGlaughlin, Knoop & Holliday, 2005; Rech & Harrington, 2000). Although there are other developmental math courses in higher education, those developmental courses are designed to prepare students for the college algebra course, which usually is the final pre-major requirement for quantitative cognition (Hodara & Jaggars, 2014). Unfortunately, many students don’t perform well in college algebra (McGlaughlin et al., 2005; Stephens & Konvalina, 1999). While the evidence of the failure rate of students is typically based on the numbers provided by specific schools (Thomas & Higbee, 1999; Lazari & Reid, 2013), implications suggest that at the end of any given semester, the national failure rate for college algebra is nearly 50% (Overmyer, 2014). What follows in this chapter is an introduction of the researcher developed Group Performance and Assessment Program (GPA Program) for College Algebra, the conceptual framework of this study, and a research-based description of how the GPA Program works. After that, the purpose of this research is discussed and the research questions are presented. This is followed by a chapter summary, and concluding with the definitions of terms and acronyms used in this study.

The GPA Program for College Algebra

Considering the importance of the college algebra course, and the problems associated with performance, the Group Performance and Assessment Program (GPA Program), created by the author of this study, was developed as a pedagogical approach aimed at improving student performance by improving psychosocial factors of performance in college algebra (Eagan & Jaeger, 2008; Kendricks, 2011; Lazari & Reid, 2013; Stephens & Konvalina, 1999). The GPA Program is designed to positively impact student performance as well as its psychosocial factors which include: math interest, effort, self-efficacy, and peer influence.

In Figure 1, the model of the proposed impact of the GPA Program intervention on the psychosocial factors of student performance is illustrated. The line at the bottom of the illustration connecting GPA Program interaction with student performance represents other factors that may be in play, but, not measured in this study.

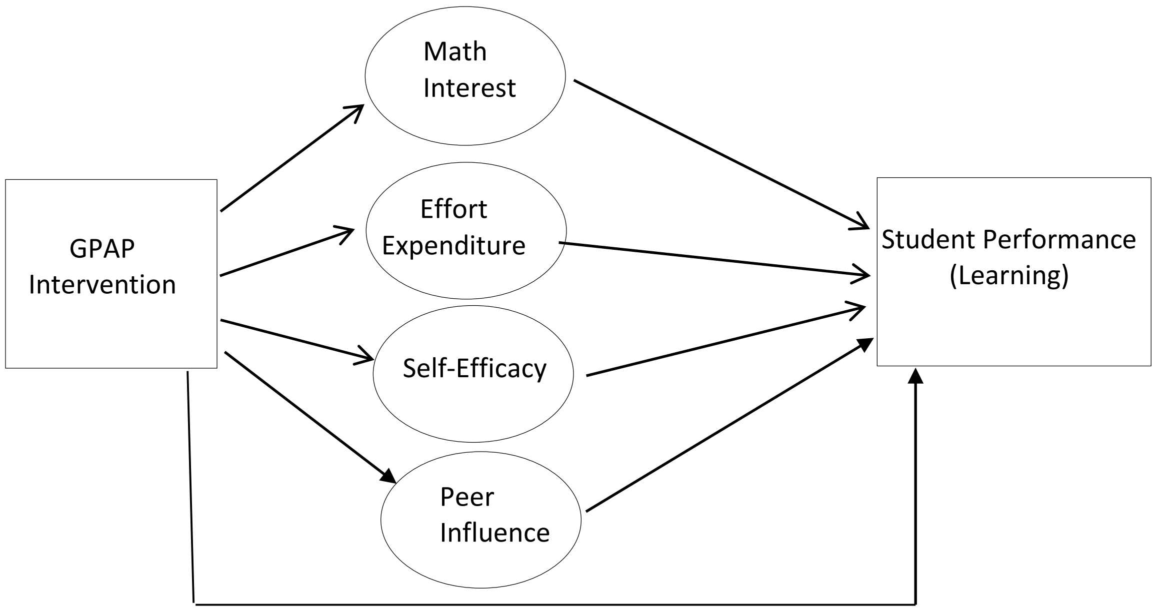

Figure 1. Model of the impact of the GPA Program intervention on the psychosocial factors of student performance. (Stevens, & Olivárez, 2005; Matarazzo et al., 2010; Chen, 2005; Kranzler, & Pajares, 1997; Nasiriyan et al., 2011; Stankov et al., 2014; Vygotsky, 1962, 1978)

Conceptual Framework: Vygotsky's Social Learning Theory and the Zone of Proximal Development

According to Vygotsky's social learning theory (1962, 1978), student group interaction involving communication and collaboration are central components to student learning and performance (César & Santos, 2006; Kim & Baylor 2006; Powell & Kalina, 2009; Steele & Reynolds, 1999). Vygotsky's social learning theory is characterized as learner-centered with a collaborative approach where students view learning as a social endeavor, which promotes independent and reflective thinking (Kim & Baylor 2006; Vygotsky, 1962, 1978; Wang, Bruce & Hughes, 2011).

Vygotsky's social learning theory is widely studied in the K-12 educational arena (Berninger, Dunn, Shin-Ju & Shimada, 2004; Gredler, 2012; Karimnia, 2010) and with primary and secondary mathematics (De Abreu, 2000; Francisco, 2013; Lau, Singh &

Hwa, 2009; Schmittau, 2004; Warren, 2009), but, unfortunately, less so in the college algebra environment. The success of Vygotsky's social learning theory is well documented particularly in non-mathematical arenas of higher education where quantitative cognition is not the focus. Such arenas include, but are not limited to: information literacy (Wang et al., 2011), elementary education, (Jacobs, 2001), and foreign languages (Roebuck, 2001). The success of Vygotsky's social learning theory is documented in mathematical courses in higher education such as developmental and intermediate algebra, which are levels just below college algebra (Goldstein, Burke, Getz & Kennedy, 2011; Mireles, Offer, Ward & Dochen, 2011). This study seeks to test Vygotsky's social learning theory in the college algebra environment. In the following sections, a definition and conceptualization of the Zone of Proximal Development (ZPD) followed by a discussion of using peer influence to close the ZPD from student to instructor.

The ZPD

The ZPD is defined as the extent to which ability improves based on the collaborative engagement and allowed influence of an external source of expert ability (Chak, 2001; Gredler, 2012; Kravtsova, 2009; Levykh, 2008; Sokolova, Tarasova & Korepanova, 2009; Zuckerman, 2007). The "zone" is the distance from what the learner knows to what the learner can learn from the external source and represents a gap to be closed, which is evidenced by performance (Chak, 2001; Gredler, 2012; Kravtsova, 2009; Wass & Golding, 2014; Zuckerman, 2007).

The components of ZPD include: a subject matter to be learned, someone to learn the subject matter, some collaborative engagement, and some external source of expertise

(Chak, 2001; Gredler, 2012; Kravtsova, 2009; Levykh, 2008; Wass & Golding, 2014; Zuckerman, 2007). Moreover, the ZPD, originally individualized, can be transposed in aggregate form when considering items such as overall class environment and performance (Gredler, 2012). However, the extent to which the ZPD exists is not automatic in the presence of its perceived components (Levykh, 2008; Zuckerman, 2007). Instead, the extent of the ZPD is largely dependent on the willingness of the learner to learn, which is largely dependent of the environment of positive influence created by the external source (Levykh, 2008; Tudge, 1990; Zuckerman, 2007). This environment of positive influence must be perceived by the learner to be conducive for learning (Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Gredler, 2012; Levykh, 2008; Lund, 2008; Tudge, 1990; Zuckerman, 2007).

Using Peer Influence to Minimize the ZPD Gap Between the Student and Instructor

Ideally, pedagogy that minimizes the ZPD would also include an environment that promotes positive peer influence (Goos, Galbraith, & Renshaw, 2002; Lund, 2008). For this study, peer influence was defined as the influence exerted from one peer to another peer that serves as a catalyst for changes in attitude, belief, or behavior (Furrer, Skinner, & Pitzer, 2014; Korir & Kipkemboi, 2014). Implications from previous research suggest that creating classroom environments that promote positive peer influence can help to increase student performance and shorten the gap of knowledge from student to instructor (Faulk & Ichino, 2006; Goos, 2004; Goos, Galbraith, & Renshaw, 2002). In addition, research suggests that using positive peer influence as part of a pedagogical strategy can help to foster student accountability and classroom structure. Both student accountability and classroom structure have been reported to help improve performance.

Improved performance indicates a shortened ZPD between the students and the instructor (Faulk & Ichino, 2006; Furrer, Skinner, & Pitzer, 2014; Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Korir & Kipkemboi, 2014). Based on these implications, the GPA Program utilized peer influence to help close the ZPD between the students and the instructor.

Implications from research suggest, based on the components of the ZPD, that both the lecture pedagogy and the GPA Program may be capable of decreasing created ZPDs (Gredler, 2012; Kravtsova, 2009; Levykh, 2008; Zuckerman, 2007). The differentiating component for this study was the environment of peer influence created based on the different pedagogy employed (Kim & Baylor 2006; Kravtsova, 2009; Levykh, 2008; Ningjun & Herron, 2010; Porter, 2010; Vygotsky, 1962, 1978). This difference in environmental influence should create a different type of ZPD (Goos, Galbraith, & Renshaw, 2002; Kravtsova, 2009; Levykh, 2008). This also yields two measurable comparisons between the two pedagogies concerning the ZPD.

First, the empirical differences in overall class performance were observed (Gredler, 2012; Kravtsova, 2009; Wass & Golding, 2014). Second, peer influence as conceptualized through its definitional characteristics provided from current research was observed (Faulk & Ichino, 2006; Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Korir & Kipkemboi, 2014). This study seeks to compare the self-reported extent to which students in each group (lecture versus GPA Program) feel a positive peer influence. The GPA Program includes elements of an optimized ZPD which is predicted to yield better outcomes than that of traditional lecture.

How the GPA Program Works

Motivated by Vygotsky's social learning theory and the zone of proximal development, the GPA Program was a pedagogical approach aimed at addressing the need to improve learning in college algebra that provides an opportunity for peer group social engagement (Smith & MacGregor, 1998; Thomas & Higbee, 1999; Vygotsky, 1962, 1978). The GPA Program was a set of collaborative group activities in which students worked together to solve math problems and assess the work of other peer groups (Klecker, 2003; Smith & MacGregor, 1998; Webb et al., 2009). Students who participated in the GPA Program were placed into four groups, one in each corner of the classroom. Each group was asked to cooperatively complete an example problem of the content at their work space. After completion of the problem, each group left their work and rotated to their right towards another group's work space to assess their work (still shown) and were asked to re-solve the problem to the side, if they believed the work was incorrect. This action provided immediate visual feedback to each group, as they could clearly see that their work had been re-solved.

Each associated action within the GPA Program represented the application of a practice suggested by current research. The application of this program was timed for 25 minutes and was applied twice in a 50 minute math class which met three time over the course of a week. Therefore, this program was applied a total of six times; two times per class for three class periods. Four learning objectives were covered in each 50 minute time span which was very comparable to the pace of a normal lecture. The following is an explanation of how the procedural attributes of the GPA Program reflected previous research implications.

Lecture notes. Before the start of the class sessions, lecturer's notes were provided for each student participating in the GPA Program. Students do not usually take completely accurate notes because of the inconvenient challenge of taking time to copy down notes while trying to listen and understand the material all at once (Armbruster, 2002; Keiwra, 1985b; Landrum, 2010). However, the benefit from students obtaining lecturer's notes comes when students actually review them to help facilitate learning (Landrum, 2010; Sreinert, 2004). Yvonne Sreinert's 2004 study of student perceptions of effective small groups revealed student affinity towards reviewing learning aids within student groups to help facilitate learning. The GPA Program applied this notion by having students keep their individual copy of the lecture notes so that the notes could be reviewed collectively for the duration of all group activities. Therefore, in conforming to the implications from previous research, this study provided lecture's notes to each student as a matter of student convenience as well as a guide for collaborative learning within groups.

Lecture time allocation. Class time is finite so if time is going to be allowed for social learning through group activities, then lecture time must be shortened (Higbee & Thomas, 1999; Yazedjian & Kolkhorst, 2007). In applying this notion, the lecture time for the GPA Program was cut to five minutes per learning objective. Lecture notes were given out before the lecture, so students already had the lecturer's notes and therefore it was anticipated that students would have an easier time absorbing the material which saves time for implementing the group activities (Higbee & Thomas, 1999; Keiwra, 1985b; Landrum, 2010). As a result, only an abbreviated review of the given learning objective and a quick but thorough demonstration of associated example problems (learning objective activities) was needed per learning objective. This style of lecture would take five minutes for each learning objective activity. Two sequential learning objectives were covered for a total of ten minutes of lecture time. Immediately afterwards, the student group activity portion of the program was undertaken. The student group activity portion of the program would take a total of 15 minutes, concluding one application of the program. The sequence of the ten minute lecture plus the 15 minutes allocated for the student group activities represented the 25 minute application of the program. Current research suggests allocating time for social learning is better than lecturing for all of the class time (Higbee & Thomas, 1999; Persky, & Pollack, 2010; Yazedjian & Kolkhorst, 2007)

Group performance. For this study, students were placed into groups in order to collaboratively complete math problems during class time which represented a non-traditional pedagogical approach to teaching math that encourages positive student group interaction (Higbee & Thomas, 1999). Students were systematically placed into four groups versus selectively because there was initially no way to accurately judge which students were stronger in the content than others. The assessment of pretest scores would have been the ideal tool for selective group placement, however, the GPA program began immediately after the last pretest was taken up to alleviate any outside influences on the subject content. This means, however, pretest scores were not available for assessment until after the first day of the program. Moreover, implications from the pretest scores suggested the vast majority of students had no useful experience in the content material. Therefore, there did not appear to be enough evidence of differentiation in the pretest scores to make an accurate judgement as to which students were stronger than others. As a result, students were systematically placed into four groups.

