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The Relationships Between Flow, Mathematics Self-Efficacy, and Mathematics Anxiety Among International Undergraduate Students in the United States

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ABSTRACT

THE RELATIONSHIPS BETWEEN FLOW, MATHEMATICS SELF-EFFICACY, AND MATHEMATICS ANXIETY AMONG INTERNATIONAL UNDERGRADUATE STUDENTS IN THE UNITED STATES

by

Samah Abduljabbar

Chair: Nadia Nosworthy

ABSTRACT OF GRADUATE STUDENT RESEARCH

Dissertation

Andrews University

College of Education and International Services

Title: THE RELATIONSHIPS BETWEEN FLOW, MATHEMATICS SELF-EFFICACY, AND MATHEMATICS ANXIETY AMONG INTERNATIONAL UNDERGRADUATE STUDENTS IN THE UNITED STATES

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Problem

A worldwide problem, math anxiety is defined as an anxious state with an unpleasant feeling of tension characterized by fear of failing to achieve mathematics targets. Psychologically, math anxiety involves anxiety, tension, discomfort, nervousness, fear, shock, and insecurity. Math anxiety has been perceived as a key influencer of reduced math achievement, and avoidance of math-related careers. On the other hand, abilities, *flow*, interests, and psychological conditions contribute to student mathematics success. Belief in one's ability to perform a specific task boosts self-efficacy, which has been studied widely as a predictor of student academic performance. When students are interested in, concentrated on, and passionate about doing an activity, they are experiencing *flow*. How math anxiety is affected by both mathematics self-efficacy and

flow experience has not been well researched, especially among international undergraduate students in the United States.

Method

To bridge this gap, this study investigated the influence of *flow* experience on math anxiety, the influence of mathematics self-efficacy on mathematics anxiety, and the influence of *flow* experience on mathematics anxiety through math self-efficacy as a mediator. To conduct this quantitative study, a questionnaire was designed to collect participant demographic data, and data about the research variables: (a) math anxiety, (b) math self-efficacy, and (c) *flow* experience. The Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) developed by May (2009) was used to measure student mathematics self-efficacy and mathematics anxiety. The Core *Flow* Scale developed by Martin and Jackson (2008) measured student *flow* experience. Based on a convenience sampling method, 614 international undergraduate students were surveyed and 503 (136 males, 367 females) produced valid responses which were analyzed statistically using SPSS and AMOS. Descriptive statistics were computed to understand the data distribution and to measure the levels of *flow* experience, math self-efficacy, and student mathematics anxiety. Math self-efficacy, *flow* experience, and math anxiety scales demonstrated high reliability (Cronbach alpha values 0.94, 0.94, 0.93 respectively). Structural equation modelling technique (SEM) was used to test the proposed research model.

Results

The findings revealed that the level of mathematics anxiety was moderate (M = 3.18, SD = 0.87). All the anxiety dimensions revealed a similar pattern. Most participants felt stressed (*M* = 3.22, *SD* = 0.98), confused (*M* = 3.21, *SD* = 0.90), less motivated (*M* = 3.06, *SD* = 1.02), and less confident (*M* = 3.00, *SD* = 0.95) while solving mathematics problems. Second, most participants felt *flow* experience while solving mathematics problems (*M* = 3.25, *SD* =0.95). All dimensions of *flow* experience recorded a moderate level, except for freedom from being time-bound which was the lowest (*M* = 2.72, *SD* = 1.23).

Females (*M* = 3.16, *SD* = 0.89) felt more mathematics anxiety than males (*M* = 2.99, *SD* = 0.78) while solving mathematics problems; this difference was statistically significant (t (501) = -1.95, $p = 0.05$) with a large effect size ($d = 0.86$). Additionally, the application of an independent sample t-test on *flow* experience data showed that males (*M* = 3.39, *SD* = 0.87) experienced more *flow* experience than females (*M* = 3.20, *SD* = 0.97) while solving mathematical problems; this difference was statistically significant (t (501) = 2.04, $p = 0.04$), with a large effect size ($d = 0.95$).

Finally, the results of the relationships tested showed that (a) *flow* experience had a strong, positive, and significant impact on math self-efficacy ($\beta = 0.709$, $p < 0.001$), (b) math self-efficacy had a moderate to strong, negative, and significant impact on mathematics anxiety ($\beta = -0.466$, $p < 0.001$), (c) *flow* experience was negatively related to math anxiety (r = -0.39) (d) *flow* experience had a weak, negative, and insignificant direct impact on mathematics anxiety ($\beta = -0.058$, $p > 0.1$), and (e) *flow* experience had a moderate but significant negative indirect effect on mathematics anxiety through self-efficacy ($\beta = -0.330$, $p < 0.05$).

