Mathematics Self-Efficacy and Flow in Developmental Mathematics Students

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ABSTRACT

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This study examined mathematics self-efficacy and the characteristics of flow in the context of performing mathematical tasks. In particular, it explored the subjective experiences of 113 undergraduate students enrolled in a developmental mathematics course while they were independently solving certain mathematical problems. This study supplemented the literature on the role of self-efficacy as a mediator of the effect of the challenge/skill ratio on flow by applying it to the context of mathematical problem solving. This study also expanded the discussion on how findings may indicate a direction for further research on mathematics anxiety. Additionally, the relationship between mathematics self-efficacy and flow-like experiences as measured by the Flow Short Scale was considered.
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DEDICATION

I dedicate this dissertation to the two most important people in my life.

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Mathematics Anxiety

Mathematics anxiety continues to be a topic of interest among mathematics education researchers as it is an issue that still remains unresolved. According to Geist (2010), more students today are being plagued with mathematics anxiety and are developing negative attitudes toward mathematics. Betz (1978) found that 68 percent of college students at a particular university suffered from it, and that it had negative consequences for their mathematics performance. Beilock & Willingham (2014) estimated that 25% of four-year college students and up to 80% of community college students suffer from moderate to high levels of mathematics anxiety. Scarpello (2007) suggests that mathematics anxiety is correlated with having little confidence in the ability to do math and, in turn, mathematics anxious students tend to take the minimum number of required math courses. He also notes that, according to the National Research Council, this results in 75% of American students not taking any further mathematics courses before completing the educational requirements for their careers.

In extant research about mathematics anxiety, various aspects have been considered and several definitions have been offered. For this discussion, a psychological, and specifically emotional, approach to the term will be most relevant. McMahon (2009) stated that “math anxiety is the feeling of worry, frustration, agitation, and a fear of failure with regard to taking a math class, completing math problems, and/or taking a math exam” (p.1). Similarly, Tobias &
Weissbrod (1980) described it as “the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem” (p.65). While several symptoms are associated with mathematics anxiety, helplessness and having a sense of loss of control over the situation are some of the most commonly mentioned.

Research suggests a variety of causes for mathematics anxiety, yet a common point of intersection is that origins of mathematics anxiety differ broadly, but are frequently linked to lower ability perceptions (Rounds & Hendel, 1980). Ashcraft (2002) notes that, “highly math-anxious people also espouse negative attitudes towards math, and hold negative self-perceptions about their math abilities” (p. 181). Studies have noted that mathematics anxiety usually arises from lack of confidence when working in mathematical situations (Stuart, 2000; Gourgey, 1984). According to Acelajado (2004) mathematics anxiety is also associated with a loss of self-esteem in confronting a mathematical situation. Fennema & Sherman (1976) found that math anxiety is very highly and negatively correlated with perceptions of math ability. Similarly, Scarpello (2007) argues that mathematics anxiety can be caused by “past classroom experiences, parental influences, and remembering poor math performance” (p.34).

Mathematics Self-Efficacy

As noted by Hall & Ponton (2005), “enhancing mathematics self-efficacy should be an important part of any effort to aid in the academic growth of students enrolled in lower level mathematics” (p.30). Thus, self-efficacy will be a main factor to be explored in this study. General self-efficacy is defined by Bandura (1997) as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (p. 3). Particularly, mathematics self-efficacy has been defined as “a situational or problem-specific assessment of an individual’s confidence in his or her ability to successfully perform or accomplish a particular
As mentioned above, students’ perceived mathematical ability and self-confidence in mathematics have been shown to being a significant cause of mathematics anxiety. In fact, Bandura (1997) notes that “scholastic anxiety is examined solely as a function of perceived self-efficacy to fulfill academic demands” (p.236). In particular, Betz & Hackett (1983) suggest that low mathematical self-efficacy is often concurrently accompanied by high math anxiety. Hall & Ponton (2005) found that mathematics self-efficacy among freshman college students enrolled in Calculus I was significantly higher than that of those enrolled in Intermediate Algebra. Furthermore, they proposed an enhancement of mathematics self-efficacy as a key contributor to student success in lower-level mathematics courses.

There is widespread research that suggests that mathematics self-efficacy, as opposed to mathematics anxiety, is the most important factor in mathematics achievement. Bandura (1997) notes that when anxiety correlates with academic performance, the relation usually disappears or is markedly diminished when the influence of perceived self-efficacy is removed. Moreover, Meece, Wigfield, & Eccles (1990) found that, “past performance experiences with mathematics do not affect anxiety directly. Rather, the impact of past successes and failures on anxiety is mediated entirely through their effects on beliefs of personal efficacy” (Bandura, 1997, p.236).

A focus on student experience mediated through their mathematics self-efficacy as being a leading cause for mathematics anxiety calls for an attempt to understand and address these factors in their mathematics performance. Bonham & Boylan (2011) found that improving the experience of developmental mathematics students can increase their success and persistence. Similarly, Higbee, Arendale, and Lundell (2005) suggested that learning about student experiences and perceptions might produce further insights into improving performance. That is,
the analysis of students’ experiences in solving mathematical problems should drive any efforts for improvement. One promising approach to evaluating subjective experiences is Csikszentmihalyi’s (1990) theory of flow or “optimal experience,” widely discussed in various fields including education. However, little research explores the role of flow in mathematics education specifically. This is surprising considering Csikszentmihalyi’s (2014) own perspective that,

Science and math, for instance, have the initial disadvantage of presenting too many challenges to students, who start out being anxious and often remain in that state without ever enjoying the learning process. But once skills are matched to challenges, it is probably easier to sustain the flow experience in science and mathematics than in humanities or social sciences because the goals, the rules, and the feedback are much less ambiguous in the former. (p.185).

The details of the conceptual connection between flow and mathematics problem solving as a context are explained in the following section.

Flow

Csikszentmihalyi (1990) introduced the concept of flow as a state of mental absorption where one’s abilities are well-matched to the demands at hand. To better understand when and how individuals around the world experienced this state, Csikszentmihalyi conducted a series of long interviews, distributed questionnaires, and collected other data with the objective of understanding how people felt when they were most enjoying themselves and why (Csikszentmihalyi, 1990). He focused on individuals working in areas such as art, music, and dance, “because these people were obviously doing things for which they didn’t expect to be
rewarded, but they still spent enormous amounts of time and energy practicing these activities” (Csikszentmihalyi, 2014, p.132).

A compilation of Csikszentmihalyi’s flow data yielded a list of characteristics consistently reported among the respondents: intense and focused concentration on what one is doing in the present moment, merging of action and awareness, loss of reflective self-consciousness, a sense of control, distortion of temporal experience, and experience of the activity as intrinsically rewarding (Nakamura and Csikszentmihalyi, 2002).

Some of the characteristics are related to those included in the discussion on mathematics anxiety. For example, the notion of being in control of a situation was also central in the previous discussion on mathematics anxiety. The helplessness that mathematics anxious students described is related to the perspective that “we only learn when we feel in control” (Tobias, 1978, p.71). Also, the loss of reflective self-consciousness contrasts with the lack of self-efficacy that mathematics anxious students typically face. These types of connections invite an exploration into how mathematical anxious individuals might be lead to experience flow-like feelings that counteract those they normally feel in the mathematics classroom.

Csikszentmihalyi (1991) determined a set of conditions for flow to occur. Nakamura and Csikszentmihalyi (2002) found that in order for a state of flow to occur, two main conditions are necessary. The first is that the perceived challenge of the task at hand is balanced with the perceived skill level. Figure 1 illustrates the state that the individual is expected to experience as a function of the perceived challenge-to-skill ratio of the task. In particular, the model proposes that when perceived challenge and skill are in balance, labeled $A_1$ and $A_4$, flow is most likely to occur. Otherwise, boredom, $A_2$, or anxiety, $A_3$, may be experienced.
The fact that perceived ability and perceived challenge lie at the heart of Csikszentmihalyi’s conditions for flow to be experienced, most directly draws a connection with Bandura’s construct of self-efficacy. For example, Zimmerman (1995) notes that, “self-efficacy involves judgements of capabilities to perform activities rather than personal qualities,” (p.203). This characteristic of scholastic self-efficacy aligns with a precondition of flow being a balance of perceived challenge and skill. Additionally, Hampton (2014) notes the close relationship between self-efficacy and a psychological construct called locus of control which refers to one’s perception of whether or not they can control key factors or determinants to their success. Again, the notion of being in control is central to the flow experience as well as self-efficacy. Overall, recent research has suggested that the concept of self-efficacy is an important antecedent that can enhance the flow experience (Bassi, Steca, Delle Fave, & Caprara, 2007; Salanova, Bakker, & Llorens, 2006).

In the context of mathematical problem solving, the two main conditions of flow mentioned above can be easily integrated. Given that “mathematics learning exhibits such a high
order of sequential dependence that unless the student masters each step in the development of
the subject, further progress is impossible” (Ausubel, 1969, p.143). Therefore, it would be
plausible to expect that a problem to be presented to a student can be chosen so that it falls
within the ideal flow channel as proposed by Csikszentmihalyi (1990).

The second of the two conditions of flow as described by Nakamura and
Csikszentmihalyi (2002) is that the task must include clear proximal goals and immediate
feedback about the progress being made. This condition presents yet another connection
between mathematical problem solving and activities that are favorable for a flow state. Polya
(2004) discussed the advantages of presenting students with problems in his book *How To Solve
It*: “If the student is lacking in understanding or in interest, it is not always his fault; the problem
should be well chosen, not too difficult and not too easy, natural and interesting” (p.6). Furthermore, one of the problem solving strategies proposed by Polya (2004) is to attempt
an easier problem than the one at hand if you are having difficulty with the one at hand. The
purpose of the strategy can be considered in the context of flow where the point is for students to
successfully complete a similar problem lower on the challenge level scale, and with that, raise
their own skill level so that the subsequent, more challenging problem moves into the flow
channel. However, it is important to clarify that not all problems share this characteristic. In fact,
cognitive psychologists have categorized problems into two classes: well-defined and ill-defined.
For Csikszentmihalyi’s second condition to be met, one must be dealing with a well-defined
problem, which is described as “those problems whose goals, paths to solution, and obstacles to
solution are clear based on the information given” (Pretz, et. al, 2003, p.4).

Csikszentmihalyi (2014) notes that his approach to learning is affective, emotional, and
motivational rather than cognitive or intellectual. Past studies of flow in the field of education
have focused on comparing intensity of flow across various activities or moments during an activity using the Experience Sampling Method (ESM) (Moneta, 2012). This method consists of interrupting students at certain points during an activity or several activities to administer one of the experience sampling forms. This study will focus on a single task and explore the presence of any flow-like characteristics within students’ subjective experience. Concurrently, students will also respond to answers about their perceived challenge, perceived skill, and mathematics self-efficacy so that a connection among factors that contribute to student experience can be made.

*Developmental Mathematics*

Developmental education has become increasingly necessary among postsecondary students. Provasnik et al. (2008) reported that in 2004, 15% of students at four-year colleges had enrolled in remedial mathematics course, while Smittle (2003) noted that 40% of all freshmen at four-year colleges required developmental education of some kind. Additionally, Bailey (2009) stated that almost 60% of all enrolling college students are in need of remedial courses, and only 32% of high school graduates are ready to complete college level mathematics according to Greene & Winters (2006). Furthermore, Rosin (2012) argues that students in developmental mathematics experience the highest level of mathematics anxiety that frequently stems from past failures. Overall, past research indicates that in developmental mathematics students, factors such as mathematics self-efficacy and mathematics anxiety affect their goals, performances, and attainments in mathematics (Breneman & Haarlow, 1998; Highbee & Thomas, 1999). Additionally, Howard & Whitaker (2011) suggest that affective factors that would help improve students’ learning experience should be included in the effort to understand students’ perceptions
of their learning in developmental mathematics. Thus, the context for this study was chosen as a remedial mathematics course with a focus on students’ subjective experience.