Each group, positioned in each corner of the room, was given an example problem associated with the previous learning objectives. Since there were two learning objectives covered, the first and third groups received an example problem associated with the first learning objective and the second and fourth groups received an example problem associated with the second learning objective. Implications from previous research suggest the importance of organizing clear time boundaries for student group activities (César & Santos, 2006; Higbee & Thomas, 1999). In response to the research, each student was challenged to work collaboratively in their groups to successfully complete their example problem within five minutes. This group activity implemented in the GPA Program represented an application of Vygotsky's social learning theory that suggests student group interaction, involving communication and collaboration, are central components to student learning and performance (Higbee & Thomas, 1999; Vygotsky, 1962, 1978).

Group assessment and feedback. Group assessment and feedback was another example of group activities implemented in the GPA Program designed to reflect Vygotsky's social learning theory (Higbee & Thomas, 1999; Vygotsky, 1962, 1978). After the group performance portion of the GPA Program, each group rotated to the corner to their right hand side to take another five minutes to collaboratively assess the work of the previous group. The previous group's work was assessed by either deciding to leave the original problem solution as is, or by re-solving the problem to the side of the original group's work displaying a different result, but being careful not to erase the work of the previous group. The first and third groups worked to solve the same type of problem associated with the first LOA, and the second and fourth groups worked to solve the same type of problem associated with the second LOA. In this order, groups who tried solving one type of problem rotated over to assess a different type of problem. This way, student groups were exposed to the challenge of both types of learning objectives. The aim was for students to learn as much from assessing the previous group's work on the different type of problem as they would have had they initially worked the problem out themselves. While assessment is different from performance, it does not seem unreasonable to assume the same knowledge would be required for either completing a math problem or assessing a previously completed a math problem. After groups finished their assessments, they took another five minutes to gain visual feedback of their own previous group work. An untouched example problem indicated group success, or groups saw a duplicate problem reworked with a different result displayed beside their original work.

Instructor's role during group activities. The instructor's role was based on the tenants of formative assessment as a way to gauge students' comprehension of the content (Huba & Freed, 1999) and was displayed by observing and monitoring all group activities. During the first five minutes when groups were solving a problem, the instructor observed and monitored student engagement as well as overall performance based upon group progress. During the second five minutes when groups are assessing the work performed by the previous group, the instructor observed and monitored the assessment efforts of each group. The instructor assessed any re-worked problems because those problems would not be reviewed by the students other than for feedback purposes and, therefore, must be displayed accurately. The instructor could may provide assistance with this by answering any questions, if need be.

Purpose of the Research and Research Questions

In testing Vygotsky's social learning theory in college algebra, this study investigated whether or not utilizing the GPA Program as a pedagogical approach to teaching college algebra had a more positive impact on four psychosocial factors of performance than that of the traditional lecture pedagogy. More specifically, this research was intended to determine whether the pedagogical incorporation of the GPA Program had a more positive impact versus the impact of traditional lecture on the psychosocial factors of student performance (math interests, self-efficacy, effort, and peer influence) as well as student performance itself. Also, this research sought to compare the distances of the ZPD created in the GPA Program versus lecture.

Based on current and previous research, this study was intended to answer the following research questions:

1. Does the GPA Program increase student self-reported math interest greater than the lecture pedagogy?
2. Does the GPA Program increase student self-reported effort greater than the lecture pedagogy?
3. Does the GPA Program increase student self-reported self-efficacy greater than the lecture pedagogy?
4. Does the GPA Program provide evidence of a more minimized ZPD than lecture pedagogy as evidenced by student perception of peer influence?

5. Does the GPA Program increase student performance (as measured by the ability of students to successfully complete a set of pre and posttest math questions) greater than the lecture pedagogy?

The general hypothesis of all five research questions was that the GPA Program would perform better on the dependent variables (Vygotsky, 1962, 1978; Meyer & Eley, 1999; Thomas & Higbee, 1999; Kim & Baylor 2006; Wang, Bruce & Hughes, 2011).

Summary

Before most students graduate from college, they must pass a college algebra course. (Eagan & Jaeger, 2008; Kendricks, 2011; McGlaughlin, Knoop & Holliday, 2005; Rech & Harrington, 2000). The concern regarding how to improve student performance in math courses is not new (McGlaughlin et al., 2005; Stephens & Konvalina, 1999). In response to current research, the GPA Program was designed to positively impact key factors of student learning which have been found to be legitimate contributors of student performance in math (Meyer & Eley, 1999; Thomas & Higbee, 1999). These factors of performance for this study are math interest, effort, self-efficacy and peer influence. In this chapter, and introduction of, the conceptual framework for, and a research-based description of the GPA Program were all discussed, including peer influence as an indicator of the ZPD. Next in Chapter II, each other factor measured in this study will be defined and conceptualized based on current and previous literature. Problems associated with each factor will also be explained and a researched-based description of how the GPA Program was expected to improve each factor will be given. In Chapter III, the methods of this study will be discussed followed by the results of the research in Chapter IV. This dissertation will conclude with a Chapter V discussion of the results as well as implications from this study.

Definition of Terms and Acronyms

The following are terms, their definitions, and acronyms that will be used throughout the paper.

Gatekeeper Courses: Particular courses, usually pre-major in nature, offered by the university in which students are required to show enough evidence of proficiency in order to move forward in their respective majors.

Quantitative Cognition: The ability to successfully show evidence of having solved problems that are numeric in nature. Research also describes this as quantitative reasoning or quantitative literacy.

GPA Program: Refers to the acronym for the Group Performance and Assessment Program, which has been developed as a teaching pedagogy to help improve student performance through psychosocial as well as empirical means.

Vygosky's Social Learning Theory: Characterized as a learner-centered, collaborative approach to learning where students view learning as a social endeavor, which promotes independent and reflective thinking.

The Zone of Proximal Development (ZPD): The extent to which ability improves based on the collaborative engagement and allowed influence of an external source of expert ability.

Math Interest: A generally positive attitude towards a specific experience (in this case, a college algebra class.

Effort: The amount of energy, attention, or consideration exerted on the behaviors or actions designed to cause the successful completion of a task(s) or solution to a problem(s).

Self-Efficacy: The positive belief in one's own ability to successfully perform the completion of a task(s) or solve a problem(s).

Peer Influence: The influence exerted from one peer to another peer that serves as a catalyst for changes in attitude, belief, or behavior.

CHAPTER II

LITERATURE REVIEW

Objectivism and College Algebra

Objectivism is an epistemological view that reality is revealed through reason and is independent of perception and sense (Carson, 2005; Cronjé, 2006; Elkind, 2004; Jonassen, 1991; Luitel, 2013; Majka, 2013; Peikoff, 1993). In an attempt to conceptualize the co-existence of objectivism and constructivism in the same learning domain with a 2 X 2 (four quadrant) design, Cronjé, (2006) recites Jonassen (1991) in the characterization of objectivism as an "externally mediated reality" (Cronjé, 2006; Jonassen, 1991). Jamin Carson's 2005 published article responding to David Elkind's (2004), "The problem with constructivism" characterizes objectivism as interpreting knowledge as truth independent of individual perception and that there exists an ordinal value regarding knowledge procurement.

College algebra as a mathematics course is an example of a learning space that highlights the characteristics of the objectivism epistemology and pedagogy (Carson, 2005; Cronjé, 2006; Elkind, 2004; Jonassen, 1991). Within the college algebra course, the content explored represent algebraic information, accepted as absolute truth, for which students must show evidence of having learned. While other pedagogical approaches are used for teaching math, lecturing is usually the most common pedagogical approach for teaching math (Wynegar & Fenster, 2009). The lecturer is the primary source of truth for that learning space, given their expert knowledge of the content. Given the computational nature of that content, the lecture is basically a set of instructions for solving the math problems associated with a given content area (there are a lot of rules as well) which equates to students just being told what to do (Jonassen, 1991; Luitel, 2013; Majka, 2013; Peikoff, 1993). This pedagogy has minimum social utility which means that learning could be potentially limited by the absence of collaborative and cooperative learning (Vygotsky, 1962, 1978). Therefore, a fundamental question arises regarding how to balance social learning intentions with the nature of the course. In this current research, the GPA Program represents an attempt to address the issue of making sure students are learning the content of college algebra while minimizing the objectivism nature of the course (Jonassen, 1991; Luitel, 2013; Majka, 2013; Peikoff, 1993; Vygotsky, 1962, 1978).

Psychosocial Factors of Student Performance

Psychosocial factors of student learning have been found to be legitimate sources of variance in student performance in math (Meyer & Eley, 1999; Robbins, Lauver, Le, Davis, Langley, & Carlstrom, 2004; Thomas & Higbee, 1999). For this study, psychosocial factors of performance included: math interest, effort, self-efficacy, and peer influence (Stevens, & Olivárez, 2005; Matarazzo et al., 2010; Chen, 2005; Kranzler, & Pajares, 1997; Nasiriyan et al., 2011; Robbins, et al., 2004; Stankov et al., 2014; Vygotsky, 1962, 1978). There is consistent agreement that maintaining student performance in college algebra courses is a challenge (Cortés-Suárez & Sandiford, 2008; Stephens & Konvalina, 1999; Thiel et al., 2008). Next in this section, the definition of, problems associated with, and a researched-based description of how the GPA Program is expected to improve math interest, effort, and self-efficacy are explained.

Math Interest

For this study, math interest was defined as a general state or disposition of a person that emerges from their reaction to interacting with their environment and is widely considered a factor of performance (Allen & Carifio, 1999; Fisher et al., 2012; Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Matarazzo et al., 2010; Renninger & Hidi, 2011; Riconscente, 2014; Stevens & Olivárez, 2005). Moreover, math interest was characterized by situational (short-term) and individual (long-term) math interest (Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Riconscente, 2014; Stevens & Olivárez, 2005).

Situational and individual math interest. Bradford Allen and James Carifio, (1999) developed a Math Affect Trait Questionnaire (MATQ) whose instrument validation produced the notion that if the situation of students with interest in math who may not perform well in math classes persists unaddressed, then those students will eventually lose interest in math. While Allen and Carifio do not deeply define math interest, they do however suggest, based on the statements of their MATQ, that math interest is associated with some sense of enjoyment and curiosity.

Taking matters further, Hidi and Harackiewicz (2000) published a literature review on student interest implying math interest as defined and characterized by two dimensions: situational and individual math interest. While Allen and Carifio (1999) sought to maintain existing student math interest, Hidi and Harackiewicz’s study (2000) did not assume that students were initially interested in math. Instead the authors, considering the attributes associated with each, suggested situational or individual math interest may be developed. The patterns of development associated with situational and individual math interest as described in Hidi and Harackiewicz's study (2000) are similar to John Dewey's notion of "catching" and "holding" student interest. This current study interprets the aforementioned research as having described situational activities with which to "catch" math interest such as puzzles and group work, while "holding" student math interest was associated with elements of individual intrinsic meaning and personal involvement (Dewey, 1913; Hidi & Harackiewicz, 2000; Mitchell, 1993).

Tara Stevens and Arturo Olivárez, Jr. (2005) developed their math interest measurement instrument conceptualizing each dimension in the same manner as Hidi and Harackiewicz (2000). This current study used the items from the MATQ (Allen & Carifio, 1999) to measure math interest, but modified them to reflect the conceptualization of the situational and individual math interest dimensions (Dewey, 1913; Hidi & Harackiewicz, 2000; Mitchell, 1993; Stevens & Olivárez, Jr., 2005). For the current study, the enjoyment represented in the questionnaire statements of the MATQ (Allen & Carifio, 1999) is reflected in the short-term or situational math interest and the curiosity represented in the questionnaire statements is reflected in the long-term or individual math interest (Hidi & Harackiewicz, 2000; Stevens & Olivárez, Jr., 2005).

Current research on student math interest calls upon educators to figure ways of increasing student math interest (situational or individual) for the purpose of improving student performance. The implications are in tune with Higbee and Thomas' (1999) insistence that employing pedagogy other than lecture can be beneficial to student achievement in mathematics classes. This current study was an attempt to answer the implicit call of re-working traditional pedagogy to spur short term math interest and encourage individual math interest in order to improve student performance. In addition, it sought to determine whether the GPA Program improves self-reported student math interest better than the solely lecture-based pedagogy (Allen & Carifio, 1999; Dewey, 1913; Hidi & Harackiewicz, 2000; Higbee & Thomas, 1999; Mitchell, 1993; Stevens & Olivárez, Jr., 2005).

Problems With Math Interest

Many students find algebra not only hard to comprehend due to gaps in previous learning, but also uninteresting (Cortés-Suárez & Sandiford, 2008; McGlaughlin et al., 2005; Stephens & Konvalina, 1999; Thiel et al., 2008). Current and previous research on student interest, and particularly in math courses, suggests an acceptance of the notion that math interest is a factor of performance, a majority of students lack interest in math, and the lack of student interest contributes to low student performance (Dewey, 1913; Cortés-Suárez & Sandiford, 2008; Hidi & Harackiewicz, 2000; McGlaughlin et al., 2005; Mitchell, 1993; Stephens & Konvalina, 1999; Thiel et al., 2008).