Conclusions

Recommendations for teachers include trying to maintain a challenge-skill balance and establishing clear goals to escalate *flow* experience, and provision of immediate constructive feedback to boost self-efficacy. To reduce math anxiety, instructors should apply positive psychology strategies, including special strategies for students with exceptionalities. The current study could be extended by employing a mixed-design research strategy, collecting primary data both quantitively and qualitatively to provide more in-depth information about these variables.

Andrews University

College of Education and International Services

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A Dissertation

Presented in Partial Fulfillment

of the Requirements for the Degree

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APPROVAL BY THE COMMITTEE:

Chair: Nadia Nosworthy	Dean, College of Education and International Services Alayne Thorpe
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DEDICATION

To my mom, who keeps me in the *flow* of her love. You are missed.

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LIST OF ABBREVIATIONS

AGFI	Adjusted Goodness of Fit Index
AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CR	Composite Reliability
GFI	Goodness of Fit Index
IRB	Andrews University Institutional Review Board
MaxH	Maximal Reliability
MSEAQ	Mathematics Self-Efficacy and Anxiety Questionnaire
MSV	Maximum Shared Variance
PCLOSE	Probability of Close Fit
RMSEA	Root Mean Squared Error of Approximation
SEM	Structural Equation Modeling
SPSS	Statistical Package for Social Sciences
SRMSR	Standardized Root Mean Square Residual

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CHAPTER 1

INTRODUCTION

Background

Although mathematics skills are crucial for both human development and some careers, many students at various educational levels find math difficult to understand (Attard, 2013). With few exceptions, students in the United States find difficulty in understanding math. Based on a recent international exam in 2018, the United States ranked 9th in math and 31st in math literacy among 79 countries and economies (Richards, 2020). This demonstrates that the percentage of top-performing math students in the United States was smaller than the global average (Richards, 2020). Other countries teach math differently than the United States, seeing higher achievement, as explained by Richards (2020). Additionally, 93% of American students confirmed experiencing a certain level of math anxiety (Beilock, 2019). Learning difficulties in mathematics that have been experienced by children, even into adulthood, have a negative consequence both in school, and in everyday real-life situations (Salihu & Räsänen, 2018).

Because students perceive mathematics as a difficult subject, student interest and engagement in learning math has declined (Deringöl, 2018; Shishigu, 2018). As a result, student perceptions about the difficulty of mathematics creates different emotional states such as stress and math anxiety (Herawati et al., 2020; Shishigu, 2018). Beilock and Willingham (2014) reported that "in the United States, an estimated 25% percent of four-year college students and up to 80% of community college students suffer from moderate to high levels of mathematics anxiety" (p. 29). Arens et al. (2017) established that 65% of college students surveyed in their study had mathematics and self-efficacy issues that negatively influenced their mathematics performance. Comparable findings to those of Recber et al. (2018) were reported by Skagerlund et al. (2019), whose study on mathematics anxiety revealed that mathematics anxiety was correlated directly with limited confidence in one's ability to do or perform math. Consequently, highly math anxious students may opt to take the minimum number of required mathematics courses (Paechter et al., 2017).

Mathematics anxiety has been defined as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). According to Helal et al., (2011) math anxiety exists in college students, influencing their lives and can impact career choices. These authors report that females are more affected by math anxiety than males. Perry (2004) illustrated that almost 85% of college students enrolled in math courses reported at least moderate math anxiety.

Previous researchers paid a great deal of attention to factors causing math anxiety including low mathematics self-efficacy, past performance experience, disengagement, and losing interest in mathematics (Allan, 2015; d'Entremont & Voillot, 2021; Golnabi, 2017; Radisi et al., 2015; Slameto, 1988). According to Olango (2016), low mathematics self-efficacy can be a strong predictor of math anxiety. In the same realm, previous research has stated that high mathematics self-efficacy enables individuals to control math anxiety (Desai et al., 2018; Nizham & Suhendra, 2017). Bandura (1997) noted that perceived self-efficacy fully mediated the relationship between math anxiety and math performance, so that the relationship usually disappears or was markedly diminished when the influence of perceived mathematics self-efficacy was removed. Moreover, Meece et al., (1990) found that, “past performance experiences with mathematics do not affect anxiety directly. Rather, the impact of past successes and failures on anxiety was mediated entirely through their effects on beliefs of personal efficacy” (Bandura, 1997, p. 236).

According to Blotnicky et al. (2018) many students who are affected by mathematics anxiety also have low mathematics self-efficacy. They are not likely to engage in solving mathematical problems. Moreover, Hamza and Helal (2013) claimed that college students who have math anxiety are more likely to avoid taking math courses. Based on these explanations, variables such as *flow* experience and mathematics self-efficacy are predictors that influence math anxiety. Hence, making it necessary to conduct explanatory research to investigate how these two variables influenced math anxiety. This study aimed to: (a) explore the relationships among *flow* experience, math self-efficacy, and math anxiety; (b) measure undergraduate international student core *flow* experience during math courses, (c) and investigate whether there were significant differences between male and female students in experiencing any core *flow* characteristics.