This study will explore the presence of a flow-like experience among developmental mathematics students. The focus on developmental mathematics students is supported by extensive evidence that they have higher levels of mathematics anxiety than other college students (Biggs & Preis, 2001). Additionally, it has been found that 27% of all college students first report feelings of math anxiety in their freshman year of college (Jackson & Leffingwell, 1999). Also, as Bandura (1997) notes, “[scholastic] anxiety is best allayed not by anxiety palliatives but by building a strong sense of efficacy…” (p. 236). “Past research failed to simultaneously test both antecedents of flow experiences, that is, the challenges and skills combination and efficacy beliefs” (Rodriguez-Sanchez et al., 2011, p.429). Hence, based on the above mentioned evidence to support the central role of mathematics self-efficacy in reducing mathematics anxiety and improving mathematics achievement, this study will focus on making connections between mathematics self-efficacy and flow. In particular, this study will introduce the notion of flow into the developmental mathematics context as an expansion of the literature that currently exists on flow in educational contexts.

**Purpose of Study**

The purpose of this study is to examine mathematics self-efficacy and the characteristics of flow in the context of performing mathematical tasks. The study will explore the subjective experiences of students enrolled in a developmental mathematics course while they are independently solving certain mathematical problems. This study will supplement the literature
on the role of self-efficacy as a mediator of the effect of the challenge/skill ratio on flow by applying to the context of mathematical problem solving and by expanding the discussion on how these findings may indicate a direction for further research on mathematics anxiety. Additionally, the relationship between mathematics self-efficacy and flow-like experiences as measured by the Flow Short Scale (Rheinberg, Vollmeyer, & Engeser, 2003) will be considered. The research questions to be addressed by this study are the following:

1. Can developmental mathematics students experience any characteristics of flow, as measured by the Flow Short Scale, while performing certain mathematics tasks?
2. Does students’ perceived balance of challenge and skill correspond to their perception of a flow-like experience according to the flow-channel and quadrant models?
3. What relationships (if any) exist between mathematics self-efficacy as measured by the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), flow, and perceived importance of the task as measured by the Flow Short Scale?

**Procedures of Study**

Students who are placed in the developmental mathematics course, Basic Algebra, at a four-year public university were the population for this study. The sections of this course that ran during the Fall 2016 semester were recruited to participate. Only those taught by instructors who were willing to allow the study in their class session were included for the sample of the study. Among the students who attended the participating sections, only those willing to participate were included in the study. The sample for this study was chosen from among developmental mathematics students as research indicates they often experience mathematics
anxiety and low mathematics self-efficacy. Also, this particular course is structured so that each class session includes an independent practice time at the end of the session which allows students to work independently on mathematics problems on personal computers. This allows for the study to be administered electronically and anonymously through the Qualtrics online survey software. Additionally, the tasks from the practice sessions are not graded, and thus, student performance is not evaluated by the instructor.

The study was administered during one class session of the final two weeks of the semester. At a particular time during their work in the practice session, students were administered the 16-item Flow Short Scale (Rheinberg, Vollmeyer, & Engeser, 2003) (see Appendix A) and the General Mathematics Self-Efficacy Factor of the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (May, 2009) (see Appendix B). The Flow Short Scale items 1-10 measure flow, items 11-13 measure students’ perceived importance of the task, and items 14-16 measure students perceived challenge, perceived skill, and perceived demands of the task. The results of the two surveys were analyzed in relation to the research questions in the following manner.

The first research question was addressed by analyzing the Flow Short Scale results for an indication of a flow-like experience (items 1-10). Individual item responses revealed more on specific aspects of students’ experience, and those feelings will be contrasted with those of mathematics anxiety. The second research question involved Flow Short Scale items 14-16 which indicate students’ perceived challenge, skill, and demands. Responses for these items were used to plot each student’s perceived challenge-to-skill ratio on two different flow channel models. Additionally, perceived challenge, perceived ability, and perceived demands of the task were compared in relation to flow intensity among students. For the final research question,
correlations were explored among the following variables: mathematics self-efficacy as measured by the MSEAQ Factor 1, flow (Flow Short Scale items 1-10), and perceived importance of the task (Flow Short Scale items 11-13).
Chapter II
LITERATURE REVIEW

Introduction

This study seeks to explore mathematics self-efficacy and flow-like characteristics in developmental mathematics students as they perform mathematical tasks. Hence, the interdisciplinary nature of this study causes it to encompass a wide range of concepts from the fields of mathematics education and psychology. To provide a theoretical background, this chapter will begin with a discussion of mathematics anxiety with a particular focus on the context of developmental mathematics students. Further, mathematics anxiety and its relation to Bandura’s (1997) concept of self-efficacy will be discussed as a segue into a discussion about mathematics self-efficacy. Additionally, studies demonstrating the important role of mathematics self-efficacy in students’ mathematical achievement and performance will be reviewed. Then, Csikszentmihalyi’s (1980) concept of flow will be introduced with a particular focus on the characteristics that relate to those pertinent to mathematics self-efficacy and mathematics anxiety.

Mathematics Anxiety

Mathematics anxiety is defined by Tobias (1990) as an “anxious state” induced by fear of failing when attempting to learn or demonstrate one’s learning of mathematics. Malinksy et al. (2006) define it as, “the inability by an otherwise intelligent person to cope with quantification, and
more generally, mathematics” (p.274). The issue has been approached from various perspectives by scholars resulting in a variety of definitions along with studies considering its many aspects.

Wigfield & Meece (1988) showed that the affective domain of math anxiety correlated more strongly and negatively to elementary and middle school students’ math ability perception and math performance than the cognitive domain of math anxiety. Finlayson (2014) notes that “addressing anxiety and self-esteem of children and improving their confidence and related attitudes to math are crucial” (p. 102).

Also, as suggested by Geist (2010), “our attitudes towards mathematics are set because of past experiences” (p.28). Hence, for this discussion, a psychological, and specifically emotional, approach to understanding students’ subjective experience will be most relevant. Tobias and Weissbrod (1980) described it as “the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem” (p.65).

Researchers have also noted that mathematics anxiety may result in a high level of emotional interference that can disrupt memory (Handler, 1990; Tolar, 2007).

Hembree (1990) found that developmental mathematics students were more math anxious than other students. Recent studies have also shown that mathematics anxiety is higher in remedial mathematics students (Asera, 2011; Brothen & Wambach, 2004; Fike & Fike, 2012). Further, Latterell & Frauenholtz (2007) notes that mathematics anxiety is one of the main causes for students’ difficulty in successfully passing a remedial mathematics course. Miller (2000), in a case study of elementary algebra students at a community college, found that most low-achieving students have mathematics anxiety.

The cause of mathematics anxiety has also been of great interest to scholars as it has proven to be quite complex and multidimensional. Turner and Meyer (2004) found that
classroom environments where students were overwhelmed by the challenges and were overpowered emotionally were more prone to developing mathematics anxiety. Conversely, Nakamura (1988) found that students who have good experiences in mathematics tend to be less math-anxious. Hoyles (1981) showed that students’ “anxiety, feelings of inadequacy, and shame were common in interpreting their bad experiences in mathematics” (p.368). Additionally, Ashcraft (2002) suggests that, “math anxiety lowers math performance because paying attention to these intrusive thoughts acts like a secondary task, distracting attention from the math task” (p.183).

A recurring consensus among researchers is that origins of mathematics anxiety differ broadly, but are frequently linked to lower ability perceptions (Rounds & Hendel, 1980). Similarly, Perry (2004) argues that mathematics anxiety stems primarily from students’ fears of failure and feelings of inadequacy. Studies have also revealed that mathematics anxiety usually arises from the lack of confidence when working in mathematical situations (Stuart, 2000; Gourgey, 1984). Hackett (1985) notes, “Confidence in learning mathematics is a rather global estimate of how well one expects him or herself to do, or how well one has done, in math courses in general. Mathematics self-efficacy is more specific in one’s ability to perform well with regard to a particular math task or in some related course” (Hackett, 1985, p.48).

According to Acelajado (2004) mathematics anxiety is also associated with a loss of self-esteem in confronting a mathematical situation. Fennema & Sherman (1976) found that math anxiety is very highly and negatively correlated with perceptions of math ability. Particularly, among high school students, they found that mathematics anxiety and mathematical ability concepts were highly correlated (r = -.89). Hendel (1980) found perceived mathematics ability to
be highly correlated with mathematics anxiety and also strongly related to mathematics performance. The relation to mathematics performance will be explored in a later section.

**Mathematics Self-efficacy**

Bandura (1997) defines self-efficacy as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (p. 3). According to Schunk (1991), mathematics self-efficacy refers to students’ convictions that they can successfully perform given academic tasks at designated levels. It is defined by Hackett & Betz (1989) as “a situational or problem-specific assessment of an individual’s confidence in his or her ability to successfully perform or accomplish a particular [mathematical] task or problem” (p.262).

As noted above, students’ perceived mathematical ability and self-confidence in learning mathematics have been found to be an important source of mathematics anxiety. “Scholastic anxiety is examined solely as a function of perceived self-efficacy to fulfill academic demands” (Bandura, 1997, p.236). With Bandura’s self-efficacy construct, several studies have been carried out to explore the relationship between mathematics self-efficacy and mathematics anxiety. Past studies have shown that self-efficacy has a negative correlation with mathematics anxiety (Bandalos et al., 1995; Cooper & Robinson, 1991; Jain & Dowson, 2009; Ma & Xu, 2004; Meece et al., 1990). In particular, “the influence of efficacy beliefs on anxiety over scholastic activities has been examined most extensively in relation to mathematics, which is a common source of apprehension among students. A low sense of mathematical efficacy is accompanied by high math anxiety both concurrently and longitudinally (Betz & Hackett, 1983; Krampen, 1988)” (Bandura, 1997, p.236). In other words, research has shown that domain specific self-
concept and self-efficacy substantially predict mathematics anxiety (Hembree, 1990; Meece, Wigfield, & Eccles, 1990; Pajares & Miller, 1994).

In the context of developmental mathematics, several studies have shown that developmental students have a low self-efficacy compared to other students. Hall & Ponton (2005) conducted a study of college freshmen that set out to explore the differences between students enrolled in a developmental mathematics course and those enrolled in a calculus course. Students enrolled in developmental mathematics had lower mathematics self-efficacy than the calculus students did. Furthermore, they argued that this finding confirmed Bandura’s (1997) belief that mathematics achievement is the greatest source of self-efficacy since developmental mathematics students are less likely to have previous successful mathematics achievement than calculus students and are therefore less likely to have higher levels of mathematics self-efficacy (Hall & Ponton, 2002, p.9).

An additional factor that should be noted is that there is a growing tendency for reform in developmental mathematics curricula and modes of instruction. Tisch (2014) notes that, “traditional methods of teaching and learning mathematics have failed these students,” (p. 35). Consequently, programs such as the Changing the Equation program supported by the National Center for Academic Transformation (NCAT) have focused on redesigning developmental mathematics classes. In particular, many reforms have included inquiry-based instruction as a recommendation, where it involves a process of learning that is driven by questioning, thoughtful investigating, making sense of information and developing new understandings (Diggs, 2009).
Mathematics Performance

Hendel (1980) contended that math self-efficacy, math anxiety, and math performance were highly correlated. There is a significant amount of literature that suggests that mathematics self-efficacy, rather than mathematics anxiety, is the factor that most affects mathematics performance and depends on past performance experiences with mathematics. Bandura (1997) notes that when anxiety correlates with academic performance, the relation usually disappears or is markedly diminished when the influence of perceived self-efficacy is removed. In fact, Meece, Wigfield, & Eccles (1990) found that, “past performance experiences with mathematics do not affect anxiety directly. Rather, the impact of past successes and failures on anxiety is mediated entirely through their effects on beliefs of personal efficacy” (Bandura, 1997, p.236). When the causal role of efficacy beliefs was compared with that of attitudes and anxiety about mathematics, efficacy beliefs were found to be the primary mediator of achievement outcomes (Meece, Wigfield, & Eccles, 1990; Randhawa, Beamer, & Lundberg, 1993).