When examining the developing math interest in children, however, math interest has been shown to have a positive correlation with performance. Higher math interest levels equated to higher performance and vice-versa, which implies an upward cycle of matriculation towards sustained interest and performance in math (Fisher et al., 2012). Unfortunately, interest in math for most students decreases as they get older (Hidi & Harackiewicz, 2000). Therefore, by the time many students see algebra at the collegiate level, interest in math is at a minimum and the stage seems already set for poor performance (Cortés-Suárez & Sandiford, 2008; Hidi & Harackiewicz, 2000;

McGlaughlin et al., 2005; Stephens & Konvalina, 1999; Thiel et al., 2008). Current and previous research suggests that most students enrolled in college algebra courses are more interested in subjects other than math and would rather do something other than participate in college algebra (Brophy, 2008; Chouinard, Karsenti, & Roy, 2007; Hidi & Harackiewicz, 2000; McFarlane, 2010; Sibulkin & Butler 2008; Tollefson, 2000).

Activities may be employed to “catch” student math interest (Dewey, 1913; Hidi & Harackiewicz, 2000; Mitchell, 1993), but success at “catching” can be rare if at all. Research suggests that since solving math problems is usually a challenge for many students, they tend not to be very interested in trying to solve them (Chouinard, Karsenti, & Roy, 2007; McFarlane, 2010; Sibulkin & Butler 2008). Therefore, it comes as no surprise that solving math problems was not listed as one of the activities which stimulate student interest in math (Dewey, 1913; Hidi & Harackiewicz, 2000; Mitchell, 1993). Since solving math problems is the core of any activity employed in math courses, it is challenging to implement activities in math courses that students will find interesting. So if “puzzles” means, for a math course, the instructor manipulating the structure of some puzzle system to involve students solving math problems, or if “group work” refers to the group working to solve math problems, then it may be more difficult to energize student situational math interest simply due to the mathematical nature of the activity. The pedagogical achievement of “holding” student math interest is altogether more difficult and even less frequent. With respect to the pace required in order to deliver all of the semester’s content, usually the very attempt to “hold” students’ math interest, as interpreted by this study (Dewey, 1913; Hidi & Harackiewicz, 2000; Mitchell, 1993), could be considered unwise given the energy it may take to develop a curiosity for a deeper understanding of even a small portion of the entire content material over the course of the semester.

How the GPA Program was Expected to Improve Math Interest

Conclusions from the research of Rowan-Kenyon and colleagues (2012) suggest evidence of a positive interaction between student group collaboration and math interest with early adolescent students. The current study applied this notion in a college algebra setting by the implementation of activities within the GPA Program that involve student groups working together collaboratively in order to increase math interest. Therefore, based on the findings of Rowan-Kenyon and colleagues (2012), it is expected that an increase in math interest should occur from the implementation of the following group activities within the GPA Program: students working in groups to successfully complete an example math problem, students working in groups to assess the previous work of the former group now repositioned to the right, and students together looking back on their prior group work to see the visual feedback from the group that has just assessed their work (Rowan-Kenyon, Swan, & Creager, 2012; Slavin, 1995).

Effort

For this study, effort was defined as the amount of energy, attention, or consideration exerted to complete a task or find a solution to a problem (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Nasiriyan et al., 2011; Pintrich & Smith, 1993; Strage, 2007). Implications from previous research provide a theoretical conceptualization of effort as being a result of work ethic combined with persistence, emerging in the presence of challenge (dullness), and increasing difficulty (Duncan and McKeachie, 2005; Eisenberger & Masterson, 1983; Pintrich & Smith, 1993).

Work ethic and persistence. Work ethic is the willingness to exert the sufficient energy required for successful performance (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Strage, 2007). Work ethic combined with persistence tends to lead to effort (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Strage, 2007). Duncan & McKeachie (2005) reviewed the development of and components within Pintrich and Smith's (1993) the Motivated Strategies for Learning Questionnaire (MSLQ). The authors characterized effort as "persisting in the face of difficulty or dullness" (Duncan & McKeachie, 2005). Strage (2007) administered a 96-item Likert-style survey to 1296 students across 46 classes in 25 academic departments to measure self-reported effort. The author's constructs of effort included "perseverance" as defined by persistence in the face of "challenge", and "task involvement", which was defined as focus in the face of "difficulty". The authors found, in accordance with existing research, that regardless of the course context (there were 8 used), effort played a major role in the academic success of the students insomuch as the more students worked, the more successful they became. Strage's ideas, in accordance with previous research, provide a theoretical conceptualization of effort, as a result of work ethic combined with persistence, emerging in the presence of challenge (dullness), and increasing difficulty (Duncan and McKeachie, 2005; Eisenberger & Masterson, 1983; Pintrich & Smith, 1993).

Contrasts in research on effort. Interestingly, not every study has reported a strong correlation between effort and performance. Schuman, and colleagues (1985) performed a series of studies beginning in the fall of 1973 and ending in 1984 where they examined the correlation between effort and performance. The authors characterized effort behaviorally in terms of the energy students invested for studying both generally and domain specifically. The authors found “at best very little” evidence to support the accepted notion that effort strongly correlates to performance. This study raised serious questions of whether effort is a factor of performance as is historically presumed (hard work = success). Given the longevity and scope of their research, the results and implications could not be ignored.

To address the historical notion that effort expenditure, as conceptualized by work ethic (in this case, demonstrated through the extent to which students study) leads to success (student performance), Michaels and Miethe (1989) administered a questionnaire on study habits to 676 undergraduate students at a large Mid-Atlantic university, aimed at citing errors of specification in the work of Schuman and colleagues that misled their conclusions. The authors, keeping with the idea of effort as characterized by Schuman and colleagues, (the energy exerted to study), investigated its relationship to performance in a more robust manner by controlling for additional variables and factors not used in the studies in question. These variables and factors were associated with the quality of study. For example, Michaels and Miethe controlled for such variables as study techniques and best practices, future expectations (i.e. the expectation of more schooling beyond the current degree), and the utility of high grades (socially, economically, etc.). Such variables and factors were not controlled for in the research conducted by Schuman and colleagues.

Moreover, there were predictors that Michaels and Miethe cited as more relevant to performance than were the predictors used by Schuman and colleagues. Schuman and colleagues used SAT scores, class attendance, and study time as predictors of performance. Their model accounted for only 15% of the variation of overall performance.

Contrary to the results reported by Schuman and colleagues, results from Michaels and Miethe indicated that both main and interactive effects of effort tended to be rewarded with performance. The new variables and factors associated with the quality of study had a significant impact on performance across the board, except for those who were labeled as “crammers” (Michaels & Miethe, 1989, pg. 313). Michaels and Miethe defined crammers as those students who put forth very little effort until the night before an important assessment (quiz or exam). It is plausible for a test on a population of mostly “crammers” to yield no evidence of the relationship between effort and performance. The authors also obtained similar results to Schuman and colleagues in that the variance, while significant, was still modest and the new “additive model” accounted for the same amount of variance on overall performance (15%). This gave rise to the notion that there are other concepts of effort to be measured for future research. The research of Schuman and colleagues (1985) and Michaels and Miethe (1989) highlights the difficulty in contextualizing, and measuring effort expenditure. Evidence from subsequent research on effort appears to suggest a recognition of these conclusions.

Problems With Effort

Cortés-Suárez and Sandiford, (2008) examined the causal attributions for success or failure of students in college algebra. The authors used student self-reported attribution statements to explain the cause of their performance. Statements showed evidence that students understand exerting more effort to do well in the class promotes better class performance. Results indicated that effort attributions correlated with performance. The implications of this type of research suggest that when students do not perform well in college algebra, it is because they lack the effort required for successful performance (Covington & Omelich, 1985; Matteucci & Gosling, 2004; Weiner, 2000).

Students might not exert the required effort because previous research suggests the effort exerted on an endeavor can be subject to the perceived difficulty of that endeavor (Cortés-Suárez & Sandiford, 2008; Covington & Omelich, 1985; Lannie & Martens, 2004; Neef & Lutz, 2001; Reed & Martens, 2008; Thiel, Peterman & Brown, 2008). This notion coincides with elements of the Self-Worth Theory which suggests that people, in order to maintain a positive sense of themselves, will choose to either increase or decrease their effort in the face of difficulty (Covington, 1984; Covington & Omelich, 1985). Regarding the difficulty in performing in College Algebra, an increased amount of effort may be possible, but usually when students decide that the material is too challenging, they tend to decrease their effort (Cortés-Suárez & Sandiford, 2008; Eisenberger & Masterson, 1983; Stephens & Konvalina, 1999; Thiel et al., 2008). In this context, the ideal pedagogy would balance the overall challenges of the course so that effort is maximized over the whole of the class (Cortés-Suárez & Sandiford, 2008; Lannie & Martens, 2004; Pintrich & Smith, 1993; Strage, 2007). The difficulty of mathematics and content areas within mathematics is well documented (Stephens & Konvalina, 1999), so students are expected to, at some point, be challenged by the content of the math course (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Strage, 2007).

How the GPA Program was Expected to Improve Effort

Evidence from current and previous research seem to suggest a utility in student group collaboration as a way to increase student effort (Hooker, 2011; Hüffmeier, Wessolowski, Van Randenborgh, Bothin, Schmid-Loertzer, & Hertel, 2014; Walker & Angelo, 1998). The current study employs this view in a college algebra setting by the implementation of activities within the GPA Program that involve student groups working together collaboratively in order to increase the effort of the students in the class. Therefore, based on current and previous research, it is expected that an increase in effort should occur from the implementation of the following student group activities within GPA Program: students working in groups to successfully complete an example math problem, students working in groups to assess the previous work of the former group now repositioned to the right, and students together looking back on their prior group work to see the visual feedback from the group that has just assessed their work (Hooker, 2011; Hüffmeier et al., 2014; Walker & Angelo, 1998).

Self-Efficacy

For this study, self-efficacy was defined as a belief in one's own ability to successfully perform the completion of a task or solve a problem (Betz & Hackett, 1983; Fennema & Sherman, 1976; Hall & Ponton 2005; Kranzler & Pajares, 1997; Lim & Chaptman, 2013; Nasiriyan et al., 2011; Nicholson, Putwain, Connors, & Hornby-Atkinson, 2013; Stankov et al., 2014; Tariq & Durrani, 2012). Conceptual constructs used in this research for self-efficacy were expectations and self-awareness (Lim & Chapman, 2013; Tariq & Durrani, 2012).

Expectations. What students expect from themselves also indicates how confident they are in their abilities (Betz & Hackett, 1983; Kranzler & Pajares, 1997; Nicholson et al., 2013; Tariq & Durrani, 2012). Current research suggests that students who possess a greater expectation of themselves to perform, are more confident that they can perform, and tend to outperform those students who have less expectation of themselves (Kranzler & Pajares, 1997; Lim & Chapman, 2013; Tariq & Durrani, 2012).

Self-Awareness. Self-awareness refers to the ability of students to realistically see themselves in an academic manner as opposed to an inflated or inaccurate sense of self-efficacy (Lim & Chapman, 2013; Tariq & Durrani, 2012). How they see themselves academically is a factor of how self-confident they will be in completing tasks (Kranzler & Pajares, 1997; Silvia & Duval, 2001; Tariq & Durrani, 2012). It is important for students to see themselves as capable of completing the tasks required for successful navigation of the course material (Betz & Hackett, 1983; Kranzler & Pajares, 1997; Lim & Chapman, 2013; Silvia & Duval, 2001; Tariq & Durrani, 2012).

Problems With Self-Efficacy

Many students are not confident in college algebra courses because they are usually unprepared for the course material (Lazari & Reid, 2013). This could mean that they do not think they have the ability it takes to complete required tasks in the course (Kranzler & Pajares, 1997; Lim & Chapman, 2013; Tariq & Durrani, 2012). This also means students do not expect to do very well in their college algebra course and in many cases, they do not care as long as they get a passing grade (Betz & Hackett, 1983; Kranzler & Pajares, 1997; Nicholson et al., 2013; Tariq & Durrani, 2012). Implications of the aforementioned research suggest that students do not and would not see themselves as academically capable of success in math (Kranzler & Pajares, 1997; Silvia & Duval, 2001; Tariq & Durrani, 2012). This can make for low self-efficacy in college algebra classes.

How the GPA Program was Expected to Improve Self-Efficacy

Self-efficacy and the instructor's input. Findings from Velez & Cano (2012), Rodger and colleagues (2007), and Gorham (1988) highlight the potential impact actions and behaviors of the instructor can have on student self-efficacy. Applying these findings, the GPA Program provides actions for the instructor to take in order to promote an increase in self-efficacy. Therefore, based on this previous research, an increase in self-efficacy was expected to occur from the following actions of the instructor during the implementation of the GPA Program: providing instructor generated lecture notes, keeping each lecture to a five minute review of example problems for each learning objective, and facilitating all student activities within the program by observing and monitoring student groups (Gorham, 1988; Rodger, Murray, & Cummings, 2007).

Self-efficacy and group collaboration. Previous research has produced evidence of increases in self-efficacy from group collaboration (Dunlap, 2005; Eric Zhi Feng, Chun Hung, & Chiung Sui, 2010; Poellhuber, Chomienne, & Karsenti, 2008). The research of Poellhuber and colleagues (2008) was an effort to maximize student retention and self-efficacy through group engagement in a distance-learning setting with favorable results. Eric Zhi Feng and colleagues (2010) examined preservice teachers learning LEGO robotics. Results showed evidence of an increase in self-efficacy based on changes in teaching method to employ collaborative learning. Joanna Dunlap's 2005 research explored nontraditional teaching methods with students in a software engineering course and named collaboration among the primary catalysts for students' improved self-efficacy.