Problem Statement

Mathematics is among the core units of knowledge that students must be acquainted with to boost their competitiveness in the labor market. According to Olango (2016), almost all professions require mathematical knowledge for individuals to qualify.

However, the number of students failing developmental mathematics has doubled in the past five years, raising concerns about how this situation has gotten so out of hand (Everingham et al., 2017). According to a Statista report, the United States had 914,095 international students in the 2020/21 academic year (Duffin, 2021). Since they are usually perceived as a problem needing to be addressed, with their voices left out of conversations about their experience as students, they are now receiving increased attention (Heng, 2019). On the other hand, the top-performing teenage students in math in the United States overall were ranked lower than average when compared to other countries (Richards, 2020). This shows a general mathematics-related problem among all U.S. students including the international undergraduate students. The quality of U.S. educational performance in mathematics and science requires federal intervention in general (Suter & Camilli, 2019). In light of this, work is being conducted in the United States to understand the nature of math achievement and its associated factors. Math anxiety has been found to be one of the affective factors in math achievement (Barroso et al., 2021). Remarkably, most students in the United States (93%) confirmed experiencing a certain level of math anxiety (Beilock, 2019). Math anxiety can be affected by several factors including *flow* and self-efficacy (Golnabi, 2017; Herawati et al., 2021; Rozgonjuk et al., 2020). Math self-efficacy implies that students who do not believe that they can master a lesson content, or even a certain course in its entirety, are not very likely to take action, nor to achieve satisfactory results (Zivlak & Stojanac, 2019). Academic *flow* has a significant impact on development of mathematical abilities (Golnabi, 2017). Consequently, it became vital to establish a new study to unravel the relationships among *flow*, mathematics self-efficacy, and mathematics anxiety among international undergraduate students in the United States. The goal of this study was to discover how and to what extent *flow* and math self-efficacy influence mathematics anxiety among international undergraduate students in the United States.

Purpose of the Study

The aim of this study was to understand how *flow* and math self-efficacy influenced mathematics anxiety in international undergraduate students in the United States. The study examined the experiences of students during their math class while they were working on mathematical problems. Moreover, it focused on international student mathematical anxiety to see whether they suffered from additional anxiety and whether there were any differences in math anxiety or *flow* experience among different genders. This aim was achievable through the following objectives:

1. To investigate how the nine characteristics of *flow* theory (a) balance between challenge and skill, (b) clear goals, (c) unambiguous and immediate feedback, (d) deep concentration, (e) merging of action and awareness, (f) sense of control, (g) loss of self-consciousness, (h) the transformation of time, and (i) presence interacted with mathematics self-efficacy and influenced international undergraduate student mathematics anxiety.
2. To investigate of the relationship between *flow* and mathematics anxiety.
3. To investigate the relationship between *flow*, mathematics self-efficacy and mathematics anxiety
4. To investigate the relationship between *flow* experience and mathematics self-efficacy.

5. To investigate the role of mathematics self-efficacy as a mediator between core *flow* experience and mathematics anxiety.

Research Questions

The following research questions were addressed in this study:

RQ1: What levels of mathematics anxiety did international undergraduate students report?

RQ2: To what extent did international undergraduate students experience characteristics of *flow*, when doing mathematical problems?

RQ3: Were there gender differences among international undergraduate students in math anxiety and *flow* experience?

RQ4: To what extent was mathematics anxiety related to *flow* and mathematics self-efficacy in international undergraduate students?

Significance of the Study

For many, math anxiety is an unresolved problem, constituting a negative experience that can affect adult lives as well as career choice. According to Helal et al., (2011) millions of adults with math anxiety are forced to change their career choice because they have to avoid majors that require math skills. The authors added that "the cost of math anxiety is high for societies because career choices, including those that rely on higher education, can be influenced by its presence" (p. 213). Since most countries are becoming more embedded in the technology and digital environment, math anxiety on the college level may arise as a critical issue hindering students from contributing to the new millennium.

Although some studies documented factors influencing mathematics anxiety, such as *flow* experience and mathematics self-efficacy, at the college level (Engeser & Rheinberg, 2008; Golnabi, 2017; Radu & Seifert, 2011), no single study was found to address these three variables among international undergraduate students. This study extended prior research on the topic by providing more information regarding the effect of *flow* experience and mathematics self-efficacy on reducing mathematics anxiety among international students. Therefore, the knowledge gained from this study relating to mathematics anxiety and mathematics self-efficacy could be used by instructors to understand risk factors for low mathematics self-efficacy and anxiety among undergraduate international students. The findings could be of great value as they inform researchers about integrating various *flow* theory variables to improve student mathematics self-efficacy for better academic achievement (Dos Santos et al., 2018).