Studies have shown a reciprocal relation between perceived competence and academic performance (Guay, Marsh, & Boivin, 2003; Marsh & Martin, 2011; Valentine, DuBois, & Cooper, 2004). In fact, Parajes & Urdan (2006) showed that student academic achievement can be predicted by self-efficacy. Ercikan, McCreith and Lapointe (2005) also found that confidence in mathematics was the strongest predictor of mathematics performance. Betz and Hackett (1989) found a moderate positive correlation between mathematics self-efficacy and mathematics performance among 262 undergraduate students. In a study of 301 adults, Davis (2009) explored the factors that affect academic achievement in a college quantitative business course based on exam scores and found that, while general self-efficacy did not significantly predict performance, mathematics self-efficacy did. Similarly, mathematics self-efficacy was
found to have a positive correlation with performance of mathematics examinations (Hodge, 1999).

In order to continue a discussion on the existing literature relevant to the present study, another psychological construct will now be introduced.

**Flow**

M. Csikszentmihalyi began research on understanding (1990) introduced the concept of flow as a state of mental absorption where one’s abilities are well-matched to the demands at hand. To better understand when and how individuals around the world experienced this state, Csikszentmihalyi conducted a series of long interviews, distributed questionnaires, and collected other data with the objective of understanding how people felt when they were most enjoying themselves and why (Csikszentmihalyi, 1990). Those studies analyzed the responses of several thousand respondents from various cultures. The domains that have been primarily analyzed in past flow research include leisure activities such as sports and music, the workplace, and education.

A compilation of Csikszentmihalyi’s flow data yielded a list of characteristics consistently reported among the respondents: intense and focused concentration on what one is doing in the present moment, merging of action and awareness, loss of reflective self-consciousness, a sense of control, distortion of temporal experience, and experience of the activity as intrinsically rewarding (Nakamura and Csikszentmihalyi, 2002).

Csikszentmihalyi (1991) determined a set of conditions for flow to occur. Nakamura and Csikszentmihalyi (2002) found that in order for a state of flow to occur, two main conditions are necessary. The first is that the perceived challenge of the task at hand is balanced with the
perceived skill level. Figure 2 illustrates the original flow model Csikszentmihalyi (1975) where flow is expected to occur when there is a perceived challenge-to-skill balance of the task. Hence, the original flow channel model proposes that flow occurs when challenge level and skills are both low, when both are medium, or when both are high. However, when perceived skills exceed the challenge, attention may shift, and boredom will be experienced. When the ratio between challenge and perceived skills becomes too large, people may become even more distracted from the task and will be more likely to make mistakes. As a consequence, people may experience anxiety. (Schiepe-Tiska, 2013).

Figure 2. The flow channel model (Csikszentmihalyi, 1975).

This model was challenged by subsequent research that found theoretical inconsistencies with it. In particular, that flow did not always occur within the proposed channel. Csikszentmihalyi & Csikszentmihalyi (1988) reformulated the model into a quadrant model that took into account how high perceived skill and challenge were. The quadrant model (Figure 3) predicts that flow only occurs when skill and challenge are perceived at above the average level. Still, the quadrant model, and a subsequent octant model Massimi & Carli (1988)
with the following states: apathy, worry, boredom, anxiety, relaxation, arousal, control, and flow, were found to not always accurately predict flow in successive research (Ellis, Voelkl, & Morris, 1994; Engeser & Rheinberg, 2008; Schüler, 2007; Stoll & Lau, 2005).

Consequently, researchers began proposing the existence of moderators of the relation between challenge/skill balance and flow. Csikszentmihalyi (1975) proposed the concept of an autotelic personality which refers to the tendency to experience challenging situations as rewarding (Csikszentmihalyi & LeFevre, 1989). Also, a large body of research began to explore the role of achievement motive, defined as the desire to surpass personal standards of excellence (McClelland, et al., 1953). For example, Engeser & Rheinberg (2008) explored flow during learning for an obligatory course in statistics in Germany. 246 psychology students taking a statistics course were given a statistical task to work on one week before their final exam. This task included items they would have normally worked on in preparation for the final exam. They

Figure 3. Reformulated quadrant model (Csikszentmihalyi & Csikszentmihalyi, 1988)
were instructed to set an alarm clock ten minutes after they had begun the task in order to complete the questionnaire which measured prior knowledge, implicit achievement motive, explicit need of achievement, and flow using the Flow Short Scale (Rheinberg et al., 2003). Engeser & Rheinberg (2008) determined that flow depends on difficulty and skill, but not the interaction between the two variables. Also, they found that the direct measure of balance between difficulty and skill confirmed the flow model’s prediction that flow decreases when task demand is too high. In particular, they showed that only in the case of individuals having a high achievement motive, was the challenge/skill balance positively correlated with flow. However, their findings concluded that for highly important activities, individuals experience flow even if skill exceeds difficulty.

Also, Eisenberg et al. (2005) found that among employees with a high need for achievement, the experience of high skills and challenges of a job task reported to be positive, while those with a low achievement motivation did not. Similarly, Schuler (2007) conducted a study among undergraduate students taking an elementary course in psychology. Participants were asked whether the challenge of the course content was too high for their skills, too low for their skills, or just right for their skills. Additionally, they were administered the Flow Short Scale (Rheinberg et al., 2003) and achievement motive was found to have a moderating effect in the academic setting.

**Flow in Relation to Mathematics Self-Efficacy and Mathematics Anxiety**

Theoretical connections can be made between self-efficacy and flow. In the case of academic self-efficacy, Zimmerman (1995) notes that, “self-efficacy involves judgements of capabilities to perform activities rather than personal qualities,” (p.203). This characteristic of
academic self-efficacy coincides with the condition of flow mentioned above in which perceived demands of an activity is a significant predecessor to flow. In other words, for flow to occur, it has been argued that perceived challenge and perceived skill to perform a specific activity must be in balance, and this balance is also a measure that students use in determining their self-efficacy. Usher and Pajares (2009) found that “perceived mastery experience is a powerful source of students’ mathematics self-efficacy. Students who feel they have mastered skills and succeeded at challenging assignments experience a boost in their efficacy beliefs” (p. 100).

Another example of a conceptual connection between flow and mathematics self-efficacy constructs is a notion called locus of control which refers to one’s perception of whether or not they can control key factors or determinants to their success (Rotter, 1966). For example, a study that explored the role of locus of control in mathematics self-efficacy was conducted in Japan by Matsui, Matsui, & Ohnishi (1990). Locus of control was found to moderate the relationship between math self-efficacy and modeling, verbal persuasion, and emotional arousal, although they were rather weak (Matsui, et al., 1990). It was further noted by these researchers that locus of control did not moderate the relationship between math self-efficacy and performance accomplishment. Similarly, in flow research, Keller & Blomann (2008) focused on understanding the locus of control as a moderator of the effect of the challenge/skill balance and flow. They conducted experiments where participants would play computer games, and found that individuals with a strong internal locus of control were more likely to enter the flow state in the challenge/skill balance condition than outside of it.

Past studies have explored the relationship between self-efficacy and flow in various settings. Bassi et al. (2007) investigated which learning activities associated the quality of student experience with different levels of perceived academic self-efficacy. They had 130
Italian secondary school students participate and be divided into two groups: those with high academic self-efficacy and those with low academic self-efficacy. Then, they implemented the Experience Sampling Method (ESM) for one week to determine which activities students associated with an optimal experience. One of their findings was that, “contrary to high self-efficacy students, low self-efficacy students did not perceive a great amount of opportunities for optimal experience in learning tasks” (Bassi et al., 2007, p.309).

Furthermore, Rodriguez-Sanchez et al. (2011) conducted a longitudinal study among 258 secondary school teachers of various disciplines with the objective of extending the channel model of flow to include self-efficacy as a predictor of the challenge-skill combination and of flow itself. Their results showed that, “the channel model of flow, including self-efficacy as antecedent of flow, fitted better the data,” and that, “the more self-efficacy the more flow frequency and higher levels of challenge and skills, which in turn, predicted flow over time. Moreover, the influence of self-efficacy on flow over time was mediated by subjects’ perception of the challenges and skills combination” (p.427).

In a study that applied flow to the mathematics classroom, Heine (1996) conducted a longitudinal study consisting of mathematically talented students and found that those experiencing flow in the first half of the course performed better during the second half of the course. Past studies of flow in mathematics classrooms have also found that perceived challenge was negatively correlated to efficacy (Schweinle et al., 2006; Eccles & Wigfield, 1995). One explanation for this is that the context in which these studies were applied consisted of individuals who view challenges negatively. In the original elaboration of the theory, Csikszentmihalyi analyzed the experiences of experts performing tasks in their area of expertise,
and thus, valued challenge as a positive endeavor. The context for this study was also a mathematics classroom, and as such, the expectation is that similar results will follow.

Schiefele & Csikszentmihalyi (1995) conducted a study on 108 high school freshman and sophomore students that examined their quality of experience while doing mathematics. They included independent measures of interest in mathematics, achievement motivation, and mathematical ability as measured by the Preliminary Scholastic Aptitude Test (PSAT). They used a version of the Experience Sampling Form created by Csikszetmihalyi & Larson (1987) with the Experience Sampling Method (ESM) over the course of a week to measure their quality of experience. The results showed that quality of experience was “mainly related to interest in mathematics and, to a lesser extent, to achievement motivation. Even feelings of self-esteem, concentration, or skill seemed to be unaffected by ability” (Schiefele & Csikszentmihalyi, 1995, p. 176).

The present study seeks to interpret some of the characteristics of flow in relation to those included in the discussion on mathematics anxiety. For example, the notion of being in control of a situation was also central in the previous discussion on mathematics anxiety. The helplessness that mathematics anxious students described is related to the perspective that “we only learn when we feel in control” (Tobias, 1978, p.71). Also, the loss of a sense of self or reflective self-consciousness contrasts with the worry about one’s abilities that mathematics anxious students typically face. These types of connections invite an exploration into how mathematical anxious individuals might be led to experience flow-like feelings that may increase their self-efficacy and, in turn, decrease their mathematics anxiety.
Chapter III

METHODOLOGY

Institutional Setting

The study was conducted at a public four-year university in northern New Jersey. At that university, entering students are required to take the ACCUPLACER Elementary Algebra placement examination. The score ranges and corresponding course placement for the exam are shown in the Table 1.

Table 1. Mathematics course placement table based on ACCUPLACER scores.

<table>
<thead>
<tr>
<th>Score Ranges</th>
<th>Math Course Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 57</td>
<td>Basic Algebra Required</td>
</tr>
<tr>
<td>58 - 74</td>
<td>Basic Algebra Required - Retest (recommended) Students are eligible to repeat the Elementary Algebra test section. It is strongly recommended that students review Basic Algebra prior to retesting. A free ACCUPLACER Web-Based Study App is provided at <a href="https://accuplacer.collegeboard.org/students/prepare-for-accuplacer">https://accuplacer.collegeboard.org/students/prepare-for-accuplacer</a> Elementary Algebra section. (Only one retest is permitted.)</td>
</tr>
<tr>
<td>≥ 75</td>
<td>Basic Algebra Not Required</td>
</tr>
</tbody>
</table>

Basic Algebra is a developmental mathematics course that does not count towards graduation/college credit. The classroom where all sections of Basic Algebra are held is a large classroom with smart board and personal computers available for each student. The course is designed to allow students classroom time during each class session for independent practice on
the material that had been previously taught by the instructor during the lecture. It was during this independent practice time that the online survey was administered. Hence, although subjects of the study were physically in the classroom setting, the instruments for the survey were administered online using students’ personal laptops or the laptop provided to them as a part of their regular classroom material.