The current study employs this view in a college algebra setting by the implementation of activities within the GPA Program that involved student groups working together collaboratively in order to increase the self-efficacy of students in the class. Therefore, based on current and previous research, it was expected that an increase in self-efficacy should have occurred from the implementation of the following student group activities within the GPA Program: students working in groups to successfully complete an example math problem, students working in groups to assess the previous work of the former group now repositioned to the right, and students together looking back on their prior group work to see the visual feedback from the group that has just assessed their work.

Other Pedagogical Approaches Aimed at Improving Math Performance

Higbee and Thomas (1999) explored the relationship between psychosocial variables (i. e. confidence, attitude, and anxiety) and performance by observing the effect of employing group collaboration in developmental algebra courses at the University of Georgia. Results from the research indicated a significant increase in all psychosocial variables in the intervention group compared with just lecturing. However, the authors also discussed the importance of understanding that not every pedagogical approach may work due to the individual differences in the learning styles of students as well as the academic setting within which instructors are working. With that in mind, the authors encouraged educators not to give up thinking of ways to employ pedagogical strategies other than lecturing. Furthermore, the authors cited the need for more research into what, other than lecturing, may or may not work best for improving performance. This current study represents a contribution to the scholarly discussion with the employment of the GPA Program as a pedagogical approach different from solely lecturing.

Other Pedagogical Approaches That Have Used Social Learning in College Algebra

In 2011, the Mathematical Association of America (MAA) published a book called *Partnership Discipline Recommendations for Introductory College Mathematics and the Implications for College Algebra*. Discussed in this book are several examples of where a "model-based" pedagogical approach was tested versus the traditional lecture. This non-traditional approach used technology to explore real-world applications of content areas in College Algebra and employed social learning through group collaboration. Collectively, results, while mixed, highlighted the impact of including social learning through group collaboration as a part of this pedagogical approach. The following examples from this book, while very different in a number of ways, are descriptions of success and failure had by this pedagogical approach, and underscored the potential value of social learning in College Algebra.

At Florida Southern College, Daniel Jelsovsky, Kenneth D. Henderson Jr., and Susan Serrano (2011) were three instructors who qualitatively tested the model-based pedagogical approach versus lecture. The authors also added to their report a written review of their individual experiences with the pedagogical approach. The authors claimed that the new approach had a transformative impact on the Mathematics Department. The model-based pedagogical approach was adopted and the traditional classes were deleted. Interestingly, the authors all mentioned, in their individual reviews, how their teaching has now changed to incorporate more social leaning.

At the University of North Dakota, where College Algebra is usually taught by graduate teaching assistants, Michele Iiams and Richard Millspaugh (2011) compared the impact of the mathematical modeling approach versus the lecture approach on the following factors: students' basic algebraic skills, algebraic application and interpretation skills in College Algebra as well as student overall performance in College Algebra and, subsequently, Applied Calculus. For this study, results did not reveal significant gains in the mathematical modeling approach as compared to lecturing for these factors. It was concluded that the increased instructor workload, due to the pedagogical characteristics of the model-based approach, did not pay off. As a result, this approach was not adopted for that department's College Algebra courses. Implications from the feedback of the experiment group instructors in this study suggest that the social learning was not the problem and that some form of an integration of social learning and lecturing was needed. These implications echo previous research that discussed the need to promote a balance of time between lecturing and social learning within the class period (Goos, 2004; Thomas & Higbee, 1999). In this current study, the GPA Program has designated time for lecturing and for social learning through group collaboration.

Other Non-Traditional Pedagogical Approaches Used in College Algebra

Other non-traditional pedagogical approaches in college algebra include those described by Gallo and Odu (2009). In their study, the authors explored if college algebra was more effective in the morning versus the evening. The authors reported, "… class schedules uniquely accounted for 9% of the variance in final examination scores" (p. 313). Other non-traditional pedagogical approaches include examining the impact of computerized lessons (Stephens & Konvalina, 1999), online tutoring (Kersaint et al., 2011), and mandatory tutoring disguised as supplemental instruction (Porter, 2010).

Retrospective Assessment

Retrospective assessment is the act of obtaining pretest data in accordance with posttest data. This means pretest data is obtained after the intervention. This is the major difference between retrospective assessment and the traditional pre-posttest design where the pretest data is obtained before the intervention is undertaken (Allen & Nimon, 2007; Campbell, & Stanley, 1963; Howard, Ralph, Gulanick, Maxwell, & Gerber, 1979; Townsend, Lai, Lavery, Sutherland, & Wilton, 1999; Townsend & Wilton, 2003).

Responses can be altered during the course of the intervention as participants may have falsely elevated initial measures of individual belief or opinion (i.e., individuals thinking they know more than they actually do when they don't know what they don't know) about a subject matter (Allen & Nimon, 2007; Howard et al., 1979; Townsend et al., 1999). This results in an appearance of less variance from pretest to posttest than actually occurred and causes the intervention to potentially seem less effective than empirical evidence would suggest (Howard et al., 1979; Townsend et al., 1999; Townsend & Wilton, 2003). Retrospective assessment mitigates this potential situation for affective responses.

Retrospective assessment asks participants, after the intervention, to recall how they felt before the intervention (Allen & Nimon, 2007; Campbell, & Stanley, 1963; Howard et al., 1979; Townsend et al., 1999). Given the functionality of retrospective assessment, current research supports the notion that retrospective assessment seems best used for measuring psychosocial responses (Allen & Nimon, 2007; Campbell, & Stanley, 1963). Because cognitive variables (for this study, performance) require a measurement of empirical (not anecdotal) evidence, a traditional pre-posttest design provides the most accurate measure of variance from empirical levels at Time 1 to empirical levels at Time 2 (Boyas, Bryan, & Lee, 2012; Campbell, & Stanley, 1963; Kaw & Yalcin, 2012).

This study used a retrospective assessment to measure the psychosocial factors of performance (Allen & Nimon, 2007; Campbell, & Stanley, 1963; Howard et al., 1979; Townsend et al., 1999; Townsend & Wilton, 2003) and a traditional pre-posttest design to measure performance (Boyas, Bryan, & Lee, 2012; Campbell, & Stanley, 1963; Kaw & Yalcin, 2012).

Summary

The challenge in College Algebra to establish and maintain interest, effort, self-efficacy, and peer influence is widely accepted. In addition, the objectivism epistemology of College Algebra influences the pedagogy most typically used, which is solely lecturing. This implies a potential lack of, and opportunity for, social engagement as a resource for student learning (Vygotsky, 1962, 1978). The Group Performance and Assessment Program (GPA Program) was a teaching pedagogy aimed at helping to improve performance through psychosocial factors (math interest, effort expenditure, and self-efficacy) as well as empirical student performance in college algebra. The GPA Program was theoretically framed by Vygotsky’s social learning and zone of proximal development theories (Vygotsky, 1962, 1978) and was compared to the impact of the traditional lecture pedagogy to determine which better improves these psychosocial factors of learning as well as student performance.

The importance of student performance in the college algebra class cannot be overlooked. The major psychosocial predictors of student performance, including actual student performance, were the primary focus of this research. The GPA Program pedagogy was designed to address these psychosocial factors and was tested against the impact of the traditional lecture pedagogy to see which better impacted these factors of performance as well as performance itself.

In Chapter II, the computational nature of College Algebra was discussed. In addition, the psychosocial factors (interest, effort, and self-efficacy) were each defined. Also, an explanation of the problems associated with each factor, as well as how the GPA Program was expected to improve these factors was provided. Next, in Chapter III, the methods of this study are provided.

CHAPTER III

METHODS

The purpose of this study was to investigate whether or not utilizing the GPA Program as a pedagogical approach to teaching college algebra had a more positive impact on math interests, self-efficacy, effort, peer influence, and performance. In Chapter I, an introduction of, the conceptual framework for, and a research-based description of the GPA Program were all discussed, including peer influence as an indicator of the ZPD. Next in Chapter II, each factor measured in this study was defined and conceptualized based on current and previous literature. Problems associated with each factor were also explained and a researched-based description of how the GPA Program is expected to improve each factor was given. In this current section, the methods for this study which include the selection of participants, the instruments, the design, analysis, and procedures will be described.

Participants

Participants, who remained anonymous throughout the study, included those students who were enrolled in sections of college algebra taught by the researcher in a midwestern state university's mathematics department. All research was conducted during regularly scheduled class times and at the regularly scheduled class locations. The total sample size of participants was 42 (100% response rate). There were 20 student participants in the lecture group and 22 student participants in the intervention group

(GPA Program). Students were assigned to each group based on one of two class sections they chose to enroll in at the beginning of the semester. The treatment group was randomly assigned to one of the two courses. Of the 42 participants (20-lecture, 22-GPA Program), 54.8% (n = 23) were male and 45.2% (n = 19) were female, 73.8% (n = 31) reported being between the ages of 18 and 21 years old, and 26.2% (n = 11) reported being older than 21 years old. Finally, 41 of the 42 participants reported their college enrollment levels: 56.1% (n = 23) freshmen, 26.8% (n = 11) sophomores, 9.8% (n = 4) juniors, and 7.3% (n = 3) seniors. This study was approved by the university's IRB.

Instruments

The dependent variables included the psychosocial factors of performance, as described in Chapter I (math interest, effort, self-efficacy, and peer influence) and actual performance. To account for the psychosocial factors of student performance, students were given 20 retrospective statements designed particularly for this study and asked to rate their opinions using a Likert-type scale with responses from 1 "strongly disagree" to 6 "strongly agree". In accordance with prior research on retrospective assessment, the 20 retrospective statements were given out for all student responses at only one point during the study which was immediately after exposure to the pedagogical approach and, therefore, for each statement, two categories for answer responses were provided which were labeled "Before" and "Now" (Allen & Nimon, 2007; Howard et al., 1979; Townsend & Wilton, 2003). These categories were to account for students' recollection of how they would have responded before exposure to the pedagogical approach and their current response after exposure. The retrospective nature of the instrument was based on the need to collect data on the class prior to and after exposure to the pedagogical approach (Allen & Nimon, 2007; Campbell, & Stanley, 1963; Howard et al., 1979; Townsend et al., 1999; Townsend & Wilton, 2003). There were five statements to measure each of the three factors of learning. Five more statements were also added to reflect measurement of peer influence. Statements were selected based on the relatedness to their respective factors. Some of the statements were taken verbatim from current and prior literature and some of the statements were taken from the concepts of current and prior literature. To measure math interest, five items were taken from math interest subscale items in the MATQ (Allen & Carifio, 1999) and represented the conceptualization of the situational and individual math interest dimensions (Dewey, 1913; Hidi & Harackiewicz, 2000; Mitchell, 1993; Stevens & Olivárez, Jr., 2005). To measure effort, one item was taken from Pinxten, Marsh, De Fraine, Van Den Noortgate, & Van Damme (2014) and four items were drawn from the MSLQ (Duncan & McKeachie, 2005; Pintrich & Smith, 1993). These items together represented the conceptualization of effort, as a result of work ethic combined with persistence, emerging in the presence of challenge (dullness), and increasing difficulty (Duncan & McKeachie, 2005; Eisenberger & Masterson, 1983; Pintrich & Smith, 1993). To measure self-efficacy, five items were drawn from the Math Self-Efficacy Survey and modified to be domain specific to the college algebra course (Betz & Hackett, 1983). These items represented the conceptual constructs used in this research for self-efficacy which were expectations and self-awareness (Lim & Chapman, 2013; Tariq & Durrani, 2012). To measure peer influence, five items were taken from Korir and Kipkemboi (2014) and modified to reflect the conceptualization of peer influence pedagogically used to improve learning, and, therefore, shorten the ZPD gap between student and instructor (Furrer et al., 2014; Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Korir & Kipkemboi, 2014). There are a total of twenty statements. The statements were delineated by the factors they represent in Table 1. The dependent variable for the fifth question (performance) was the score based on the rubric for 8 solvable math questions (2 questions per chapter section covered over the duration of the experiment). A copy of the rubric used is located in Appendix B.

Using Cronbach's alpha, internal consistencies for the psychosocial scales were $\alpha = .70$ (math interest Time 1), $\alpha = .70$ (math interest Time 2), $\alpha = .32$ (effort Time 1), $\alpha = .42$ (effort Time 2), $\alpha = .82$ (self-efficacy Time 1), $\alpha = .91$ (self-efficacy Time 2), $\alpha = .89$ (peer influence Time 1), and $\alpha = .88$ (peer influence Time 2). Time 1 represents the time prior to exposure to the pedagogical approach (Before) and Time 2 represents the time after exposure (Now).

Design/Data Analysis

The research questions for this study were addressed using a non-equivalent comparison group quasi-experimental design. This is because students were not randomly assigned to the groups and a comparison group is required for this study (Campbell et al., 1963; Rubin & Babbie, 2007). The independent variables for this study were the pedagogical approaches of solely lecturing and the GPA Program administered from Time 1 to Time 2. Time was cognitively defined through the pre and posttests. Time was psychosocially defined through the retrospective nature of the survey.

For each research question, a quasi-experimental 2 by 2 repeated measure between and within factorial test was used to examine and compare the interaction effect of each of the two pedagogical approaches on the dependent variables (Campbell et al.,

Table 1. Survey Statements Delineated by the Factors They Represent.