The findings may promote positive social change by bringing awareness to stakeholders in colleges on the influence of the role of *flow* experience in enhancing student engagement as well as their academic performance. By using the findings of this research study, stakeholders may promote mathematics self-efficacy among students, contributing directly to their academic success, thereby reducing the achievement gap and increasing their prospects in terms of employability and career growth.

Research Design

The study used a quantitative research design, which allowed the researcher to investigate the relationships among *flow* experience, math self-efficacy, and math anxiety. An explanatory design was used because the intention was to investigate the relationship among the variables. Explanatory research is a quantitative method that helps test hypotheses by gathering data to support or refute them. For data collection, this study utilized one survey consisting of several parts. The first part was dedicated to collecting participant demographic information. The second part was dedicated to collecting information about the three main variables of the study: math anxiety, math self-efficacy, and *flow*.

The Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) developed by May (2009) was used to measure student math self-efficacy and math anxiety. The Core *Flow* Scale developed by Martin and Jackson (2008) was used to measure student *flow* experience.

The study targeted international undergraduate students enrolled in various post-secondary learning institutions in the United States. Since this population was large, the researcher practiced convenience sampling, using the results as a representation of the entire international undergraduate student body in the United States. To decide the sample size, the sample-to-item ratio was used according to the number of questionnaire items in a study, where 5-to-1 is the minimum ratio (Memon et al., 2020). The sample size used in the study was measured in the ratio of 10-to-1 (Kline, 2011), making the sample size goal 503 participants. Data was then collected from the participants using questionnaires.

Inferential statistics were used to analyze the research questions. The first two questions used descriptive statistics to report mean math anxiety and *flow* characteristics. Afterwards, the researcher compared the mean scores of the math anxiety and *flow* characteristics to measure the ones most experienced by the students. Moreover, the SEM analysis approach was used to evaluate and analyze the relationships of the research variables. Various ethical considerations were made during this study. For instance, participants offered their consent before they engaged in this study, and they had the right to withdraw from the exercise at their will. Findings obtained from the research were used solely for academic purposes and confidentiality of the study participants was maintained at all times. The researcher protected the participants and adhered to respect for their autonomy, justice, and beneficence.

Theoretical Framework

Flow theory was selected for this study. Csikszentmihalyi (1990) was the pioneer of the concept of *flow*, defined as a state of mental absorption where individual ability is matched to current demand. To understand when and how people around the world experience this state, Csikszentmihalyi conducted several interviews and collected data through questionnaires with the intent of understanding how individuals felt when they were enjoying themselves most, and the reasons for their satisfaction. He focused on people working in different settings such as arts, music, and dance, "because these people were doing things they did not expect to be rewarded, but they still spent an enormous amount of time and energy practicing these activities" (p. 132). Csikszentmihalyi provided a list of characteristics identified consistently among the responses: (a) intense and focused concentration on what one is doing in the present moment, (b) merging of action and awareness, (c) loss of reflective consciousness, a sense of control, distortion of temporal experience, and (d) an experience of the activity as intrinsically rewarding (1990).

Some of the characteristics identified by Csikszentmihalyi (1990) relate to those included in the discussion of mathematics and self-efficacy. For instance, the concept of being in control of a given situation has been instrumental in previous discussions on mathematics anxiety. In particular, the helplessness or hopelessness that students with mathematics anxiety experience have been linked to the perception that “we only learn when we feel in control” (Tobias, 1978, p. 71). Additionally, the loss of reflective self-consciousness contrasts sharply with the lack of mathematics self-efficacy that mathematics anxious students typically encounter (Csikszentmihalyi, 1990). Such connections called for an exploration into how mathematics anxious students might be led to experience *flow*-like feelings to counteract the mathematics self-efficacy they often fail to achieve in mathematics classrooms.

Csikszentmihalyi (1990) established a set of several conditions for *flow* to occur in an individual. He established that two main conditions must be satisfied. The first relates to the perceived challenge of the task at hand being balanced with the perceived skill level. Individuals are expected to experience a certain level of balance that ensures an equilibrium between the perceived challenges-to-skill ratio of the task to be performed. Individuals can engage in some activities and perform excellently regardless of lack of monetary incentives, because they are skilled enough to perform such activities.