Sample

The population of the study was students placed in the developmental mathematics course, Basic Algebra, at a four-year public university. The sample for this study consisted of students enrolled in Basic Algebra during the Fall 2016 semester. Eight instructors held a total of 18 sections of Basic Algebra during that semester. Only four of the eight instructors granted permission for their sections to participate in the study. This yielded a total of 8 participating sections for this study. Of the approximately 200 students enrolled and attending on the date of the study in the 8 participating sections, 113 of them were willing to participate. The study was held during one class session of the final two weeks of the semester.

Given that the focus of this study is primarily on finding connections between various aspects of students’ perceived experience while performing mathematical tasks, no further information about participants was gathered. Hence, the only information gathered about the participants in this study is the fact that they scored below a 74 on the ACCUPLACER as shown in Table 1, and were consequently enrolled in the developmental mathematics course Basic Algebra.
Instrumentation

The online survey administered to participants in this study consisted of two main questionnaires: the Flow Short Scale (Engeser, 2012) (see Appendix A) and the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ): General Mathematics Self-Efficacy Factor (May, 2009) (see Appendix B). Qualtrics survey software was used with the Teachers College Columbia University student license to collect the data and create some of the reports.

The Flow Short Scale is a 16-item questionnaire that was created by Rheinberg et al. (2003) and was used to study flow in learning situations. The first ten items directly capture the flow experience and include measurement of two factors: fluency of performance (items 2, 4, 5, 7, 8, 9) and absorption by activity (items 1, 3, 6, 10). Items 11 - 13 measure the perceived importance of the task, and items 14 - 16 ask about perceived challenge, ability, and subjective balance of these two variables in the performed activity (Engeser, 2009). Items 1-13 are measured on a 7-point scale ranging from 1 (not at all) to 4 (partly) to 7 (very much), while items 14 - 16 use a 9-point scale ranging from 1 to 9. This scale has a Cronbach’s alpha of 0.85.

The MSEAQ was created by May (2009) in dissertation work that modified the Mathematics Self-Efficacy Scale (Betz & Hackett, 1983) which is a commonly used self-efficacy measurement tool. May (2009) found that the MSEAQ is “based on a general expectancy-value model, which is highly applicable to exploring students’ mathematics self-efficacy and anxiety” (p. 49). The questionnaire includes five factors, of which the first, the General Mathematics Self-Efficacy factor, was used for this study. The General Mathematics Self-Efficacy factor includes 7 items about students’ beliefs regarding their general mathematical abilities and seems to “relate to how the students felt in general about their mathematical abilities, based on a long-
term view of their experiences in mathematics” (May, 2009, p.49). According to May, this factor was reliable and viable for online administration as shown by a Cronbach’s Alpha of 0.93.

The practice problems that students were working on at the time of the survey were all from Ch. 8 “Roots and Radicals” from the Basic Algebra online textbook, *Introductory Algebra, 4th* edition by Elayn Martin-Gay, Pearson/Prentice Hall. Sample problems include the following:

1. *Simplify. Assume that all variables represent positive numbers.*
   
   a. \(\sqrt{16x^2}\)
   
   b. \(\sqrt[3]{\frac{7}{64}}\)
   
   c. \(\sqrt{81a^{12}b^{14}}\)
   
   d. \(\sqrt{\frac{36y^2}{25}}\)

2. *Add or subtract as indicated.*

   a. \(5\sqrt{2} - 5\sqrt{3}\)

   b. \(2\sqrt{x} + \sqrt{25x} - \sqrt{36x} + 3x\)

3. *Multiply and simplify if possible.*

   a. \(\sqrt{8y} \cdot \sqrt{2y}\)

   b. \((\sqrt{x} - 5)(\sqrt{x} + 2)\)
However, the exact problems that each student was working on at the time of taking the survey is unknown and not the focus of this study. This study is based solely on the perceived difficulty and perceived ability rather than actual ones. Keller & Landhäußer (2012) notes, “an absolute level of skills or demands (across activities) is not relevant in order to address the question whether a fit experience was present or not” (p.57). Hence, perceived challenge and perceived skill of the activity were the main factors for this study. Also, it is important to note that the task given to the subjects in this study was not to be formally assessed nor would it affect their grade in the course.

Variables

The following is a description of the variables included in this study.

- **Flow Mean**: Overall mean of responses to items 1-10 on Flow Short Scale.
- **Fluency of Performance**: Items 2, 4, 5, 7, 8, and 9 of the Flow Short Scale. Identified by Rheinberg, Vollmeyer, & Engeser (2003) as an individual subfactor of flow.
- **Absorption by Activity**: Items 1, 3, 6, and 10 of the Flow Short Scale. Identified by Rheinberg, Vollmeyer, & Engeser (2003) as an individual subfactor of flow.
- **Challenge**: Response to item 14 on Flow Short Scale, “Compared to all other activities which I partake in, this one is….‟.
- **Skill**: Response to item 15 on Flow Short Scale, “I think that my competence in this area is….‟.
- **Quadrant**: Categorical variable indicating the quadrant each ordered pair (skill, challenge) belongs to on the flow quadrant model. The four quadrants were Anxiety, Flow, Boredom, and Apathy. Exact methods for determining this can be found in Table
2. Individual binary variables based on this variable were also created and named Q1 Anxiety, Q2 Flow, Q3 Boredom, and Q4 Apathy.

- **Area**: Categorical variable indicating the area each ordered pair (skill, challenge) belongs to on the flow-channel model. The three areas are Anxiety, Flow, and Boredom. Exact methods for determining this can be found in Table 3. Three binary variables (Anxiety, Flow, and Boredom) were also created based on the Area variable.

- **Challenge-Skill Ratio**: A computed variable representing the ratio of perceived challenge to perceived skill.

- **Self-Efficacy Mean**: Overall mean of responses to the MSEAQ Factor 1.

- **Worry Mean**: Mean of responses to items 11-13 of the Flow Short Scale. Also referred to as “perceived importance of task”. This variable includes the following statements: “Something important to me is at stake here.”, “I must not make any mistakes here.”, “I am worried about failing.”.

**Methods**

Prior to the beginning of the study, the course coordinator for Basic Algebra at the target university was contacted for permission to contact the rest of the course instructors. Upon receiving permission, an email was sent to nine instructors of the sections of Basic Algebra being held during Fall 2016. The email contained detailed instructions (see Appendix C) on how those who were willing to participate would need to administer the online survey to their students during class time. Four of the instructors agreed to assist with the administration of the online survey, and a website was created containing a single link that would direct students to the start of the online Qualtrics survey. The online survey contained the Flow Short Scale and
immediately followed by the MSEAQ. The estimated completion time for the survey according to the Qualtrics online software was 2-3 minutes, and all responses were anonymized.

During the class session in which the survey was to be administered, each instructor would read a prompt (see Appendix C) to students that directed them to a website once they were going to begin the independent practice portion of the session on their personal computers. The website students were directed to only contained a link with visible text “Click Here”. Students were instructed to keep the website open while they worked on the practice problems. After 5-10 minutes, instructor informed students that those who were willing to participate in the study would be stopped at a random time during their independent practice and would need to click on the link to begin the survey.

Note that the use of a direct link to the survey that was already opened on the students’ laptops at the time of being interrupted was done in an attempt to minimize the time between students stopping the activity and beginning the survey in order to better capture students’ mindset as they were working on the mathematics task. This proximity allows students to make more accurate judgements about their abilities (Bandura, 1997). Also, as suggested by Engeser (2009), students were interrupted after about 10 minutes of working on the practice problems and were asked to begin the survey. “With this approach it should be achieved that the recording of the current experience would not be associated with possible retrospective distortions. Rather, the experience should be recorded as directly as possible, as is done in flow research by the ESM method.” (p. 136). When the instructor prompted those who were willing to participate to begin the survey, the rest of the students continued their independent practice. Since all students were working independently on personal computers, there was no interruption of the classroom environment by those taking the online survey. Upon completion of the survey, responses were
immediately recorded and became available to the principal investigator through the Qualtrics online software.

**Data Analysis**

IBM’s SPSS 24 statistical software was used to analyze the data and carry out statistical tests to compare the variables in several different ways using multiple regression analyses. The Shapiro-Wilk test was used to verify that all dependent variables were approximately normally distributed for each independent variable. Additionally, post-hoc analyses were performed in certain cases.

The first research question was “Can developmental mathematics students experience any characteristics of flow, as measured by the Flow Short Scale, while performing certain mathematics tasks?” To address this question, descriptive statistics determined if a flow-like experience was reported among students on the flow portion of the Flow Short Scale (items 1-10). Additional descriptive statistics also provided individual means for items 1-10 of the Flow Short Scale. Using a one-sample t-test those individual means were compared to the overall flow mean. This was done with the intention of gaining descriptive information as to the differences between individual items and the overall flow mean. Finally, the distinction of two factors identified by Rheinberg, Vollmeyer, & Engeser (2003): fluency of performance (items 2, 4, 5, 7, 8, 9) and absorption by activity (items 1, 3, 6, 10) was explored in terms of their factor means. In particular, a correlation analysis was conducted to determine the relationship (if any) between overall flow and the two factors.
In order to address the second research question, “Does students’ perceived balance of challenge and skill correspond to their perception of a flow-like experience according to the flow-channel and quadrant models?”, standardized values for challenge and skill with a mean of 0 and a standard deviation of 1 were calculated for each Flow Short Scale response (items 14 and 15). This was done so that each response’s position could be categorized into one of the regions relative to the others. Each standardized ordered pair (skill, challenge) was plotted and each point was categorized into one of the four quadrants on the flow model used for this study. Table 2 shows exactly how the categorization was made. This methodology is based on a similar procedure carried out by Wells (1988) in her categorization of experiences among mothers based on perceived challenge and perceived skill.

Table 2. Quadrant categorization based on ordered pairs (skill, challenge).

<table>
<thead>
<tr>
<th>Point (skill, challenge)</th>
<th>Quadrant on Flow Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>skill &gt;=0 and challenge &gt;=0</td>
<td>Flow (quadrant 2)</td>
</tr>
<tr>
<td>skill &lt;=0 and challenge &lt;=0</td>
<td>Apathy (quadrant 4)</td>
</tr>
<tr>
<td>skill &lt;0 and challenge &gt;=0</td>
<td>Anxiety (quadrant 1)</td>
</tr>
<tr>
<td>skill &gt;=0 and challenge &lt;0</td>
<td>Boredom (quadrant 3)</td>
</tr>
</tbody>
</table>

Once the location on the flow model was categorized by quadrant, descriptive statistics were used to analyze the intensity of flow for each quadrant. Using the flow-channel model, standardized points were categorized into three areas: anxiety, flow, and boredom. Table 3 shows
exactly how the points were categorized by area on the flow model. Descriptive statistics were also used to compare the flow means for each area based on this categorization.

Table 3. Area categorization based on ordered pairs (skill, challenge).

<table>
<thead>
<tr>
<th>Point (skill, challenge)</th>
<th>Area on Flow Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>challenge &gt;= skill + 1</td>
<td>Anxiety</td>
</tr>
<tr>
<td>challenge &lt;= skill -1</td>
<td>Boredom</td>
</tr>
<tr>
<td>Otherwise</td>
<td>Flow</td>
</tr>
</tbody>
</table>

Next, the factors related to students’ perceived balance of challenge and skill were analyzed in their relation to the flow mean. In particular, descriptive statistics were provided with mean values of flow for each response in items 11-13. A regression analysis was conducted on flow with predictors based on (i) flow quadrant model (ii) flow-channel model. This provided information on how well each flow model was able to predict flow-like experience in the case of this study.