Factors	Statement
Math Interest	• In math class, I am often curious about how a problem is solved. • Math is very interesting. • Math homework is my favorite homework. • I do not find math class to be a real bore. • I enjoy solving math problems even if I'm not good at it.
Effort	• I work hard for mathematics. • I work hard to do well even if I don't like what we are doing. • When coursework is difficult, I neither give up, nor only study the easy parts. • Even when course materials are dull and uninteresting, I manage to keep working until I finish. • I often do not feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.
Self-Efficacy	• I have the ability to successfully determine the original amount of principal investment given the accumulated amount A, the interest rate r, the compound frequency per year n, and the time in years. • I have the ability to successfully solve logarithmic equations. • I have the ability to successfully convert back and forth from exponential to logarithmic form and from logarithmic form to exponential form. • I have the ability to successfully simplify basic logarithmic expressions. • I have the ability to complete Calculus with a final grade of "A" or "B".
Peer Influence	• Most of my friends in this class seem to perform well. • I am positively influenced by the discipline of my class peers. • I am encouraged by my class peers to work hard. • My class peers affect my academic work positively. • I enjoy spending time discussing academic work with my peers.

1963; Mdege, Brabyn, Hewitt, Richardson & Torgerson, 2014). This can be interpreted as a 2 (Between: lecture, GPA program) by 2 (Within: Time 1, Time 2) mixed factorial ANOVA.

To address the first research question, the statements on the survey that were indicative of the students' perceptions of math interest were averaged and served as the measure of the dependent variable. This summative score was used in a quasi-experimental 2 by 2 repeated measure between and within factorial test to compare the two classroom treatments with the interaction effect.

To address the second research question, the statements on the survey that were indicative of the students' perceptions of their own effort were averaged and served as the measure of the dependent variable. This summative score was used in a quasi-experimental 2 by 2 repeated measure between and within factorial test to compare the two classroom treatments with the interaction effect.

To address the third research question, the statements on the survey that were indicative of the students' perceptions of self-efficacy were averaged and served as the measure of the dependent variable. This summative score was used in a quasi-experimental 2 by 2 repeated measure between and within factorial test to compare the two classroom treatments with the interaction effect.

To address the fourth research question, the statements on the survey that were indicative of the students' perceptions of peer influence were averaged and served as the measure of the dependent variable. This summative score was used in a quasi-experimental 2 by 2 repeated measure between and within factorial test to compare the two classroom treatments with the interaction effect.

To address the fifth research question, the scores based on the rubric for 8 solvable math questions served as the measure of the dependent variable. The scores were summed and used in a quasi-experimental 2 by 2 repeated measure between and within factorial test to compare the two classroom treatments with the interaction effect.

As was aforementioned, the general hypothesis of all five research questions was that students who experienced the GPA Program would perform better on the dependent variables (Kim & Baylor 2006; Meyer, & Eley, 1999; Thomas, & Higbee, 1999; Vygotsky, 1962, 1978; Wang, Bruce, & Hughes, 2011). This means the GPA Program was expected to have a better interaction with the dependent variables.

In order to implement the aforementioned design, students were given pretest math problems prior to being exposed to either of the pedagogical delivery methods (IV). Upon completion of the exposure to the delivery methods, students were given the aforementioned statements described in Table 1.

Procedures

Figure 2 provides a pictorial view of the total procedures used in this study. The figure will be elaborated on below.

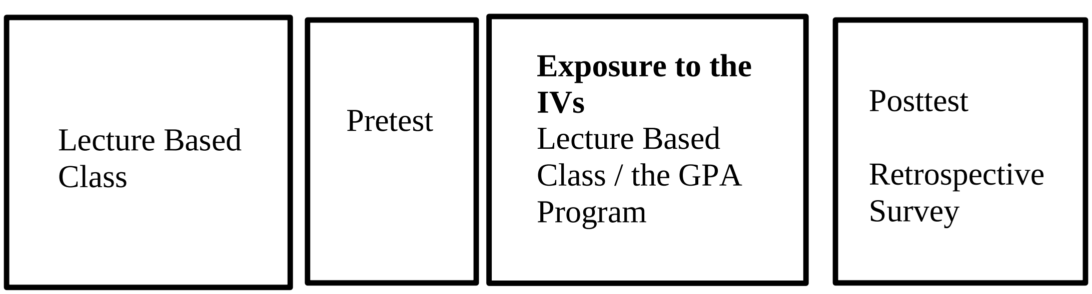

Figure 2. Model of procedures.

Students were asked to rate themselves on the statements retrospectively as to their perceptions before the exposure to the delivery methods and then again after exposure (“Before” and then “Now”). The purpose of the retrospective approach is that it allowed students to reflect back on their perceptions of the affective variables (math interest, effort expenditure, self-efficacy, and peer influence) before exposure to the delivery methods (Campbell et al., 1963; Townsend & Wilton, 2003). A copy of the survey is located in Appendix C.

After completing the survey of statements for which to rate, students received posttest math questions to complete. Students received the posttest after the survey in order to attempt to control for the influence of completing the posttest on their perceived self-efficacy.

With respect to emphasizing the validity of the pre and posttests scores, an isomorphic (same meaning) approach was taken, which is to mean that not every student received the same exact pre and posttest, but every student was tested on the same content (Arendasy & Sommer, 2013; Bejar & Yocom, 1991; Cauzinille-Marmeche, & Julo, 1998). Some students randomly received an “A” version while other students randomly received a “B” version of each test (pre and post). A copy of both the pre and posttests are located in Appendix A.

Procedural Attributes of the GPA Program

Procedural attributes of the GPA Program included class lecture notes, lecture time allocation, group achievement, and the instructor’s role during the group’s activities. Each attribute is defined below.

Class lecture notes. Student participants in the experimental group received copies of the class lecture notes at the start of the experiment from the instructor. Class lecture notes were given to student participants in the experimental group so that they copy less than they would for a regular lecture and so that the instructor could abbreviate his/her monologue. As a result, time is saved and pace is maintained. Class lecture notes were not given to the lecture group.

Lecture notes were organized by learning objectives, which are the chapter sections of the math book. Each learning objective was comprised of at least one learning objective activity (LOA). LOAs are a "things to do list" used to address and meet the learning objectives. In a math class, LOAs are math problems. Each different LOA represented a different type of math problem. Each LOA described in the class lecture notes had a listed algebraic process for how to successfully complete the LOA. After the listed strategy was displayed, an application of the employment of that strategy in the form of a successfully solved example problem also was displayed. There was at least one successfully solved example problem displayed for each LOA. The actual number of example problems was dependent upon the nature of the LOA. Some LOAs require more steps while others are more intuitive.

Lecture time allocation. In accordance with Higbee and Thomas (1999), the instructor lectured to the experimental group for no more than ten minutes, covering no more than two learning objective activities. Because students already had a copy of what was to be addressed, the lecture consisted of an immediate demonstration of the associated example problem(s) for each LOA, talking through the application of the strategy. Two LOAs were covered in the ten minute lecture.

Group performance. After the lecture, students in the experimental group were systematically placed into four groups and positioned in the four corners of the classroom. All corners had chalkboard space for group work display. Groups were given five minutes to collaboratively solve an example problem associated with the previous lecture and to display it on the board in their corner of the classroom. After five minutes, each group rotated to the corner to their right hand side and took another five minutes to assess the work of the previous group. The first and third groups worked to solve the same type of problem associated with the first LOA, and the second and fourth groups worked to solve the same type of problem associated with the second LOA. In this order, groups tried solving one type of problem and then rotated over to assess the work of the previous group which tried solving a different type of problem. In this way, students were able to learn how to successfully complete both types of LOAs.

Group assessment. The current group assessed the work of the previous group displayed at the corner by either deciding to leave the original problem solution as is, or by re-working the problem to the side of the original group's work, displaying a different result, but being careful not to erase the work of the previous group. After groups finished their assessments, they took another five minutes to gain visual feedback of their own previous group work. An untouched example problem indicated group success, or groups saw a duplicate problem reworked with a different result displayed beside their original work.

Instructor's role during group activities. The instructor observed and monitored all group activities. During the first five minutes when groups were solving a problem, the instructor observed and monitored student engagement as well as overall performance based upon group progress. During the second five minutes when groups were assessing the work performed by the previous group, the instructor observed and monitored the assessment efforts of each group. This is important because corrected problems must be displayed accurately. This way, the instructor focused more on assessing the assessors, and, in doing so, indirectly assessed the previous group's original work.

The sequence of the ten minute lecture plus the 15 minutes allocated for the student group activities represented the 25 minute application of the program. This program was applied twice in a 50 minute math class which met three time over the course of a week. Therefore, this program was applied a total of six times; twice per class for three class periods.

Procedural Attributes of the Control Group

The control group also met for a 50 minute class period, three times per week and received instruction through the traditional lecture pedagogy and. For the traditional lecture pedagogy in this study, the instructor provided a verbal and demonstrative description of how to solve the same LOAs students in the experiment group were exposed to, covering the same amount of content as the experimental group. Students in the control group received a total of three 50 minute lectures over the duration of this study, which lasted for one week's worth of class time. Students in the control group were not given lecture's notes before the lecture, as was done in the experimental group. Students were not placed into groups to collaborate on any work, nor were they invited to interact with each other socially during class. Instead, the overwhelming majority of any social interaction in the control group came from any questions students may have asked the instructor about what was said or demonstrated on the board throughout the class period. The traditional lecture procedures for this study represented objectivism and computational nature of the traditional math class (Carson, 2005; Cronjé, 2006; Elkind, 2004; Jonassen, 1991).

In this chapter, the methods of this study are provided. Next in chapter IV, the results of the research are discussed.

CHAPTER IV

RESULTS

To address each research question, a quasi-experimental 2 by 2 mixed factorial design was used to examine and compare the interaction effect both pedagogical methods had on the dependent variables (Campbell, Stanley & Gage, 1963; Mdege, Brabyn, Hewitt, Richardson & Torgerson, 2014). Information is provided in Table 2 regarding the skewness and kurtosis of each factor measured. What follows are the results from analysis along with tables for descriptive statistics and correlations for each factor. Calculated that results fall between -1 and +1 represent accepted assumptions of error normality for kurtosis and skewness (Bulmer, 1979). Based on accepted these assumptions of error normality, the measures generally show tendencies of moderate to approximate skewness and moderately flat kurtosis. In addition, a chart of a comparison of the reported means scores of each factor is provided.

Math Interest

The first research question was: Does the GPA Program increase student self-reported math interest greater than the lecture pedagogy.

There was a significant main effect of time, Wilk's Lambda $= .757,\ F(1, 38) = 12.17,\ p < .05$. Cohen's d (d = 0.62), revealed a moderately large main effect size in the sample. There was no significant main effect of pedagogy, $F(1, 38) = .344, p > .05$ (Cohen's d = 0.41) and there was also no significant interaction between time and

Table 2. Table of Skewness and Kurtosis for Each Factor.

	N	Skewness	Std. Error	Kurtosis	Std. Error
Interest Before	40	-0.59	0.37	0.39	0.73
Interest Now	40	-0.66	0.37	0.53	0.73
Effort Before	41	-0.31	0.37	0.10	0.72
Effort Now	41	-0.59	0.37	-0.03	0.72
Self-Efficacy Before	42	0.24	0.37	-0.84	0.72
Self-Efficacy Now	41	-0.71	0.37	0.30	0.72
Peer Influence Before	41	0.02	0.37	-0.87	0.72
Peer Influence Now	41	-0.57	0.37	-0.05	0.72
Performance Before	39	0.76	0.38	-0.61	0.74
Performance Now	39	0.40	0.38	-0.80	0.74

pedagogy, Wilk's Lambda = $.952,\ F(1,38) = 1.9, p > .05$ (Cohen's d = 0.45). Descriptive statistics for self-reported math interest are shown in Table 3. Correlations between Interest Before and Interest Now are shown in Table 4. Correlations show an increase in math interest from Time 1 (Before) to Time 2 (Now). A comparison of the reported means scores for math interest is displayed in Figure 3.

Table 3. Descriptive Statistics for Self-Reported Math Interest.

	Pedagogy	Mean	Std. Deviation	N
Math Interest Before	Lecture	18.6	3.9	19
	GPA Program	18.6	4.7	21
	Total	18.6	4.4	40
Math Interest Now	Lecture	21.2	4.6	19
	GPA Program	19. 7	4.5	21
	Total	20.4	4.5	40

Table 4. Correlations Between Interest Before and Interest Now.

		Interest Before	Interest Now
Interest Before	Pearson Correlation	1	.724**
Interest Now	Pearson Correlation	-	1

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

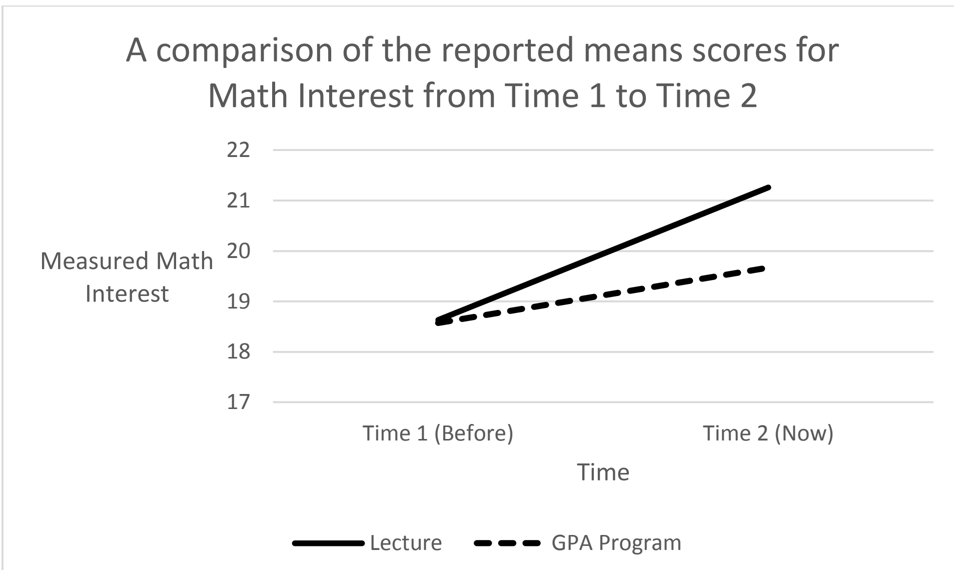

Figure 3. A comparison of the mean scores of reported math interest as reported by the students in both the lecture and GPA Program groups.