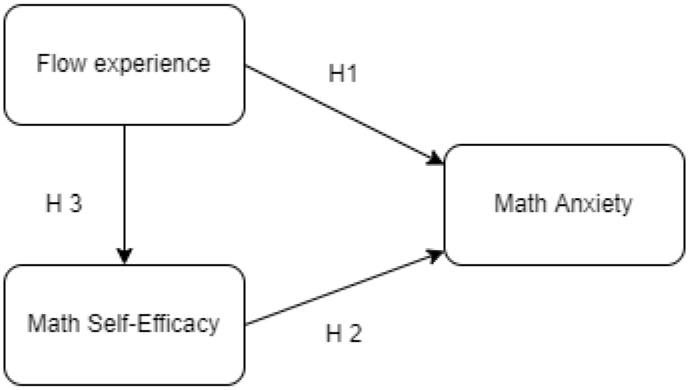
The second condition under which *flow* occurs is that the task to be performed must include clear proximal goals and immediate feedback relating to the progress being attained (Csikszentmihalyi, 1990). This condition presents another link between mathematical problem solving and other activities required to attain the *flow* state. Therefore, theory variables were used to understand how *flow* theory characteristics can influence student mathematical self-efficacy for improved academic outcomes This condition presents another link between mathematical problem solving and other activities required to attain the *flow* state. Therefore, theory variables were used to understand how *flow* theory characteristics can influence student mathematical self-efficacy for improved academic outcomes.

Conceptual Framework

Figure 1 diagrams the planned conceptual framework or research model for checking the relationships among math anxiety, math self-efficacy, and *flow* experiences in a math class context. Theoretical connections were made here among *flow* experience, mathematics self-efficacy, and math anxiety. In the case of math self-efficacy, Zimmerman’s (1995) model of relation of mathematics self-efficacy beliefs to self-regulatory beliefs and process has shown that student beliefs about their abilities to perform a task “involves judgements of capabilities to perform activities rather than personal qualities” (p. 203). This characteristic emphasizes the importance of the golden dimension of *flow*: “the balance of challenge and skill.” As Zimmerman (1995) noted how challenging tasks matching student skills are more effective in influencing student motivational beliefs and willingness to perform the task. Usher and Pajares (2009) established 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). Further, Zimmerman (2000) identified the second *flow* dimension (clear goals) that involves specifying outcomes as one of the required conditions to attain the Mathematics Self-Efficacy beliefs in the first phase of his Mathematics Self-Efficacy model.

Figure 1

The Research Model



In the model created and shown above, math anxiety is the dependent variable and is impacted by both *flow* and math self-efficacy. When students experience *flow*, their math anxiety decreases; the reason for this decrease is that *flow* increases math self-efficacy. Increased math self-efficacy raises student confidence and reduces the anxiety they feel while doing math problems.

The proposed hypotheses were:

H1: there is a relationship between *flow* and math anxiety.

H2: there is a relationship between math self-efficacy and math anxiety.

H3: there is a relationship between *flow* and math self-efficacy.

H4: there is a relationship between *flow* and math anxiety through math self-efficacy.

Another theoretical connection among *flow* experience, math self-efficacy, and math anxiety was based on Bandura's (1977) observation that individual beliefs in their own capacity becomes instrumental in controlling the task they seek to achieve. The characteristic of controlling the task can be measured by the math self-efficacy and Anxiety Questionnaire developed by May (2009). This tool was based on Bandura’s self-efficacy social cognitive theory and concurred with the condition of the sixth dimension of *flow* (sense of control) in that feeling empowered over the situation caused an increase in student math self-efficacy beliefs; it can also be one of the indicators that students are in the *flow* zone. Students who have high math self-efficacy beliefs and self-esteem perceived themselves as competent and in control over the situation (Schunk et al., 2008). The paradox of control related to math anxiety was demonstrated in previous studies, in which mathematics students who had low math self-efficacy became more anxious causing them to lose control over the task (Golnabi, 2017; Tobias, 1978). The *flow* dimension of loss of self-consciousness as opposed to being stressed and anxious about beliefs in one’s capabilities to perform a math task provides insight into the quality of student experiences inside the mathematics classroom. Schiefele and Csikszentmihalyi (1995) reported that student 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” (p. 176). In light of these considerations, the conceptual framework seeks to explain how these and the other *flow* dimensions (deep concentration, immediate feedback, merging of action and awareness, transformation of time) are related to mathematics anxiety. These connections invited an exploration into how mathematically anxious students who experience *flow* could increase their math self-efficacy and decrease their math anxiety.

Delimitations of the Study

Delimitations refer to the scope or boundaries set by the researcher to define the limit to which the study should be conducted (Theofanidis & Fountouki, 2018). In this study several delimitations were present. The first delimitation related to the use of undergraduate students from multiple campuses and different majors. The implication was that only international undergraduate students from different academic majors were used and not any other students. In addition, the study was delimited to the current location, whereby only participants from the selected states were recruited to participate in the study. The study focused only on students enrolled in developmental math courses who might suffer from math anxiety. The implication was that no other form of anxiety or self-efficacy relating to other subjects was investigated. Lastly, the study was delimited by the theoretical framework selected.