The final research question, “What relationships (if any) exist between mathematics self-efficacy as measured by the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), flow, and perceived importance of the task as measured by the Flow Short Scale?”, involved the variables self-efficacy, flow mean, and worry mean. First, descriptive statistics were provided for the overall self-efficacy mean as well as individual items on the MSEAQ Factor 1 survey. Also, a one-sample t-test was conducted to compare the individual means for each item with the overall self-efficacy mean. This was done with the intention of gaining descriptive information as to the differences between individual items and the overall self-efficacy mean. Descriptive
statistics were also provided for the worry variable, (items 11-13 of the Flow Short Scale) which measure students’ perceived importance of the activity. A one-sample t-test was also conducted to compare individual means for each item with the overall mean of the three items. Then, a correlation analysis was conducted on mathematics self-efficacy, flow (items 1-10), and perceived importance of the task (items 11-13). After all variables were verified to being approximately normally distributed, a regression analysis was conducted to explore the relationships between the variables further.
Chapter IV
RESULTS

Introduction

This study involved 113 undergraduate students enrolled in a developmental algebra course at a four-year university. The particular course used in this study includes a practice session during each class meeting that allows students to work independently on personal computers to solve practice problems related to the lecture they just received. At a random time during their work in the practice session, students were administered the 16-item Flow Short Scale (Rheinberg, Vollmeyer, & Engeser, 2003) (see Appendix A) and the General Mathematics Self-Efficacy Factor of the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (May, 2009) (see Appendix B). The Flow Short Scale items 1-10 measured flow, items 11-13 measured students’ perceived importance of the task, and items 14-16 measured students perceived challenge, perceived skill, and perceived demands of the task. In this chapter, the results from the data analysis described in the previous chapter will be presented. The results obtained in this study will be organized based on the research question they address. A summary of the results will follow.

Research Question One

To address the first research question, “Can developmental mathematics students experience any characteristics of flow, as measured by the Flow Short Scale, while performing certain mathematics tasks?”, descriptive statistics on the flow portion of the Flow Short Scale
(items 1-10) provided insight into if a flow-like experience was reported among students while performing the mathematical task. As shown in Figure 4, the overall flow mean among the respondents was 4.33 with a standard deviation of 0.92 where 1 was “Not at all”, 4 was “Partly”, and 7 was “Very Much” when asked about the presence of each flow-like experience in the flow portion of the Flow Short Scale (items 1-10). These findings show that, overall, developmental students’ subjective experience while performing a mathematical task was at least in part a positive one. For the purpose of this study, the main result that is gathered from this finding is that students did not experience negative, anxious feelings during this portion of their developmental mathematics course activity. This is due to the fact that the original flow concept originally researched among experts during their work is not completely applicable to this context. Instead, the specific flow-like characteristics were analyzed in comparison to those that may have been present in mathematics anxious students.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>N</th>
<th>Minimum Statistic</th>
<th>Maximum Statistic</th>
<th>Mean Statistic</th>
<th>Std. Deviation Statistic</th>
<th>Skewness Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Mean</td>
<td>113</td>
<td>1.56</td>
<td>6.40</td>
<td>4.3339</td>
<td>.91685</td>
<td>-.260</td>
<td>.227</td>
</tr>
</tbody>
</table>

Figure 4. Descriptive Statistics for Flow Mean.

As illustrated in Figure 5, the distribution of flow means among respondents showed that 28.3% of students reported less than “Partly” to feeling flow-like characteristics, while 71.7% reported those feelings “Partly” or more. Again, this indicates that the majority of the developmental students in this particular sample at least experienced somewhat positive flow-like characteristics while solving mathematics practice problems. Also, as previously mentioned,
the distribution of the flow mean data is approximately normally distributed as verified by the Shapiro-Wilk test. This can also be appreciated visually by Figure 5.

![Histogram of Flow Mean](image)

**Figure 5.** Frequency distribution table for Flow Mean.

Additional descriptive statistics were also presented for individual items 1-10 of the Flow Short Scale. The means and standard deviations for each individual item on the flow questionnaire are shown in Figure 6, and reveal differences in how much each specific feeling was experienced. Students reported feeling “just the right amount of challenge” the most with a mean of 5.03, while reporting feeling “completely lost in thought” less (mean = 2.97) than the overall mean (4.33). In other words, students felt appropriately challenged for the most part, but did not feel much absorbed by the task at hand.
Figure 6. Descriptive Statistics for each item on flow questionnaire.

The next analysis conducted to address the first research question was a comparison of the individual means of each item with the overall flow mean of 4.33. This was carried out by conducted using a one-sample t-test shown in Figure 7. The purpose of this t-test was to gain descriptive information as to the differences between individual items and the overall flow mean. There were only significant differences in mean responses between individual items "I feel just the right amount of challenge.", "My thoughts/activities run fluidly and smoothly.", "I am completely lost in thought." and the overall flow mean (p < .05). Particularly, students felt "just the right amount of challenge" and that their "thoughts/activities run fluidly and smoothly"
more than the flow mean (.69 and .36 respectively). On the other hand, they felt "completely lost in thought" much less (1.36 less) than the overall flow mean.

<table>
<thead>
<tr>
<th>Test Value = 4.3339</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel just the right amount of challenge.</td>
<td>5.825</td>
<td>112</td>
<td>.000</td>
<td>.693</td>
<td>.46</td>
</tr>
<tr>
<td>2. My thoughts/activities run fluidly and smoothly.</td>
<td>2.792</td>
<td>112</td>
<td>.006</td>
<td>.356</td>
<td>.10</td>
</tr>
<tr>
<td>3. I do not notice time passing.</td>
<td>.977</td>
<td>109</td>
<td>.331</td>
<td>.157</td>
<td>-.16</td>
</tr>
<tr>
<td>4. I have no difficulty concentrating.</td>
<td>.344</td>
<td>110</td>
<td>.731</td>
<td>.053</td>
<td>-.25</td>
</tr>
<tr>
<td>5. My mind is completely clear.</td>
<td>-1.695</td>
<td>109</td>
<td>.093</td>
<td>-.279</td>
<td>-.61</td>
</tr>
<tr>
<td>6. I am totally absorbed in what I am doing.</td>
<td>1.435</td>
<td>111</td>
<td>.154</td>
<td>.202</td>
<td>-.08</td>
</tr>
<tr>
<td>7. The right thoughts/movements occur of their own accord.</td>
<td>1.266</td>
<td>112</td>
<td>.208</td>
<td>.162</td>
<td>-.09</td>
</tr>
<tr>
<td>8. I know what I have to do each step of the way.</td>
<td>.524</td>
<td>112</td>
<td>.602</td>
<td>.073</td>
<td>-.20</td>
</tr>
<tr>
<td>9. I feel that I have everything under control.</td>
<td>-.023</td>
<td>111</td>
<td>.982</td>
<td>-.004</td>
<td>-.31</td>
</tr>
<tr>
<td>10. I am completely lost in thought.</td>
<td>-9.368</td>
<td>112</td>
<td>.000</td>
<td>1.360</td>
<td>-1.65</td>
</tr>
</tbody>
</table>

Figure 7. One-Sample T-Test for Individual Means versus Overall Mean of 4.33.

Finally, the distinction of two factors identified by Rheinberg, Vollmeyer, & Engeser (2003): fluency of performance (items 2, 4, 5, 7, 8,9) and absorption by activity (items 1, 3, 6, 10) was explored in terms of their factor means. In particular, descriptive statistics were presented to determine the distinction (if any) of the two factors. This distinction, presented in Figure 8, showed that students reported a sense of fluency of performance (mean = 4.39, standard deviation = 1.21) slightly more than absorption by the activity (mean = 4.25, standard
deviation = 0.77). In other words, based on the categorization of flow-like characteristics suggested by Rheinberg, Vollmeyer, & Engeser (2003), developmental mathematics students felt a greater sense of fluency while performing the tasks than an absorption by the task.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency of Performance</td>
<td>113</td>
<td>1.33</td>
<td>7.00</td>
<td>4.3903</td>
<td>1.21439</td>
</tr>
<tr>
<td>Absorption by Activity</td>
<td>113</td>
<td>2.00</td>
<td>6.00</td>
<td>4.2500</td>
<td>.76797</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>113</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 8. Descriptive Statistics for Two Factors of Flow*

**Research Question Two**

The second research question, “Does students’ perceived balance of challenge and skill correspond to their perception of a flow-like experience according to the flow-channel and quadrant models?”, involved standardizing values for items 14 and 15 of the Flow Short Scale. This was done so that regions and quadrants could be clearly identified within the data set. These items measured perceived challenge (“Compared to all other activities which I partake in, this one is….”) and perceived skill (“I think that my competence in this area is….”). Then, each standardized ordered pair (skill, challenge) was plotted and each point was categorized into one of the four quadrants on the flow quadrant model (Figure 3) used for this study based on the indications of Table 2. The ordered pairs (skill, challenge) were plotted into one of the four quadrants as labeled on the flow quadrant model (Figure 3). The four quadrants were anxiety (quadrant 1), flow (quadrant 2), boredom (quadrant 3), and apathy (quadrant 4). Figure 9 shows this plot with mean reference lines x = 0 and y = 0. Also, the point labels indicated the flow mean that corresponds to each response.
Figure 9. Scatterplot of standardized challenge and skill values with corresponding flow mean values. Reference lines at x=0 and y=0.

Once the location on the flow model was categorized by quadrant, descriptive statistics were used to analyze the intensity of flow for each quadrant. As shown in Figure 10 and Figure 11, responses coded into quadrants 2 (Flow) and 3 (Boredom) reported the highest intensity of a flow-like experience, while quadrants 1 (Anxiety) and 4 (Apathy) had lower means. These findings are not completely consistent with the flow quadrant model since the Flow quadrant (when perceived challenge and perceived skill were both high) did not include the responses with the highest flow intensity. Instead, responses in the Boredom quadrant (when perceived skill exceeded perceived challenge), indicated the highest intensity of a flow-like experience. What is consistent in this findings with the model is that the Anxiety (when perceived challenge
exceeded perceived skill) and Apathy (when perceived challenge and perceived skill were both low) quadrants included the lowest intensity of flow-like characteristics. In short, the responses of students were categorized by the quadrant in which they belonged, and their corresponding flow intensities were also noted.

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow</td>
<td>3.98</td>
<td>4.64</td>
<td>4.78</td>
<td>4.05</td>
</tr>
<tr>
<td>Boredom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apathy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 10.* Mean values of flow for each quadrant.

![Figure 11](image)

*Figure 11.* Bar chart illustrating mean flow for each quadrant.

A similar categorization of responses was done using the flow-channel model. When using the flow-channel model (Figure 2), the standardized ordered pairs (challenge, skill) were
categorized into three areas: anxiety, flow, and boredom. For a detailed categorization method, see Table 3. Figure 12 shows this categorization of the plotted points and includes the three reference lines $y=x$, $y=x+1$, and $y=x-1$. In this model, the responses that lay within the channel created by lines $y=x+1$ and $y=x-1$ and centered at $y=x$ are considered in this study as being within the flow channel and are considered to belong to the Flow area of this model. Responses falling outside of the channel in the upper left triangle and lower right triangle correspond to Anxiety and Boredom areas respectively according to the flow channel model.

![Figure 12. Scatterplot of standardized challenge and skill values with corresponding flow mean values. Reference lines at $y=x$, $y=x+1$, and $y=x-1$.](image-url)
Similar to the findings when using the quadrant model, the flow-channel model categorization of the points yielded highest intensity of flow in the Flow and Boredom areas as shown in Figure 13. Hence, students felt the most intense flow when their responses fell within the flow and boredom regions. However, the findings indicate that the flow intensity among responses categorized in the Flow area (when perceived challenge and perceived skill were in balance) was lower than for those in the Boredom area (when skill exceeded challenge). This is not consistent with the flow-channel model prediction that flow intensity would be highest within the Flow area. As will be discussed later, these findings do make sense in the context of the study where students tend to be more comfortable with problems at which they can succeed. On the other hand, the flow-channel model was consistent in predicting that for responses falling in the Anxiety area (when challenge exceeded skill), the lowest mean flow intensity was reported at 3.79.

<table>
<thead>
<tr>
<th>Area</th>
<th>Anxiety</th>
<th>Flow Channel</th>
<th>Boredom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Mean</td>
<td>3.79</td>
<td>4.36</td>
<td>5.02</td>
</tr>
</tbody>
</table>

Figure 13. Mean values of flow for each area of flow channel model.