Effort

The second research question was: Does the GPA Program increase student self-reported effort greater than the lecture pedagogy.

Further investigation into the particularly low internal consistencies for this scale revealed confusion in the wording of the fifth statement: “I often do not feel so lazy or bored when I study for this class that I quit before I finish what I planned to do". When that statement was removed, internal consistencies, using Cronbach's alphas for this scale became α = .72 (effort Time 1), α = .75 (effort Time 2). Therefore, the numbers presented below reflect the four item scale for effort.

There was a significant main effect of time, Wilk's Lambda $= .871,\ F(1,39) = 5.76,\ p < .05$ (Cohen's d = 0.23), but there was no significant main effect of pedagogy, $F(1,39) = .78, p > .05$ (Cohen's d = 0.10) and also, there was no significant interaction between time and pedagogy, Wilk's Lambda = $.993,\ F(1,39) = .27, p > .05$ (Cohen's d = 0.44). Descriptive statistics for self-reported effort are shown in Table 5. Correlations between Effort Before and Effort Now are shown in Table 6. Correlations show an increase in effort from Time 1 (Before) to Time 2 (Now). A comparison of the reported means scores for effort is displayed in Figure 4.

Table 5. Descriptive Statistics for Self-Reported Effort.

	Pedagogy	Mean	Std. Deviation	N
Effort Before	Lecture	16.4	4.0	20
	GPA Program	17.6	3.5	21
	Total	17.0	3.7	41
Effort Now	Lecture	17.8	3.9	20
	GPA Program	18.5	3.4	21
	Total	18.1	3.6	41

Table 6. Correlations Between Effort Before and Effort Now

		Effort Before	Effort Now
Effort Before	Pearson Correlation	1	.656**
Effort Now	Pearson Correlation	-	1

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

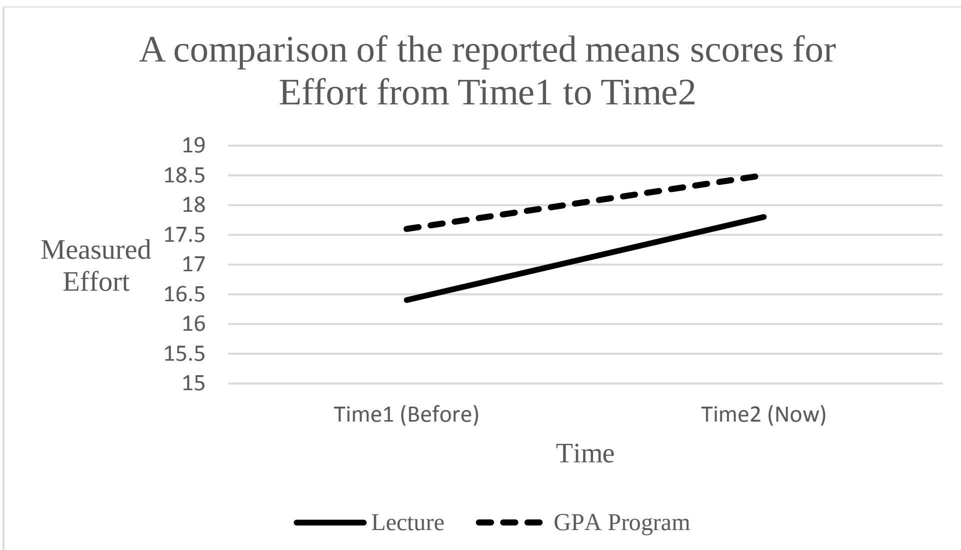

Figure 4. A comparison of the mean scores of effort as reported by the students in both the lecture and GPA Program groups.

Self-Efficacy

The third research question was: Does the GPA Program increase student self-reported self-efficacy greater than the lecture pedagogy.

There was a significant main effect of time, Wilk's Lambda $= .269$, $F(1, 39) = 106.046$, $p < .05$ (Cohen's d = 0.44), but there was no significant main effect of pedagogy, $F(1, 39) = .151, p > .05$ (Cohen's d = 0.12) and also, there was no significant interaction between time and pedagogy, Wilk's Lambda = $.998, F(1,39) = .093, p > .05$ (Cohen's d = 0.13). Descriptive statistics for self-reported self-efficacy are shown in Table 7. Correlations between Self-Efficacy Before and Self-Efficacy Now are shown in Table 8. Correlations show an increase in self-efficacy from Time 1 (Before) to Time 2 (Now). A comparison of the reported means scores for self-efficacy is displayed in Figure 5.

Table 7. Descriptive Statistics for Self-Reported Self-Efficacy.

	Pedagogy	Mean	Std. Deviation	N
Self-Efficacy Before	Lecture	12.4	5.7	19
	GPA Program	12.8	5.3	22
	Total	12.6	5.4	41
Self-Efficacy Now	Lecture	20.9	7.1	19
	GPA Program	21.8	4.8	22
	Total	21.4	5.9	41

Table 8. Correlations Between Self-Efficacy Before and Self-Efficacy Now

		Self-Efficacy Before	Self-Efficacy Now
Self-Efficacy Before	Pearson Correlation	1	.548**
Self-Efficacy Now	Pearson Correlation	-	1

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

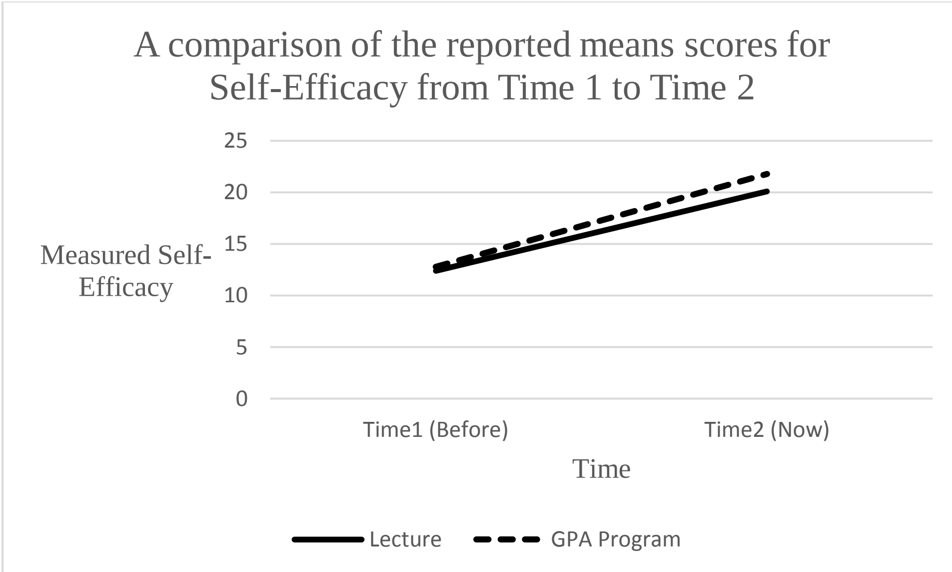

Figure 5. A comparison of the mean scores of self-efficacy as reported by the students in both the lecture and GPA Program groups.

Peer Influence

The fourth research question was: Does the GPA Program provide evidence of a more minimized ZPD than lecture pedagogy as evidenced by student perception of peer influence.

There was a significant main effect of time, Wilk's Lambda $= .635,\ F(1, 39) = 22.396,\ p < .05$ (Cohen's d = 0.44), but there was no significant main effect of pedagogy, $F(1, 39) = .297, p > .05$ (Cohen's d = 0.37) and also, there was no significant interaction between time and pedagogy, Wilk's Lambda = $.917, F(1, 39) = 3.508, p > .05$ (Cohen's d = 0.83). Descriptive statistics for self-reported peer influence are shown in Table 9. Correlations between Peer Influence Before and Peer Influence Now are shown in Table 10. Correlations show an increase in peer-influence from Time 1 (Before) to Time 2 (Now). A comparison of the reported means scores for peer influence is displayed in Figure 6.

Table 9. Descriptive Statistics for Self-Reported Peer Influence.

	Pedagogy	Mean	Std. Deviation	N
Peer Influence Before	Lecture	18.4	6.1	20
	GPA Program	18.2	5.5	21
	Total	18.3	5.7	41
Peer Influence Now	Lecture	21.2	5.9	20
	GPA Program	19.4	5.3	21
	Total	20.3	5.6	41

Table 10. Correlations Between Peer Influence Before and Peer Influence Now

		Peer Influence Before	Peer Influence Now
Peer Influence Before	Pearson Correlation	1	.882**
Peer Influence Now	Pearson Correlation	-	1

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

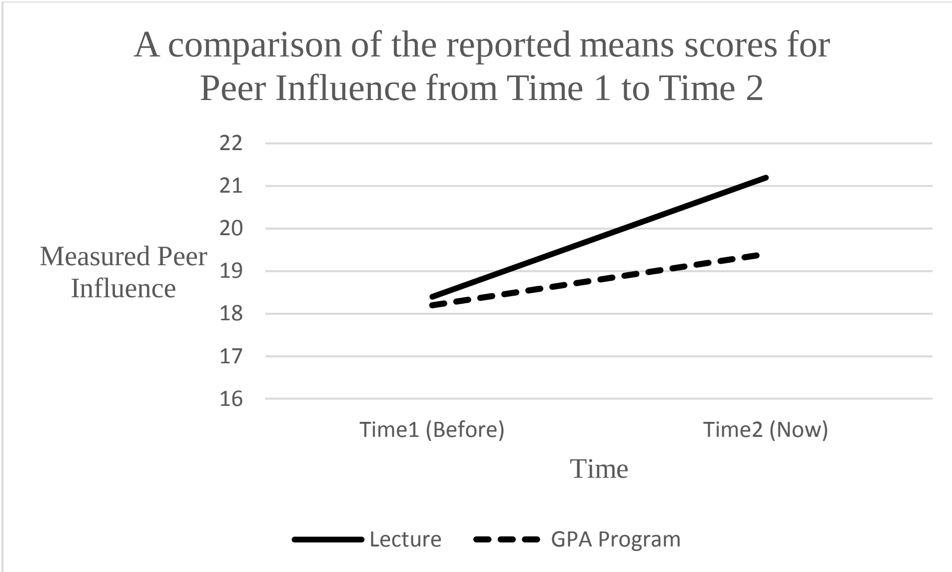

Figure 6. A comparison of the mean scores of peer influence as reported by the students in both the lecture and GPA Program groups.

Performance

The fifth research question was: Does the GPA Program increase student performance (as measured by the ability of students to successfully complete a set of pre and posttest math questions) greater than the lecture pedagogy.

There was a significant main effect of time, Wilk's Lambda $= .281,\ F(1, 37) = 94.860,\ p < .05$ (Cohen's d = 0.45), but there was no significant main effect of pedagogy, $F(1, 37) = .032, p > .05$ (Cohen's d = 0.32) and also, there was no significant interaction between time and pedagogy, Wilk's Lambda = $.999, F(1, 37) = .045, p > .05$ (Cohen's d = 0.096). Descriptive statistics for self-reported performance are shown in Table 11. Correlations between Performance Before Performance Now are shown in Table 12. Correlations show an increase in performance from Time 1 (Before) to Time 2 (Now). A comparison of the reported means scores for performance is displayed in Figure 7.

Table 11. Descriptive Statistics for Student Performance.

	Pedagogy	Mean	Std. Deviation	N
Performance Before	Lecture	3.8	3.5	20
	GPA Program	3.7	3.1	19
	Total	3.7	3.2	39
Performance Now	Lecture	11.3	5.7	20
	GPA Program	10.9	5.4	19
	Total	11.1	5.5	39

Table 12. Correlations Between Performance Before and Performance Now

		Performance Before	Performance Now
Performance Before	Pearson Correlation	1	.538**
Performance Now	Pearson Correlation	-	1

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

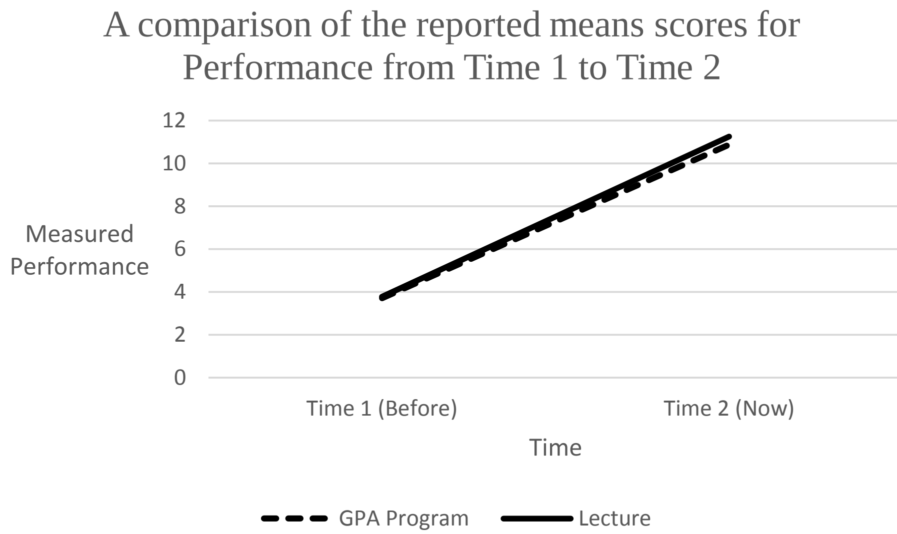

Figure 7. A comparison of the mean scores related to performance in both the lecture and GPA Program groups.