Limitations of the Study

Limitations refer to things beyond researcher control that could affect the validity of the study (Theofanidis & Fountouki, 2018). Therefore, the researcher needed to identify possible limitations of the study. The following limitations applied to this study.

First, the study was limited by the sample size. A limited sample size of participants is recommended in quantitative studies, given the amount of data to be collected and analyzed. In this study, the researcher intended to recruit 390 undergraduate international students from different college majors in the United States. The population may be less representative of the entire population, causing challenges with the possible generalizability of the study findings. However, the researcher ensured that all participants were scrutinized for eligibility and well knowledgeable about the topic of the study.

Another limitation related to the voluntary nature of the study. In social research, most of the participants are volunteers. In this study, the researcher surveyed volunteer students. However, since participants were volunteers who might not be motivated to participate in the study, the researcher had limited control over their responses. This could limit the validity and reliability of the study findings if participants became deceptive with their responses. However, given that participants were asked to sign a consent form, they were reminded that they are acknowledging they planned to be truthful in their responses.

Definition of Terms

Developmental math courses: These courses enable students to learn basic mathematical literacy skills to prepare for college. Most developmental math courses include algebra, quantitative reasoning, and statistics (Developmental Mathematics, n.d.).

Flow: “A psychological state in which the person feels simultaneously cognitively efficient, motivated, and happy” (Moneta & Csikszentmihalyi, 1996, p. 277).

Goal clarity: The degree to which an individual can tell the nature of goals being pursued, including the standards and measures that are likely to be used to gauge their performance (Ramirez et al., 2018).

International students: “Those who have crossed borders for the purpose of study” (OECD, 2013, p. 1).

Mathematics anxiety: “A feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551).

Mathematics self-efficacy: Pekrun et al. (2017) defined mathematics self-efficacy 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 problem” (p. 262).

Self-efficacy: Bandura (1997) defined self-efficacy as “beliefs in one’s capabilities to organize and execute the causes of action required to produce given attainment” (p. 3).

Summary

The problem addressed in this study was to investigate how *flow* experience and mathematics self-efficacy influence mathematics anxiety among international undergraduate students in the United States, attempting to investigate how *flow* influences math anxiety directly and indirectly through self-efficacy (Dos Santos et al., 2018; Golnabi, 2017). The purpose of this quantitative descriptive study was to investigate how or to what extent *flow* theory variables or characteristics influenced student mathematics anxiety and mathematics self-efficacy to improve academic performance among students enrolled in developmental math. Chapter 1 provided an introduction, background, problem statement, study purpose, research question, research design, theoretical framework, study significance, limitations and delimitations, definition of terms, and summary. Chapter 2 includes a literature review of research related to this topic. Chapter 3 presents the methodology used to gather study data.

Chapter 4 details results, analysis, and interpretation of the data. Chapter 5 sums up findings and recommendations for practical use and outlines opportunities for further study.

CHAPTER 2

LITERATURE REVIEW

Introduction

This chapter reviews the related literature on mathematics anxiety in terms of the causes of mathematics anxiety, strategies to overcome mathematics anxiety, mathematics self-efficacy, causes of low mathematics self-efficacy, strategies to increase self-efficacy, and *flow* experience in relation to mathematics self-efficacy and mathematics anxiety.

Humans live in a society where extraordinary and accelerating changes are experienced within social lives and the work environment. Every individual needs to be equipped with mathematical skills and knowledge to enable them to make significant decisions in life. Among other tasks, mathematical prowess is applied in globalization of markets, technological innovations and inventions, the spread of information, and balancing spread sheets at places of work. Whereas learning mathematics is efficient in collaborative and supportive environments which promote creativity and critical thinking, it requires individual students to be in their right mental state and to develop the right attitude towards the subject. Various research studies have focused on the performance of students in mathematics. Therefore, a good deal of literature was available on student math performance and how math performance was influenced by various variables. However, a gap exists in the fact that international undergraduate students have not been represented effectively by these studies despite the various concerns about the performance of this group in mathematics; since international students appeared to struggle in mathematics, it was essential to examine variables that may contribute to this struggle (Ramirez et al., 2018). Previous research has investigated *flow*, math self-efficacy, and mathematics anxiety in math performance. The current study examined the relationship of these variables among international undergraduate students enrolled in developmental math courses in the United States (Bhowmick et al., 2017; Ramirez et al., 2018).

Math anxiety impacts almost 80% of U.S. college students (Ramirez et al., 2018) and affects not only the academic performance of these students, but creates physiological disturbances, reducing their self-efficacy level. Self-efficacy was defined as a person's belief in their ability to succeed in a task, and math self-efficacy was defined specifically as a person's belief in their ability to engage successfully with math (Bhowmick et al., 2017). Math anxiety and math self-efficacy are closely related because "anxiety may interfere with the demonstrations of competence needed for building self-efficacy" (Bhowmick et al., 2017, p. 105). *Flow* theory was one of many theories that can assist educators in understanding the relationship between math anxiety and self-efficacy, who can then develop techniques and strategies to help students overcome this problem.