Additionally, the individual factors related to students’ perceived balance of challenge and skill were analyzed in their relation to the flow mean. In particular, descriptive statistics were provided with mean values of flow for each response in items 14-16. Figures 14a, 14b, and 14c show the mean values of flow for each value of students’ perceived challenge, ability, and balance of activity respectively. The tables show that flow was more intense when perceived challenge of the task was lower and when the perceived ability was higher. However, no pattern was shown in the intensity of flow in relation to students’ perceived balance of the task. In fact,
the highest intensity of flow was recorded when the activity demands were perceived as being either too low or too high.

<table>
<thead>
<tr>
<th>Compared to all other activities which I partake in, this one is...</th>
<th>Flow Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9 low</td>
<td>5.007 4.80 4.28 4.26 4.68 4.09 3.62 3.96 3.22 difficult</td>
</tr>
</tbody>
</table>

*Figure 14a.* Mean values of flow for each value of perceived challenge.

<table>
<thead>
<tr>
<th>I think that my competence in this area is...</th>
<th>Flow Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9 low</td>
<td>3.37 2.88 3.88 4.12 4.17 4.33 4.78 5.05 5.47 high</td>
</tr>
</tbody>
</table>

*Figure 14b.* Mean values of flow for each value of perceived ability.

<table>
<thead>
<tr>
<th>For me personally, the current demands are...</th>
<th>Flow Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9 too low just right too high</td>
<td>4.90 4.07 4.00 4.56 3.71 3.95 4.89</td>
</tr>
</tbody>
</table>

*Figure 14c.* Mean values of flow for each value of perceived balance of activity.

Figure 15 shows the correlations among the overall flow mean and the factors relating to students’ perceived challenge and skill. In particular, items 14-16 of the Flow Short Scale were included as well as a computed variable, named Challenge-Skill Ratio, which represented the ratio of perceived challenge over perceived skill. At the 0.01 level, there was a significant positive correlation of .53 (p = .000, 2-sided) between flow and students’ perceived ability to perform the task (“I think that my competence in this area is…”). In other words, students reported more flow-like feelings when they perceived their ability to perform the task to being higher.

Correspondingly, perceiving the activity to being challenging caused a lower flow intensity among students. This was evident by the fact that flow was negatively correlated with
students’ perceived challenge/skill ratio at -.49 (p=.000, 2-sided) and with their perceived difficulty of the activity (Compared to all other activities which I partake in, this one is…”) at -.33 (p=.001, 2-sided). Another significant correlation was between the challenge/skill ratio and difficulty of the activity at .61 (p=.000, 2-sided). Similarly, a negative correlation existed between challenge/skill ratio and students’ perceived ability to perform the task at -.63 (p=.000, 2-sided).

The perceived balance of the activity (“For me personally, the current demands are…”) was only correlated with students’ perceived difficulty of the activity at .48 (p=.000, 2-sided). Hence, the perceived demand of the task was positively correlated to the perceived challenge that students felt. This factor was not significantly correlated with any other variable. Students’ perceived difficulty was also negatively correlated at -.25 (p=.011, 2-sided) at the 0.05 level with perceived ability.

<table>
<thead>
<tr>
<th>Flow Mean</th>
<th>Challenge-Skill Ratio</th>
<th>Compared to all other activities which I partake in, this one is...</th>
<th>For me personally, the current demands are...</th>
<th>I think that my competence in this area is...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Mean</td>
<td>Pearson Correlation</td>
<td>- .493**</td>
<td>-.325**</td>
<td>-.112</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.001</td>
<td>.254</td>
</tr>
<tr>
<td>N</td>
<td>113</td>
<td>106</td>
<td>110</td>
<td>105</td>
</tr>
<tr>
<td>Challenge-Skill Ratio</td>
<td>Pearson Correlation</td>
<td>- .493**</td>
<td>1</td>
<td>.613**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.000</td>
<td>.130</td>
</tr>
<tr>
<td>N</td>
<td>106</td>
<td>106</td>
<td>106</td>
<td>103</td>
</tr>
<tr>
<td>Compared to all other activities which I partake in, this one is...</td>
<td>Pearson Correlation</td>
<td>- .325**</td>
<td>.613**</td>
<td>.475**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.001</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>110</td>
<td>106</td>
<td>110</td>
<td>105</td>
</tr>
<tr>
<td>For me personally, the current demands are...</td>
<td>Pearson Correlation</td>
<td>-.112</td>
<td>.130</td>
<td>.475**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.254</td>
<td>.190</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>105</td>
<td>103</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>I think that my competence in this area is...</td>
<td>Pearson Correlation</td>
<td>.526**</td>
<td>-.632**</td>
<td>-.247**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.000</td>
<td>.011</td>
</tr>
<tr>
<td>N</td>
<td>106</td>
<td>106</td>
<td>106</td>
<td>103</td>
</tr>
</tbody>
</table>

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

*Figure 15. Correlations matrix for perceived challenge, skill, and balance, and flow.*
Finally, a regression analysis was conducted on flow with predictors based on the flow quadrant model (Figure 16) and the flow-channel model (Figure 17). This provided information on how well each flow model was able to predict flow-like experience in the case of this study.

**Figure 16.** Coefficients for regression analysis of quadrants and flow mean.

In the case of the quadrant model (Figure 16), the only statistically significant relationship involves the case when the responses of students’ perceived challenge and skill were plotted in the first quadrant (Anxiety quadrant) with the p-value being 0.04. In this case, flow intensity was lower than within the Flow quadrant (when perceived challenge and perceived skill were both high). This is consistent with the quadrant model prediction that flow-like experience would be less intense in the Anxiety quadrant. Hence, student flow intensity was only predicted when their responses fell within the Anxiety quadrant of the quadrant model.

**Figure 17.** Coefficients for regression analysis of areas of flow-channel model and flow mean.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Constant)</td>
<td>B 4.490</td>
<td>Std. Error 0.180</td>
<td>Beta -2.42</td>
<td>24.951</td>
</tr>
<tr>
<td>Q1 Anxiety</td>
<td>-.512</td>
<td>0.243</td>
<td>-.242</td>
<td>-2.107</td>
</tr>
<tr>
<td>Q3 Boredom</td>
<td>.287</td>
<td>0.234</td>
<td>.143</td>
<td>1.225</td>
</tr>
<tr>
<td>Q4 Apathy</td>
<td>-.442</td>
<td>0.241</td>
<td>-.212</td>
<td>-1.834</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Flow Mean

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Constant)</td>
<td>B 4.347</td>
<td>Std. Error 0.104</td>
<td>Beta -2.46</td>
<td>41.861</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-.557</td>
<td>0.188</td>
<td>-.264</td>
<td>-2.961</td>
</tr>
<tr>
<td>Boredom</td>
<td>.675</td>
<td>0.209</td>
<td>.288</td>
<td>3.232</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Flow Mean
In the case of the flow-channel model, with all p-values below 0.05, Figure 17 indicates that all mean differences were statistically significant. In particular, responses that fell within the Anxiety area of the flow-channel model had 0.56 less flow intensity than those who fell within the Flow area. On the other hand, those in the Boredom area had 0.68 higher flow intensity than those within the Flow area. This confirms partial inconsistency of the flow-channel model in predicting the intensity of flow in students’ experience based on the relationship between their perceived challenge and skill.

**Research Question Three**

The final research question, “What relationships (if any) exist between mathematics self-efficacy as measured by the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), flow, and perceived importance of the task as measured by the Flow Short Scale?”, involved the variables self-efficacy, flow mean, and worry mean. It should be noted that the number of responses obtained for this final portion of the survey dropped from 113 to 106 since 7 students ended the survey before reaching the MSEAQ portion. To address this question, first descriptive statistics were provided for the data obtained on student self-efficacy as measured by the MSEAQ Factor 1 and on their perceived importance of the task, or worry about the task, gathered by items 11-13 on the Flow Short Scale. The self-efficacy means for students enrolled in the developmental algebra course used for the sample was 3.17 with a standard deviation of 0.97 as shown in Figure 18. The scale for the MSEAQ used to obtain this data ranged from 1 to 5 with 1 being “Never” and 5 being “Usually”. Hence, overall, developmental students in this
sample reported agreeing to the mathematics self-efficacy “sometimes” while performing practice problems.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Efficacy Mean</td>
<td>106</td>
<td>1.00</td>
<td>5.00</td>
<td>3.1680</td>
<td>.96869</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>106</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 18. Descriptive statistics for self-efficacy mean.*

Descriptive statistics for the individual items on the MSEAQ Factor 1 survey (Figure 19) showed generally homogenous means. Also, a one-sample t-test was conducted to compare the individual means for each item more precisely with the overall self-efficacy mean. This was done with the intention of gaining descriptive information as to the differences between individual items and the overall self-efficacy mean. Figure 20 shows that, for the most part, individual mean responses for each item on the MSEAQ Factor 1 survey were similar to the overall self-efficacy mean. The only significant difference in means (p < 0.05) was between the first individual item "I believe I am the kind of person who is good at mathematics" and the overall self-efficacy mean where the difference was -0.42. In other words, the feeling that students felt the least identified with was a sense that they are the type of person that is good at mathematics.
<table>
<thead>
<tr>
<th>Item</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe I am the kind of person who is good at mathematics.</td>
<td>106</td>
<td>1</td>
<td>5</td>
<td>2.75</td>
<td>1.235</td>
</tr>
<tr>
<td>I believe I am the type of person who can do mathematics.</td>
<td>106</td>
<td>1</td>
<td>5</td>
<td>3.11</td>
<td>1.107</td>
</tr>
<tr>
<td>I believe I can do the mathematics in a mathematics course.</td>
<td>106</td>
<td>1</td>
<td>5</td>
<td>3.33</td>
<td>1.039</td>
</tr>
<tr>
<td>I believe I can get an “A” when I am in a mathematics course.</td>
<td>106</td>
<td>1</td>
<td>5</td>
<td>3.02</td>
<td>1.179</td>
</tr>
<tr>
<td>I believe I can learn well in a mathematics course.</td>
<td>106</td>
<td>1</td>
<td>5</td>
<td>3.27</td>
<td>1.074</td>
</tr>
<tr>
<td>I believe I can understand the content in a mathematics course.</td>
<td>105</td>
<td>1</td>
<td>5</td>
<td>3.43</td>
<td>.969</td>
</tr>
<tr>
<td>I feel that I will be able to do well in future mathematics courses.</td>
<td>106</td>
<td>1</td>
<td>5</td>
<td>3.27</td>
<td>1.065</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 19.* Descriptive statistics for individual items on MSEAQ Factor 1.

<table>
<thead>
<tr>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe I am the kind of person who is good at mathematics.</td>
<td>-3.524</td>
<td>105</td>
<td>.001</td>
<td>-.66, -.18</td>
</tr>
<tr>
<td>I believe I am the type of person who can do mathematics.</td>
<td>-5.10</td>
<td>105</td>
<td>.611</td>
<td>-.27, .16</td>
</tr>
<tr>
<td>I believe I can do the mathematics in a mathematics course.</td>
<td>1.806</td>
<td>105</td>
<td>.111</td>
<td>-.04, .36</td>
</tr>
<tr>
<td>I believe I can get an “A” when I am in a mathematics course.</td>
<td>-1.302</td>
<td>105</td>
<td>.196</td>
<td>-.38, .08</td>
</tr>
<tr>
<td>I believe I can learn well in a mathematics course.</td>
<td>1.012</td>
<td>105</td>
<td>.314</td>
<td>-.10, .31</td>
</tr>
<tr>
<td>I believe I can understand the content in a mathematics course.</td>
<td>2.755</td>
<td>104</td>
<td>.007</td>
<td>.07, .45</td>
</tr>
<tr>
<td>I feel that I will be able to do well in future mathematics courses.</td>
<td>1.021</td>
<td>105</td>
<td>.310</td>
<td>-.10, .31</td>
</tr>
</tbody>
</table>

*Figure 20.* One-Sample T-Test for Individual Means versus Overall Mean of 3.17.
Descriptive statistics were also provided for items 11-13 of the Flow Short Scale which measured students’ perceived importance of the activity, or worry. These items were scaled in the same way as items 1-10 were with 1 being “Not at all”, 4 being “Partly”, and 7 being “Very Much”. The mean value for perceived worry was 4.26 with a standard deviation of 1.4 as shown in Figure 21. Thus, students reported feeling worry about the task a bit more than “Partly” overall.