In this previous chapter, information was provided regarding the skewness and kurtosis of each factor measured. Also, the results from analysis, along with tables for descriptive statistics, correlations, and charts of the comparisons of the reported means scores of each factor were provided. Next in Chapter V, a discussion of the results as well as implications from this study will be provided.

CHAPTER V

DISCUSSION

Given the prior success of implementing Vygotsky's social learning theory in mathematical courses in higher education (Goldstein, Burke, Getz & Kennedy, 2011; Mireles, et al., 2011; Vygotsky, 1962, 1978), the GPA Program pedagogical approach was predicted to outperform the lecture pedagogical approach in every learning outcome. In contrast with the prior research, there was no evidence found to suggest GPA Program outperformed lecture in any of the learning outcomes (Eric Zhi Feng, Chun Hung, & Chiung Sui, 2010; Higbee & Thomas, 1999; Hüffmeier, et al., 2014; Rowan-Kenyon, Swan, & Creager, 2012). Although results indicated differences in the reported means scores, and that time had a significant impact within groups, none of the interaction effects had statistical significance for any of the learning outcomes. Therefore, for this study and available sample size, no evidence was revealed to support the presence of a differential change in the learning outcomes due to either pedagogical approach (lecture or the GPA Program).

Results also reveal overall improvement from Time 1 to Time 2 for both pedagogical approaches. The research questions were related to the differentiation between pedagogical approaches and will be discussed below.

Math Interest

The first research question was: Does the GPA Program increase student self-reported math interest greater than the lecture pedagogy.

Based on the implications from current literature on math interest (Allen & Carifio, 1999; Fisher et al., 2012; Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Matarazzo et al., 2010; Renninger & Hidi, 2011; Riconscente, 2014; Stevens & Olivárez, 2005) it was hypothesized in this study that the GPA Program would increase student perception of math interest better than the lecture pedagogy. For this study, no evidence was found to support pedagogical differentiation and therefore this study cannot report a confirmation of support for the hypothesis of this research question. In contrast with the implications of current research on math interest, no evidence was found to suggest the GPA Program increased reported math interest better than the lecture pedagogy (Allen & Carifio, 1999; Fisher et al., 2012; Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Matarazzo et al., 2010; Renninger & Hidi, 2011; Riconscente, 2014; Stevens & Olivárez, 2005).

No evidence was found to suggest the GPA Program increased reported math interest any better or worse than the lecture-based pedagogy, because no evidence was found supporting a significant differential change due to either pedagogy. Therefore this study cannot report that the students who experienced the GPA Program fared any better in increasing reported math interest than the lecture pedagogy. Both pedagogical approaches increased student perception of math interest.

Findings from this study indicated an increase in the reported situational and individual math interest of both groups of students (lecture vs. GPA Program) from

Before (Time 1) to Now (Time 2) as is described in the research of Hidi and Harackiewicz, (2000). Implications from the research of Allen and Carifio, (1999) reflected concerns regarding the maintenance of already existing math interest and suggests that it is associated with some sense of enjoyment and curiosity. In accordance with the research of Allen and Carifio, (1999), based on the results, participants in this study appeared to maintain or increase a sense of enjoyment and curiosity.

Implications from prior research conducted by suggested situational math interest could be developed through activities that could also be used to further individual involvement in the course material (Dewey, 1913; Hidi & Harackiewicz, 2000; Mitchell, 1993). In accordance with implications from current research, both aspects of math interest appeared to develop and improve.

Effort

The second research question was: Does the GPA Program increase student self-reported effort greater than the lecture pedagogy.

Based on the implications from current and prior literature on effort, it was hypothesized in this study that the GPA Program would increase student perception of effort better than the lecture pedagogy (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Strage, 2007). For this study, no evidence was found to support pedagogical differentiation and therefore this study cannot confirm support for the hypothesis of this research question. In contrast with the implications of prior research on effort (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Strage, 2007), no evidence was found to suggest the GPA Program increased student perception of effort better than the lecture pedagogy. Therefore this study cannot report that the GPA

Program fared any better in increasing reported effort than the lecture pedagogy. Both pedagogical approaches increased student perception of effort expenditure.

Effort for this current research was conceptualized by the work ethic, perseverance and task value (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Strage, 2007). In accordance with the definition and characterization of effort from current research, the aspects of effort measured in this study appeared to increase for both pedagogical approaches.

Self-Efficacy

The third research question was: Does the GPA Program increase student self-reported self-efficacy greater than the lecture pedagogy.

Based on the implications from current literature on self-efficacy (Betz & Hackett, 1983; Fennema & Sherman, 1976; Hall & Ponton 2005; Kranzler & Pajares, 1997; Lim & Chapman, 2013; Nasiriyan et al., 2011; Nicholson, Putwain, Connors & Hornby-Atkinson, 2013; Stankov et al., 2014; Tariq & Durrani, 2012) it was hypothesized in this study that students who experienced the GPA Program would increase student perception of self-efficacy better than the lecture pedagogy. For this study, no evidence was found to support pedagogical differentiation for either pedagogical approach and therefore this study cannot confirm support for the hypothesis of this research question. In contrast with the implications of current research on self-efficacy (Betz & Hackett, 1983; Fennema & Sherman, 1976; Hall & Ponton 2005; Kranzler & Pajares, 1997; Lim & Chapman, 2013; Nasiriyan et al., 2011; Nicholson, Putwain, Connors & Hornby-Atkinson, 2013; Stankov et al., 2014; Tariq & Durrani, 2012), no evidence was found to suggest the GPA Program increased student perception of self-efficacy better than the lecture pedagogy.

No evidence was found to suggest the GPA Program increased reported self-efficacy any better or worse than the lecture-based pedagogy, because no evidence was found supporting a significant differential change due to either pedagogy. Therefore, this study cannot report that the GPA Program fared any better in increasing reported self-efficacy than the lecture pedagogy. Both pedagogical approaches increased student perception of self-efficacy.

For this study, self-efficacy was defined by a positive belief in one's own ability to successfully complete a task or solve a problem (Betz & Hackett, 1983; Fennema & Sherman, 1976; Hall & Ponton 2005; Kranzler & Pajares, 1997; Lim & Chapman, 2013; Nasiriyan et al., 2011; Nicholson, Putwain, Connors & Hornby-Atkinson, 2013; Stankov et al., 2014; Tariq & Durrani, 2012). In agreement with the definition and characterization of self-efficacy from current research, the aspects of self-efficacy measured in this study appeared to increase for both pedagogical approaches.

ZPD and Peer Influence

The fourth research question was: Does the GPA Program provide evidence of a more minimized ZPD than lecture pedagogy as evidenced by student perception of peer influence.

Based on the implications from current literature on ZPD and peer influence (Chak, 2001; Gredler, 2012; Kravtsova, 2009; Levykh, 2008; Sokolova, Tarasova & Korepanova, 2009; Zuckerman, 2007) it was hypothesized in this study that the GPA Program would increase student perception of peer influence better than the lecture pedagogy. For this study, no evidence was found to support pedagogical differentiation for either pedagogical approach and therefore this study cannot confirm support for the hypothesis of this research question. In contrast with the implications of prior research on peer influence (Chak, 2001; Gredler, 2012; Kravtsova, 2009; Levykh, 2008; Sokolova, Tarasova & Korepanova, 2009; Zuckerman, 2007), no evidence was found to suggest the GPA Program increased student perception of peer influence better than the lecture pedagogy.

No evidence was found to suggest the GPA Program increased reported peer influence any better or worse than the lecture-based pedagogy, because no evidence was found supporting a significant differential change due to either pedagogy. Therefore this study cannot report that the GPA Program fared any better in increasing reported peer influence than the lecture pedagogy. Both pedagogical approaches increased student perception of peer influence.

For this study, the zone of proximal development (ZPD) was defined, as the extent to which ability improves based on the collaborative engagement and allowed influence of an external source of expert ability (Chak, 2001; Gredler, 2012; Kravtsova, 2009; Levykh, 2008; Sokolova, Tarasova, & Korepanova, 2009; Zuckerman, 2007).

Current research suggests that the extent of the ZPD is largely dependent on the willingness of the learner(s) to learn, and this willingness is largely dependent of the environment of positive influence created by the external source (Levykh, 2008; Tudge, 1990; Zuckerman, 2007). This environment of positive influence must be perceived by the learner to be conducive for learning (Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Gredler, 2012; Levykh, 2008; Lund, 2008; Tudge, 1990; Zuckerman, 2007). Based on the results of this study, and in agreement with prior research, there seemed to be an improved environment of positive influence conducive for learning as improvements appear to have been made for both treatments.

For this study, peer influence was defined as the influence exerted from one peer to another peer that serves as a catalyst for changes in attitude, belief, or behavior (Furrer, Skinner, & Pitzer, 2014; Korir & Kipkemboi, 2014) and characterized by the energy peers exert on each in encouraging individual behavior that decreases the distance the ZPD gap from student to instructor (Faulk & Ichino, 2006; Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Korir & Kipkemboi, 2014). Based on the results of this research, there appears to be an indication that the energy exerted from peer to peer improved and decreased the ZPD gap distance from student to instructor (Faulk & Ichino, 2006; Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Korir & Kipkemboi, 2014).

Additionally, peer influence was characterized, through research, as a socialization experience in which people have the ability to observe and model the norms of their peers (Korir & Kipkemboi, 2014). Implications of current research on peer influence suggested that if peer influence was positive, then it should have helped to establish student accountability and classroom structure, which contributes to the increase in performance (Furrer, Skinner, & Pitzer, 2014), thereby closing the gap of the ZPD (Faulk & Ichino, 2006; Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Korir & Kipkemboi, 2014). Given the results of this study, it appears that the positivity of the peer influences exerted from peer to peer seemed to have improved student accountability and classroom structure for both treatments (Furrer, Skinner, & Pitzer, 2014).

Implications from current research suggested that both lecture pedagogy and the GPA Program were capable of minimizing ZPDs (Gredler, 2012; Kravtsova, 2009; Levykh, 2008; Zuckerman, 2007). The differentiating component for this study was the environment of peer influence created based on the different pedagogy employed (Kim & Baylor 2006; Kravtsova, 2009; Levykh, 2008; Ningjun & Herron, 2010; Porter, 2010; Vygotsky, 1962, 1978). The GPA Program was used to create a more social environment where peer influence was pedagogically utilized to help minimize the ZPD from student to instructor. This difference in environmental influence should have created differentiation in minimizing the ZPD between groups based on the differences in pedagogy (Goos, Galbraith, & Renshaw, 2002; Kravtsova, 2009; Levykh, 2008). Based on the results of this study, and in contrast with prior research, there was no evidence found to support significant differentiation between the GPA Program and the lecture pedagogy regarding the differences in environmental influences.

In agreement with this research, results indicated that there appeared to be an improved willingness on the part of the students to learn the course material reflecting an environment of positive influence (Levykh, 2008; Tudge, 1990; Zuckerman, 2007). In accordance with the definition and characterization of peer influence from current research, the aspects of peer influence measured in this study appeared to increase for both pedagogical approaches.

Performance

The fifth research question was: Does the GPA Program increase student performance (as measured by the ability of students to successfully complete a set of pre and posttest math questions) greater than the lecture pedagogy.

Based on the implications from current literature on performance (Cortés-Suárez & Sandiford, 2008; Meyer & Eley, 1999; Stephens & Konvalina, 1999; Thiel et al., 2008; Thomas & Higbee, 1999; Vygotsky, 1962, 1978) it was hypothesized in this study that the GPA Program would increase student performance over the lecture pedagogy. For this study and available sample size, no support was found to support pedagogical differentiation for either pedagogical approach and therefore this study cannot report an affirmative "yes" to this research question. In contrast with the implications of current research on peer influence (Cortés-Suárez & Sandiford, 2008; Meyer & Eley, 1999; Stephens & Konvalina, 1999; Thiel et al., 2008; Thomas & Higbee, 1999; Vygotsky, 1962, 1978), no evidence was found to suggest the GPA Program increased student performance over the lecture pedagogy.

No evidence was found to suggest the GPA Program improved performance any better or worse than the lecture-based pedagogy, because no evidence was found supporting a significant differential change due to either pedagogy. Therefore this study cannot report that the students who experienced the GPA Program fared any better in increasing student perception of performance than the lecture pedagogy. Both pedagogical approaches increased performance.

Psychosocial Factors of Performance

Math interest. Increases in math interests should have resulted in increases in performance (Allen & Carifio, 1999; Dewey, 1913; Hidi & Harackiewicz, 2000; Higbee & Thomas, 1999; Mitchell, 1993; Stevens & Olivárez, Jr., 2005). In accordance with current research, results from this current study indicated increases in math interest reflected in resulting increases in performance.