For this literature review multiple databases were searched, including PubMed Central, Database of Abstracts of Reviews of Effects, PsycINFO, UpToDate, PubMed, PsycArticles, ProQuest, Academic Premier, Sage, JSTOR, ResearchGate, EMBASE, ScienceDirect, Google Scholar, Cochrane Library, Emerald, EBSCO, and Elsevier. All articles searched were published from 2017 onwards. The keywords used to search the databases included *developmental math, remedial math, math self-efficacy, college math*, and *math anxiety*. The topics discussed here include mathematics anxiety, causes of mathematics anxiety, mathematics efficacy, possible causes of low mathematics self-efficacy, beliefs about personal efficacy and achievement, effects of self-efficacy on the learning process and self-regulation, attempts to overcome mathematical difficulties, strategies to address self-efficacy in mathematics, attainment of challenge/skill balance, goal clarity, *flow* in relation to mathematics self-efficacy and mathematics anxiety.

Theoretical Framework

This study utilized *flow* theory as the main theoretical framework to help unravel the relationships between *flow* experience, math self-efficacy, and mathematics anxiety. Several studies have dealt with the concept of *flow*.

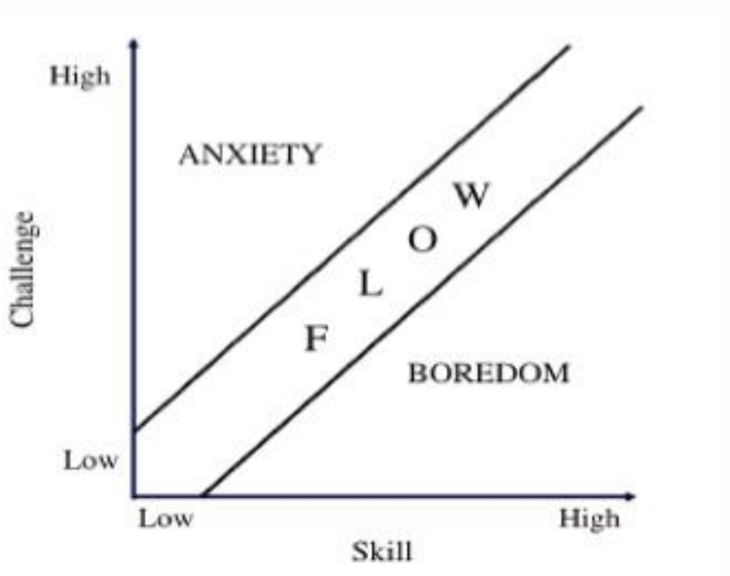
Flow was defined as a "psychological state in which the person feels simultaneously cognitively efficient, motivated, and happy" (Moneta & Csikszentmihalyi, 1996, p. 277). *Flow* theory was introduced by Mihaly Csikszentmihalyi in 1975, with a focus to "help individuals understand why some practices are autotelic or intrinsically unintended to be undertaken" (Csikszentmihalyi et al., 2020, p. 24). Csikszentmihalyi et al. (2018) explored the nature as well as conditions of enjoyment that athletes, artists, and musicians experienced. Based on the findings, it was observed that the individuals surveyed expressed a strong sense of gratitude when they felt rewarded for executing specific actions (Csikszentmihalyi et al., 2018). Participants experienced high enjoyment of fulfilment levels from their activities. Csikszentmihalyi et al. (2020) described this experience of enjoyment and expertise individuals have when participating in different activities as "*flow*."

Piniel and Albert (2019) assessed the characteristics of *flow* involved in learning mathematics. The study found that mathematical *flow* was a reliable construct and a positive experience of complete engagement with mathematics where joy is experienced while doing challenging tasks that require understanding and construction of proofs. One mathematical *flow* experience can lead to an increased enjoyment of mathematical units and the long-term increase in engagement with mathematics. A high level of focus on tasks where nothing else is valued and a desire to keep working hard to build on available knowledge for solving the problem is vital. Moreover, mathematical *flow* offers a positive experience where students learn math through activities that ensure that the learner is neither bored nor overwhelmed by the problems at hand.

Scholars have conducted studies on italic theory as an application of student engagement to improve student mathematical learning experience (Allan, 2015; D'Entremont et al., 2021; Golnabi, 2017; Herawati, et al., 2020). Csikszentmihalyi (1997) claimed that creating a safe and enjoyable environment where students enjoy performing a challenging activity would reduce mathematics anxiety, because when a mental task is more difficult, it is harder to concentrate on it (see Figure 2 for the *Flow* Channel Model). However, when people enjoy what they are doing and are motivated, they find it easier to focus their minds even when an objective observer sees great difficulties (Zollars, 2018).