As far as the individual items 11-13, Figure 22 shows that item 12 “I must not make any mistakes here.” had the highest mean of the three of 4.63. Also, a one-sample t-test (Figure 23) which compared individual item means to the overall worry mean of 4.26 showed that there was a significant mean difference of 0.37 (p < 0.05) between item 12 and the overall worry mean. Hence, students were most worried about making mistakes than any other aspect of their perceived importance of the task.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worry Mean</td>
<td>113</td>
<td>1.00</td>
<td>7.00</td>
<td>4.2566</td>
<td>1.40224</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>113</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 21. Descriptive statistics for perceived importance of activity.*
Then, a correlation analysis was conducted on mathematics self-efficacy, flow (items 1-10), and perceived importance of the task (items 11-13). As shown in Figure 24, a positive correlation of 0.52, p = .000 (2-sided) at the 0.01 level, was found between reported flow mean and self-efficacy mean. There was also a negative correlation of -.27, p = .005 (2-sided), between self-efficacy and worry, or perceived importance of the activity. However, there was no significant correlation between flow and worry. These findings indicate that self-efficacy was related to flow and worry, but no significant relationship was present between flow and worry.
After all variables were verified to being approximately normally distributed, a regression analysis was conducted to explore the relationships between the variables further. In particular, a linear regression analysis was conducted to determine if self-efficacy had an effect on flow. The linear regression line for this relationship with slope 0.5 is shown in Figure 25. Hence, as shown in Figure 26 with a p-value of .000, it is determined that self-efficacy was a significant predictor of flow.

**Figure 24.** Correlations table for flow, self-efficacy, and worry.

<table>
<thead>
<tr>
<th></th>
<th>Flow Mean</th>
<th>Self-Efficacy Mean</th>
<th>Worry Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flow Mean</strong></td>
<td>Pearson Correlation</td>
<td>1</td>
<td>.524**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.086</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>113</td>
<td>106</td>
</tr>
<tr>
<td><strong>Self-Efficacy Mean</strong></td>
<td>Pearson Correlation</td>
<td>.524**</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.005</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>106</td>
<td>106</td>
</tr>
<tr>
<td><strong>Worry Mean</strong></td>
<td>Pearson Correlation</td>
<td>-.162</td>
<td>-.274**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.086</td>
<td>.005</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>113</td>
<td>106</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
Figure 25. Linear regression line for self-efficacy and flow.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>2.757</td>
<td>.264</td>
</tr>
<tr>
<td>Self-Efficacy Mean</td>
<td>.500</td>
<td>.080</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Flow Mean

Figure 26. Coefficients for regression analysis on self-efficacy and flow.

In exploring the relationship between self-efficacy and perceived importance of the task, a linear regression was conducted to determine if perceived importance of the task had any significant effect on overall self-efficacy. Figure 27 shows that with a p-value of .005, worry was determined to be a significant predictor of self-efficacy. Substantially, the linear regression
line shown in Figure 28 with a slope of -.19 illustrates this relationship. This concludes that higher sense of worry over an activity may somewhat predict a lower sense of self-efficacy in this context and vice versa.

**Figure 27.** Coefficients for regression analysis on worry and self-efficacy.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>3.977</td>
<td>.293</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Worry Mean</td>
<td>-.193</td>
<td>.067</td>
<td>-.274</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Self-Efficacy Mean

**Figure 28.** Linear regression line for worry and self-efficacy.
CHAPTER V
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The sample for this study was 113 undergraduate students enrolled in a developmental algebra course at a four-year university. The class sessions for this course include a practice session at the end of each meeting in which students solve practice problems related to the material they had just learned. During the practice sessions, students worked on personal computers to independently solve algebraic problems. This study was carried out by administering an online survey during a random time while students were performing the practice problems. The survey included scales that measured flow, perceived importance of the task, perceived challenge, skill, and demands of the task, and mathematics self-efficacy.

To address the three research questions detailed in the following sections, several methods of statistical analysis were carried out. Descriptive statistics gave insight on the presence of flow-like characteristics, worry, and mathematics self-efficacy in students’ subjective experience while solving the mathematics practice problems. Also, a comparison of means was conducted for several of the variables to identify any significant differences among individual item means. A correlation and regression analysis was conducted in cases when variables were to be compared. Specifically, this was done to explore the relationships between mathematics self-efficacy, flow, and perceived importance of the task. Finally, two flow models, the flow-channel model and the quadrant model, were applied in this context. Responses were plotted on each model and consistency of the predictive value of the models was assessed in this case.
In summary, the study indicated that most developmental mathematics students who were performing practice problems experienced somewhat flow-like feelings. In particular, they mostly felt “just the right amount of challenge” and felt “completely lost in thought” the least. Also, no significant difference was found among the factor means of fluency of performance and absorption by activity.

Both flow models applied in this study were shown to not be completely consistent in predicting flow intensity based on the location of perceived challenge and perceived skill on each model. While they both were consistent in having a higher intensity in flow in the flow quadrant and flow channel in comparison with the anxiety and apathy regions, the boredom region showed an even higher flow intensity. Also, in the quadrant model, only anxiety and flow were shown to being predictors of the flow intensity while the flow-channel model had all three regions as being significant predictors of flow.

Students reported feelings of mathematics self-efficacy on average “sometimes” with the exception of a feeling of “I believe I am the kind of person who is good at mathematics” which was reported closer to “seldom”. Also, students reported that the activity was on average more than “partly” important with the most agreement being with the statement “I must not make any mistakes here”. Significant correlations were concluded among flow and self-efficacy and between self-efficacy and perceived importance of the task. However, flow and worry were not significantly correlated. Furthermore, self-efficacy was deemed a predictor of flow and worry a predictor of self-efficacy.
Conclusions

Research Question One

The first research question, “Can developmental mathematics students experience any characteristics of flow, as measured by the Flow Short Scale, while performing certain mathematics tasks?”, explored the presence of flow-like experiences as measured by the Flow Short Scale while students were performing certain mathematics tasks. The data revealed that 71.7% of students in a developmental mathematics course reported experiencing flow-like feelings “Partly” or more while performing practice tasks for their algebra course. The overall flow mean among students was 4.33 on a scale from 1 (Not at All) to 9 (Very Much). This indicates that during the given activity, most students were experiencing somewhat positive, flow-like feelings rather than negative, anxious feelings that one may expect developmental students to experience while practicing newly learned concepts from the final chapters of their course curriculum. In the context of mathematics education, this finding should be interpreted as an indication of a lack of anxious feelings rather than an optimal experience as may be theorized in other contexts. In other words, in the mathematics education classroom, flow itself may not have been achieved, but rather a non-anxious experience. This also relates to the fact that the problems students were given were computational in nature, and as such, did not require much engagement from the student. Hence, they may not have had the potential to induce flow as originally defined by Csikszentmihalyi.

In particular, the most reported feeling was “just the right amount of challenge”. This is a reflection of how the appropriate the problems were chosen for students to practice with, and indicates that, for that particular task, students were generally not frustrated by the task at
hand. The least agreed with statement was “I am completely lost in thought”. This could be due to a tendency for developmental mathematics students to not have the opportunity to experience activities that require much higher order thinking in mathematics. However, it is also important to note that the specific tasks that students performed during this study were mechanical in nature, and thus, did not lend themselves to much higher order thinking. On the other hand, items 4 (“I have no difficulty concentrating”) and 5 (“My mind is completely clear) both had individual means above the overall flow mean. The latter finding is not consistent with the expectancy that many of the developmental students in the course may feel distracted by their high anxiety as suggested by Ashcraft (2002).

There were also significant differences in individual means of items between “My thoughts/activities run fluidly and smoothly” and the overall flow mean. On one hand, this is surprising considering the fact that students in this study are considered low-achieving mathematics students and had only recently learned the material required for the task. However, on the other hand, the nature of the task should also be considered in the interpretation of this result as it was designed to provide students with problems that could be solved by simply repeating a similar process taught by the lecture. All other individual items from the Flow Short Scale did not have significantly different means from the overall flow mean.

Another surprising conclusion from this portion of the findings is that most students reported feeling like having “everything under control” partly or more. The notion of being in control has been discussed in relation to both mathematics anxiety and mathematics self-efficacy. In mathematics anxiety, students typically report feeling like they lose control of the situation when faced with mathematics tasks, and similarly, those with low mathematics self-efficacy have low confidence in their abilities to control a given situation. In this particular
study, this could also be explained by the fact that the problems presented to students did not require much elaboration in the responses. This created a clear step-by-step manner for answering the problems that had previously been taught by the lecture. Hence, it was rare for students to find themselves without an idea of what step to take next in solving the problem.

Finally, the distinction of two factors, fluency of performance (items 2, 4, 5, 7, 8, 9) and absorption by activity (items 1, 3, 6, 10), proposed by Rheinberg, Vollmeyer, & Engeser (2003) was not significant in this study as their factor means were very similar (4.39 and 4.25 respectively). This may be due to the fact that one of the absorption items, “I am completely lost in thought” had a significantly less mean than all other items of the Flow Short Scale. The fact that students did not report feeling “lost in thought” may follow from the mechanical nature of the problems they were solving. Thus, although many developmental students may not exhibit high mastery of the material they were practicing, it is not clear in this case that even high achieving mathematics students would have felt absorbed by these problem types.

Research Question Two

Research Question Two, “Does students’ perceived balance of challenge and skill correspond to their perception of a flow-like experience according to the flow-channel and quadrant models?”, considered students’ perceived balance of challenge and skill as a factor of their perception of a flow-like experience according to the flow-channel and quadrant models. First, the two original flow models, flow-channel model (Csikszentmihalyi, 1975) and flow quadrant model (Csikszentmihalyi & Csikszentmihalyi, 1988) were applied to the data collected in this study on students’ perceived skill and perceived challenge of the mathematics
Using the quadrant model, student responses were categorized into predicted feelings of anxiety, flow, boredom, or apathy. The flow means for those who had fallen into the flow and boredom quadrants had slightly higher means than those in the anxiety and apathy quadrants. This is not completely consistent with the flow quadrant model as it predicts that only those in the flow quadrant would have higher flow intensity and that those in the boredom quadrant would be lower. However, this is consistent with the literature suggesting that students do not value challenge positively, but rather prefer activities in which they have a high chance for success (Schweinle et al., 2006; Wigfield & Eccles, 2001). This is an example of how applications of flow theories in the mathematics education context may not coincide with those conducted on experts performing tasks of their expertise.

With respect to the flow-channel model, the highest intensity of flow was found in the boredom region of the model where skill exceeded challenge. This is not consistent with the flow-channel model prediction that students with perceived challenge and perceived skill in balance would experience the highest intensity of flow. Instead, the second highest mean flow was found within the flow channel. Again, this shows that the original flow construct was not preserved when applied in this study due to the nature of the mathematics education context as noted above. What was consistent with the model prediction was that the least flow mean was found in the anxiety region.

The fact that both models showed the highest flow intensity in the boredom region is an interesting finding that should be explored further. It indicates that developmental mathematics students perceive their experience as being more positive when their skills exceed the challenges of the problem. Also, as found by Schweinle et al. (2006), the mathematics classroom is a particular context where individuals do not value challenge positively. Hence, as Wigfield &
Eccles (2001) suggested, students prefer tasks in which they believe they can succeed rather than those that are optimally challenging.

On the other hand, students reported the least intensity of flow in the anxiety region where the challenge of the task exceeded their skills. This is consistent with past research that indicates higher levels of anxiety among students who were overwhelmed by the task at hand. This was also consistent with the expectation noted above that students do not tend to value challenge as a positive thing, but rather are often threatened by it.