Effort expenditure. In agreement with prior research regarding effort and, contrary to Schuman, and colleagues (1985), increases in effort should have resulted in increases in performance (Eisenberger & Masterson, 1983; Michaels & Miethe, 1989; Nasiriyan et al., 2011; Pintrich & Smith, 1993; Strage, 2007). In accordance with the current research, and in contrast to Schuman and colleagues (1985), increases in effort reflected increases in performance.

Self-efficacy. Self-efficacy is a commonly accepted factor of performance (Betz & Hackett, 1983; Fennema & Sherman, 1976; Hall & Ponton 2005; Kranzler & Pajares, 1997; Lim & Chapman, 2013; Nasiriyan et al., 2011; Nicholson, Putwain, Connors & Hornby-Atkinson, 2013; Stankov et al., 2014; Tariq & Durrani, 2012). Implications from current research on self-efficacy suggests that as self-efficacy improves, so should performance. In concert with current research on self-efficacy, increases in self-efficacy appeared to reflect increases in performance.

PeerInfluence. For this study, peer influence was conceptually coupled with performance to represent the evidence of a closing of the gap of the ZPD (Furrer, Skinner, & Pitzer, 2014; Korir & Kipkemboi, 2014). The reflected increases for both peer influence and performance suggest the existence of evidence to support a closed ZPD gap for the course material used for the intervention (Faulk & Ichino, 2006; Goos, 2004; Goos, Galbraith, & Renshaw, 2002; Korir & Kipkemboi, 2014).

Lecture versus the GPA Program. The lecture pedagogy is normally employed in most college algebra classes due to the objectivism nature of the course (Carson, 2005; Cronjé, 2006; Elkind, 2004; Jonassen, 1991). Therefore, it is naturally expected that some amount of improvement of performance should take place over time within the lecture group. Considering this, it is worth remarking how identical the amount of performance increases between groups (Lecture and GPA Program) were because the similarities in performance increases represent the functionality of the GPA Program. Students in the GPA Program were engaged in social learning (Thomas & Higbee, 1999; Vygotsky, 1962, 1978)) in college algebra class and no evidence was found to suggest that it hurt their performance compared to that of the lecture group. This is important because students' performance in college algebra is usually the only indication of their proficiency in college algebra (Carson, 2005; Cronjé, 2006; Elkind, 2004; Jonassen, 1991).

Summary

The problem of poor student performance in college algebra cannot be ignored and concern regarding this problem is not new (McGlaughlin et al., 2005; Meyer & Eley, 1999; Stephens & Konvalina, 1999; Thomas & Higbee, 1999). In response to current research, the GPA Program was designed to positively impact psychosocial factors of student learning which have been found to be legitimate contributors of student performance in math (Meyer & Eley, 1999; Thomas & Higbee, 1999). The general hypothesis of this study, in accordance with current literature, was that the GPA Program would perform better than the lecture pedagogy on the dependent variables including performance (Kim & Baylor 2006; Meyer & Eley, 1999; Thomas & Higbee, 1999; Wang, Bruce & Hughes, 2011; Vygotsky, 1962, 1978). In contrast with the hypothesis of this study as well as the reported conclusions from current research, results showed no evidence to suggest the GPA Program pedagogy outperformed the lecture pedagogy.

However, results also prohibit the conclusion that the GPA Program performed worse than the lecture pedagogy. By reflecting no appearance of differentiation in the pedagogical approach used, the results of this study suggest that the effects of both pedagogical approaches was comparable, particularly in student performance.

Conclusion

This study represents a potential contribution to the mosaic of research focused on the improvement of performance in the math classroom (Gallo, & Odu, 2009; Higbee, & Thomas, 1999; Kersaint et al., 2011; Porter, 2010; Stephens & Konvalina, 1999). Vygotsky's social learning theory and ZPD (Vygotsky, 1962, 1978) was tested in a college algebra environment through the implementation of the GPA Program and its comparison to the traditional lecture pedagogy. In doing so, this work set out to demonstrate the notion that students perform better socially learning math. The results appeared inconclusive as both the lecture and GPA Program groups improved on the knowledge and psychosocial factors of performance.

Research Limitations/Recommendations

First, variation in some of the factors seemed rather large given the time span of the study. For example, self-reported math interest seemed to improve quite a bit given a week's time, particularly for the students in the control group (Lecture). This may be due to students in that group, misunderstanding Time 1 as defined by this study. The students in the control group (Lecture) experienced the same pedagogical approach they had seen all semester long. Therefore, it seems reasonable that some students in that group may have misperceived Time 1 to be at or near the beginning of the semester. The instructor enjoyed a very favorable rapport among the vast majority of students in the control group and implications from research suggest that instructor rapport can contribute to the development and improvement of psychosocial factors, such as math interest, based on how the students feel about the lecturer (Hidi & Harackiewicz, 2000). The student responses given, based on this scenario, would reflect the totality of improvement this study's factors since the beginning of the semester. In addition, for the experimental group (GPA Program), it is possible that instructor rapport may have skewed the perception students have of class activities that don't involve the direct or prioritized influence of the instructor such as peer group collaboration. This could be due to the comfort students have viewing the instructor as in a position of intellectual guidance more so than that of their peers. These conditions together may have contributed to the nature of this study's results. Perhaps future analysis may add covariates to control for other items at play such as instructor rapport.

Also, the sample size available for this study was small. The size of the sample used for a study can alter the results of that study as well as the generalizability of that study (Campbell et al., 1963; Rubin & Babbie, 2007). Also, one week's worth of data collection is a short timeframe for an intervention treatment. More time for intervention treatment may provide a more accurate outcome of the effects of the treatment. Future research in this area may do well to create a greater distance between Time 1 and Time 2 in order to employ the independent variables for longer. In addition the measures in this study, while research based, were new and one statement from the Effort scale had to be removed to maintain reliability. It remains to be seen if these changes could, in the future, render results that differ from that of this study and better conform to the conclusions of current and prior research.

Finally reflexivity should be acknowledged. Reflexivity refers to biased conclusions reached by the researcher that are based on the personal impact experienced by conducting the research (Becker, 1998; Brummans & Vásquez, 2016; Kleinsasser, 2000). While this type of bias is usually reserved for qualitative research, reflexivity should be acknowledged as a possible limitation because the intervention tested in this study was created by the author of this study. It remains to be seen how future research conclusions from other researchers may differ from the conclusions reached by this study.

Implications for Practice

If the pedagogical approach for this particular study experiment had no evidence of making a pedagogical difference better than lecturing, why change up from lecturing in the first place? The reason is because of the potential for developing a pedagogical approach that could make a pedagogical difference better than lecturing (Higbee & Thomas, 1999). The GPA Program pedagogy represents time and energy spent on the part of the instructor to come up with ways that use social learning as a tool to improve student performance. The results of this study, while comparable, were inconclusive. This can invite a variety of conclusions, however, indications from this study show that students who experienced the GPA Program got as much from social engagement as those students who were solely lectured to. This fact cannot be overlooked, given the non-social nature of the lecture pedagogy and the challenges involving student math performance. Therefore, implications from the results of this study suggest that efforts to explore pedagogical approaches that utilize social learning should be encouraged.

What's Next

Every factor measured in this study increased over time with the GPA Program. That is a good reason to think that this program, with some adjustment, has the potential to successfully outperform the traditional lecture pedagogy in improving self-reported interest, effort, self-efficacy, peer influence, as well as student performance in College Algebra. I, the author of this study and creator of the GPA Program, am of the opinion that the major reason the program did not outperform the traditional lecture pedagogy was due to the short time allocated for the application of this program. In the future, I plan to test this program versus lecture again in a larger scale study allocating one full semester of time for application of the program. I believe that more time allocated for applying the GPA Program would result in the program outperforming the traditional lecture pedagogy in improving self-reported interest, effort, self-efficacy, peer influence, as well as student performance. The inconclusive results of this study do not signal an end to the GPA Program, but instead, merely indicate a humble beginning. Given the comparable increases in just one week's time, the future for the GPA Program seems quite bright.

APPENDICES

Appendix A
Pre and Post Tests

Test A

Male______ Female_______

Class section: __________

Sections 4.1 – 4.4
Instructions: Please take 15 minutes to answer the following questions.

1. If $12,500 was accumulated over 8 years at a 6% interest rate compounded quarterly, how much was the original investment?

   Answer: ___________________

2. How much money is accumulated when $2300 is continuously compounded at a 6.4% interest rate over 15 years?

   Answer: ____________________

3. Directions: Convert the given to exponential and logarithmic form.

   Given: $\sqrt[3]{64} = 4$ Answer: exponential form: ____________ log form: ___________

4. Directions: Convert the given to exponential and logarithmic form.

   Given: $\sqrt[4]{81} = 3$ Answer: exponential form: ____________ log form: ___________

5. Directions: Simplify (expand).

   Given: $\log_x(a^4 b^2)$ Answer: _____________________________

6. Directions: Simplify (condense).

   Given: $\frac{3}{5}\ln(y) + \ln(z)$ Answer: _____________________________

7. Directions: Find x.

   Given: $log_3(x + 6) = 3$ Answer: $x =$ ________

8. Directions: Find x.

   Given: $log_2(x) + log_2(x + 7) = 3$ Answer: $x =$ _______

Test B

Male______ Female_______

Class section: __________

Sections 4.1 – 4.4

Instructions: Please take 15 minutes to answer the following questions.

1. If $10,000 was accumulated over 15 years at a 4% interest rate compounded 5 times per year, how much was the original investment?

Answer: ______________________

2. How much money is accumulated when $2890 is continuously compounded at a 5.2% interest rate over 8 years?

Answer: _____________________

3. Directions: Convert the given to exponential and logarithmic form.

   Given: $\sqrt[2]{16} = 4$

   Answer: exponential form: ____________ log form: ___________

4. Directions: Convert the given to exponential and logarithmic form.

Given: $\sqrt[3]{125} = 5$

Answer: exponential form: ____________ log form: ___________

5. Directions: Simplify (expand).

Given: $\log_n(x^3y^2)$ Answer: _____________________________

6. Directions: Simplify (condense).

Given: $\frac{2}{3}\ln(a) - \ln(b)$ Answer: _____________________________

7. Directions: Find x.

Given: $log_4(x - 5) = 2$ Answer: $x =$ __________

8. Directions: Find x.

Given: $log_5(x) + log_5(x - 24) = 2$

Answer: $x =$ _______

Appendix B
Grading Rubric for Pre and Post Tests

Points	Performance Assessment
0	Demonstrates no familiarity
1	Demonstrates familiarity but no understanding
1.5	Demonstrates some understanding, but too many flaws
2	Demonstrates some understanding, but somewhat flawed
2.5	Demonstrates overall understanding, but not perfect
3	100% accuracy in both the work shown and the answer

Appendix C
Survey

Using the following response scale, please circle the one that best indicates your level of agreement that you had before and after completing the teaching styles experiment.

1 = Strongly Disagree
2 = Disagree
3 = Slightly Disagree
4 = Slightly Agree
5 = Agree
6 = Strongly Agree

Statements	Before	Now
In this math class, I am often curious about how a problem is solved.	1 2 3 4 5 6	1 2 3 4 5 6
I work hard at mathematics.	1 2 3 4 5 6	1 2 3 4 5 6
I have the ability to successfully determine the original amount of principal investment given the accumulated amount A, the interest rate r, the compound frequency per year n, and the time in years.	1 2 3 4 5 6	1 2 3 4 5 6
Most of my peers in this class seem to perform well.	1 2 3 4 5 6	1 2 3 4 5 6
This math content is very interesting.	1 2 3 4 5 6	1 2 3 4 5 6
I put a lot of effort into this mathematics course.	1 2 3 4 5 6	1 2 3 4 5 6
I have the ability to successfully simplify basic logarithmic expressions.	1 2 3 4 5 6	1 2 3 4 5 6
I am positively influenced by the discipline of my class peers.	1 2 3 4 5 6	1 2 3 4 5 6
Math homework for this class is my favorite homework.	1 2 3 4 5 6	1 2 3 4 5 6
When coursework is difficult, I neither give up, nor only study the easy parts.	1 2 3 4 5 6	1 2 3 4 5 6

Statements (continued)	Before	Now
I have the ability to successfully convert back and forth from exponential to logarithmic form and from logarithmic form to exponential form.	1 2 3 4 5 6	1 2 3 4 5 6
I am encouraged by my class peers to work hard.	1 2 3 4 5 6	1 2 3 4 5 6
I do not find this math class to be boring.	1 2 3 4 5 6	1 2 3 4 5 6
Even when course materials are dull, I manage to keep working until I finish.	1 2 3 4 5 6	1 2 3 4 5 6
I have the ability to successfully solve logarithmic equations.	1 2 3 4 5 6	1 2 3 4 5 6
My class peers affect my academic work positively.	1 2 3 4 5 6	1 2 3 4 5 6
I enjoy solving math problems this class.	1 2 3 4 5 6	1 2 3 4 5 6
I often feel so lazy when I study for this class that I quit before I finish what I planned to do.	1 2 3 4 5 6	1 2 3 4 5 6
I have the ability to complete Calculus with a final grade of "A" or "B".	1 2 3 4 5 6	1 2 3 4 5 6
I enjoy spending time discussing academic work with my peers.	1 2 3 4 5 6	1 2 3 4 5 6

Thank you very much for participating in the research and completing the survey. Please answer the demographic questions below.

Participant Demographics

Gender: ☐Male ☐Female

Race/Ethnicity: ☐White ☐Black ☐ Asian ☐Hispanic ☐Native American ☐ Other

University Classification: ☐Freshman ☐Sophomore ☐Junior ☐Senior

Age Range: ☐17-21 ☐Older than 21

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