When the individual factors related to students’ perceived balance of challenge and skill were analyzed in relation to the flow mean, the data showed that flow was more intense when the perceived challenge of the task was a lower and when the perceived ability was higher. This is again consistent with the findings mentioned above that plotted the points (skill, challenge) on each flow model in that boredom (skill exceeds challenge) corresponded to the greatest intensity of flow. On the other hand, when students were asked about their perceived balance of the task (“For me personally, the current demands are…”), no significant relationship was noted. The only pattern noted was that flow was highest when the activity demands were perceived as either being too low or too high. In other words, when students perceived the activity as being either too difficult or too easy, students also experienced more flow-like feelings.

A correlation and regression analysis also confirmed that there was a significant positive correlation between perceived ability and flow as well as a significant negative correlation between perceived challenge and flow. Also, both factors were concluded to being significant predictors of flow intensity. Similar to the findings above, perceived balance of the task was not significantly correlated to flow and thus not a significant predictor of it. A regression analysis was also conducted on the location of each response on each flow model. It is important the note
that the independent variables for this portion of the analysis were categorical variables, and thus the regression was carried out by creating binary variables for each category. In particular, for the variable named Quadrant, individual binary variables Q1 Anxiety, Q2 Flow, Q3 Boredom, and Q4 Apathy were created. For the flow-channel model analysis the variable named Area induced three binary variables: Anxiety, Flow, and Boredom.

In the case of the quadrant model, a multiple regression was conducted with the flow quadrant as the baseline. This revealed that only flow and anxiety quadrants were significant predictors of flow intensity. In other words, if a student’s perceived challenge and ability was located within the Flow or Anxiety quadrants, their flow intensity could be predicted based on that location. Similarly, on the flow-channel model, a student’s location on any of the three regions predicted how intense their experienced flow would be.

*Research Question Three*

The final research question, “What relationships (if any) exist between mathematics self-efficacy as measured by the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), flow, and perceived importance of the task as measured by the Flow Short Scale?”, sought to explore the relationships (if any) between mathematics self-efficacy as measured by the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) and flow and perceived importance of the task as measured by the Flow Short Scale. Descriptive statistics revealed that students reported a mean self-efficacy of 3.17 on a 1 to 5 point scale. In other words, they reported feelings such as “I believe I can understand the content in a mathematics course” and “I believe I can learn well in a mathematics course” on average “Sometimes”. The only significant difference in means among individual items was a significantly lower mean in the responses to the statement “I believe I am the kind of person who is good at mathematics”. These findings
indicate that students had a slightly higher than average mathematics self-efficacy. This leads the way for an exploration into how often students feel this way.

Also, this finding could be useful for educators as they break with preconceived notions about developmental mathematics students since, assuming from the literature, it was expected that most students would have a low mathematics self-efficacy given their past experiences in mathematics. Hence, this finding can serve as a way for educators to continue thinking about reformed instruction methods such as the inquiry-based approach previously mentioned. With this approach, more opportunities to receive praise may be given, and, in turn, students may gain even higher self-efficacy. As perceived mastery has been shown to have a large effect on self-efficacy (Bandura, 1997), an educator could provide students with opportunities to explain problems that they were comfortable with to their peers. In this way, students’ sense of mastery of the subject could be increased.

The perceived importance items on the Flow Short Scale had an overall mean of 4.26 with only a significant difference in individual means for the statement “I must not make any mistakes here” which had the highest item mean. These findings indicate that most students were partly or more worried about their performance on the task at hand. This may be due to their mathematics anxiety or to a low sense of mathematics self-efficacy since the external factors should not have contributed to this feeling. That is, since this task was a series of practice problems with no repercussion on their grades and no risk for their mistakes to be visible by others, one would expect internal factors to be the cause of this heightened sense of worry about the activity.

The correlation analysis on flow, self-efficacy, and worry indicated a significant positive correlation between flow and self-efficacy and a significant negative correlation between self-
efficacy and worry. However, flow and worry were not significantly related. The regression analysis revealed that self-efficacy was a significant predictor of flow and worry was a significant predictor of self-efficacy. This conclusion reveals the important role of self-efficacy in this context as it, in theory, can be increased to create a more positive flow-like experience for students. Also, these findings suggest that self-efficacy can be modified by controlling for perceived importance, or worry, of the task to being low.

**Recommendations**

The design of this study was purely quantitative, but qualitative information such as an analysis of interviews would provide additional contributions to answering the research questions. In particular, since students’ perceived subjective experience is the focus of this study, a first-hand description of the experience would give tremendous insight into the affective aspect of the experience. For example, an analysis of the expressions and terms used by students to describe their experiences while performing the mathematics task might shed light on what obstacles they may have faced and what preconceived notions they may carry about themselves or the subject matter. This may also have helped to understand what attitudes the student had when performing the task which would have allowed for additional internal factors to be considered.

The participants of this study were limited to those enrolled in the developmental algebra course. As noted above, the quadrant flow model revealed that students who had perceived challenge and skill in the boredom quadrant also perceived the highest intensity of flow-like experiences. Similarly, in the flow-channel model, responses falling into the boredom section
(perceived skill exceeds perceived challenge) corresponded to the highest intensity of flow experience. As noted previously, the findings in this study are consistent with previous findings of studies that applied flow to the mathematics classroom since they suggested that students do not value challenging tasks as much as experts may have in Csikszentmihalyi’s original research about flow. A possibility for future research is to explore if these findings are also consistent throughout other developmental mathematics classrooms where higher mathematics anxiety and lower mathematics self-efficacy are expected.

The fact that the majority of students in the developmental mathematics classroom sampled in this study reported somewhat positive, flow-like experiences while performing a mathematical task opens up an exploration into what external factors can be modified to promote these experiences further. Some of the items on the Flow Short Scale used for this study could be considered in this aspect. For example, educators may seek ways to ensure that students are provided with problems that fall within their reach and thus induce the feelings of “just the right amount of challenge”. In doing this, educators would need to use more of an inquiry-based approach to their teaching in order to continuously gage the comfort level of each student by constantly eliciting their feedback. With this information, educators could ensure that students are presented with problems that are of an appropriate level of difficulty as much as possible.

Similarly, one could also analyze the internal factors that developmental mathematics students share that contribute to their perceived experiences while in the classroom. Bandura (1997) argues that enhancing mathematics self-efficacy is an important part of any effort to improve achievement in lower-level mathematics courses. Educators may want to conduct research on how certain methodologies aimed at increasing self-efficacy in students may improve their perceived experience. Some practical ideas for implementing this theory are for
educators to explore active learning techniques that can be integrated into their classrooms. This would allow students to find more opportunities for reflecting on, and demonstrating, their understanding of concepts during the class time. Also, this may provide more opportunities for students to receive praise from their peers as well as their teacher. At the same time, the opportunities for students to work cooperatively with other students towards solving problems may enhance their mastery experience, and, in turn, increase their mathematics self-efficacy (Bandura, 1997). Flow research also suggests that, “providing instruction that engages students in a challenge worth achieving, and with the necessary instructional skills, can become a rewarding and flow-inducing experience that produces positive educational outcomes for learners” (Shernoff et. al, 2003, p. 174).

Another limitation of the study was the lack of information collected from participants. Although that was not the focus for this study, future studies may consider gathering information such as gender, age, and race in order to explore possible differences in how the various factors are related among each group.

The fact that the study was held during the final two weeks of the semester is another limitation. At that point of the semester, some students may have dropped out of the course and attendance may have also been affected. Also, one could argue that students’ mindsets at that point in the semester differs from that at the beginning of the course. This can be investigated in future research by ensuring that a larger sample is obtained from several timeframes of the course.

The series of tasks used as instruments in this study was limited to only one particular concept from the remedial algebra curriculum. This raises the question of whether student experiences would differ had other concepts or other problems been used. For example, open-
ended problems that promote more engagement among students may have a significant effect on the intensity of flow and/or mathematics self-efficacy of students. The traditional remedial algebra problems used in this study entail solving computational problems similar to those presented by the lecture. Also, the mechanical nature of the problems could have influenced the results as they may be perceived as boring by many students. Future studies might consider exploring how these factors change across different concepts and problem types.

Implementing the flow short scale during one single task diverged from the traditional Experience Sampling Method (ESM) used by past flow researchers. This was done to avoid excess interruptions in the classroom both for the classroom dynamic as well as for students’ individual concentration. Nonetheless, had ESM been used in this study, it could have revealed information on differences in flow intensity among students related to a number of factors such as timing in the semester, nature of the task at hand, and portion of the curriculum.

Also, the fact that students in this study were performing practice problems on a computer could be explored as a possible enhancement or limitation of the study. Current research on online learning includes several studies on the effect of computerized tasks and the role of flow in such research could be discussed by future studies similar to this one. In particular, the availability of online learning systems to provide clear and immediate feedback to students may be a factor contributing to its benefits.

Finally, another limitation of this study is that time frame was limited to one semester. The current study could also be extended by measuring flow among students during a longer series of mathematics tasks with gradually increasing difficulty to determine variability of flow experience as the challenge of an activity increases.
Similarly, repeated administration of a similarly difficult series of tasks can be presented to students at different points during the semester to determine how flow changes as students’ skill level increases. In turn, one could hypothesize about the ability for students to learn material while always remaining within a comfortable ratio of perceived skill and challenge so as to promote positive, flow-like feelings throughout their learning experience. In other words, further research could explore if it is possible for students to make their way up the flow channel in a gradual way that always maintains them within the channel as illustrated in Figure 29.

*Figure 29. Modified flow channel model (Csikszentmihalyi, 1975)*


Ercikan, K., McCreith, T., & Lapointe, V. (2005). Factors associated with mathematics achievement and participation in advanced mathematics courses: An examination of
gender differences from an international perspective. School Science and Mathematics. 105(1).


Minneapolis, MN: Center for Research on Developmental Education and Urban Literacy, University of Minnesota.


10.1016/j.cedpsych.2009.05.004 [Cross Ref]


### APPENDIX A

Flow Short Scale (Rheinberg, Vollmeyer, & Engeser, 2003)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Not at all</th>
<th>Partly</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I feel just the right amount of challenge</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>My thoughts/activities run fluidly and smoothly</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>I do not notice time passing</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I have no difficulty concentrating</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>My mind is completely clear</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I am totally absorbed in what I am doing</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>The right thoughts/movements occur of their own accord</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>I know what I have to do each step of the way</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>I feel that I have everything under control</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>I am completely lost in thought</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Something important to me is at stake here</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>I must not make any mistakes here</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>I am worried about failing</td>
<td>O—O—O—O—O—O</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Compared to all other activities which I partake in, this one is ... | easy       | difficult |
  |                                                                    | O—O—O      | O         |

- I think that my competence in this area is ...                      | low        | high      |
  |                                                                    | O—O—O      | O         |

- For me personally, the current demands are ...                     | too        | just      | too       |
  |                                                                    | O—O—O      | O         | O         |

<table>
<thead>
<tr>
<th>low</th>
<th>right</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
APPENDIX B
Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ): General Mathematics Self-Efficacy Factor (May, 2009)

<table>
<thead>
<tr>
<th></th>
<th>No Response</th>
<th>Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Usually</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe I am the kind of person who is good at mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe I am the type of person who can do mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe I can learn well in a mathematics course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel that I will be able to do well in future mathematics courses.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe I can understand the content in a mathematics course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe I can get an “A” when I am in a mathematics course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe I can do the mathematics in a mathematics course.</td>
<td></td>
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APPENDIX C

I would need your assistance in the following way:

1. Before students begin working on practice problems have them go to this link: _______

and say the following verbal prompt:

As part of a research study being conducted at __________ on mathematics anxiety, we are asking for your participation in a quick 2-3 minute survey. Your responses are completely anonymous so we ask that you feel free to be honest in your responses. If you are willing to participate, please click on the survey link when you are asked to.

2. About 5-10 minutes into the independent practice, stop students and say:

Please click on the survey link now if you are willing to participate in the study.