Figure 2

The Flow Channel Model (Csikszentmihalyi, 1975).



Schiepe-Tiska (2013) outlines that *flow* requires a balance of challenges and skills for individual students. *Flow* is experienced when individual minds or bodies get stretched to their limits voluntarily. In such cases, both challenge and skill-level are moderately high, hence enabling the experience of *flow*. Conversely, a mismatch in the balance can result in different emotional states such as stress and anxiety, particularly when the challenge is higher. Whenever a challenge-to-skill balance exists while solving a problem, the student is expected to experience *flow*. Therefore, the original *flow* channel model suggested there was a high probability of occurrence of *flow* when the challenge level matched the skill level. This match can be low, medium, or high.

Flow needs an equal balance between individual skill level and the expected challenge. If the challenge is too demanding, students become frustrated and develop math anxiety because of their low math self-efficacy and limited skills to perform specific math problems (Csikszentmihalyi et al., 2020). Action-awareness merging refers to the state where individuals (students) are completely absorbed in the task at hand, thus reducing math anxiety and improving math self-efficacy (Csikszentmihalyi et al., 2020). Students with clear goals and expectations experience reduced math anxiety and improve their math self-efficacy given they are aware of what needs to be done at a particular time (Moneta & Csikszentmihalyi, 1996). Unambiguous feedback in math allows students to constantly adjust their reactions to meet the current demands, thus improving their math self-efficacy, and reducing math anxiety (Csikszentmihalyi et al., 2020). Finally, concentration on the task involves students having high levels of concentration and attention by excluding any unnecessary distractions that would contribute to math anxiety and low math self-efficacy (Moneta & Csikszentmihalyi, 1996).

According to Moneta and Csikszentmihalyi (1996), *flow* experiences are achieved when individuals do math activities instead of listening to explanations. The significance of student choice was linked with the control individuals experience when achieving a *flow* state. Being in control was vital to experiences of mathematical *flow* in the learning environment. Therefore, interventions must be designed to optimize the choices and controls of the students. The study established that a balance between control and demand was vital in balancing challenges and skills which suggested that increases in challenge need to be accompanied by increases in latitude of decision-making among students. Students with a high sense of self-control in math have low math anxiety and increased self-efficacy. Loss of self-consciousness was defined as a state in which an individual was completely absorbed in an enjoyable activity, such as math, thus reducing math anxiety and improving math self-efficacy (Csikszentmihalyi et al., 2020).

The construct of transformation of time referred to a distorted sense of time. This was likely to create math anxiety among students if they feel their time is being wasted, thereby compromising their math self-efficacy (Conradty et al., 2020). Finally, autotelic experience presumed that *flow* was an intrinsically rewarding activity. Students with autotelic experiences were likely to be motivated in math, thus reducing math anxiety and improving their math self-efficacy (Csikszentmihalyi et al., 2020). However, these studies did not establish what learning activities would enhance *flow* characteristics among international undergraduate students in the United States. *Flow* experiences originate from participation in working out math activities at the expense of listening to explanations. The significance of student choice was linked to control in the achievement of *flow* state.

Csikszentmihalyi et al. (2020) summarized the factors relating to *flow* experience as a group of nine elements: (a) challenge-skill balance; (b) action-awareness merging; (c) clear goals; (d) unambiguous feedback; (e) total concentration on the task at hand; (f) sense of control; (g) loss of self-consciousness; (h) transformation of time; and (i) autotelic experience. Each of these were discussed in the context of math anxiety, in terms of challenge-skills balance.

The nine elements were grouped into two categories. The first set of elements, commonly identified as *flow* preconditions, referred to the qualifying aspect of an activity required to reach the *flow* state (Conradty et al., 2020). *Flow* preconditions included a match between challenge and skills, a clear establishment of goals, and immediate feedback. The first assumption was that *flow* occurred only when perceived challenges linked to given activities were matched to individual skills. “The implication is that challenges and skills must be high and able to balance for individuals to expand their skills to attain a challenging goal” (Csikszentmihalyi, 1975, p. 13).

The second condition required for the state of *flow* to be achieved was a clear establishment of goals. Csikszentmihalyi (1975) argued that individuals need to be aware of what they want to achieve in order to be completely immersed in different activities. Lastly, immediate feedback was required for a *flow* state to be actualized. This included providing relevant assessments and evaluations as to how well an individual is performing (Csikszentmihalyi et al., 2020). The assumption was that a *flow* state required activities or individuals to offer timely information for an individual to know the extent to which they have achieved their goals or how they are proceeding (Csikszentmihalyi et al., 2020).

The second group of elements consisted of dimensions related to the *flow* experience that could only be realized when “individuals must maintain the *flow* state by being intense and focused on what they are doing” (Subaşı, 2020, p. 329). Maximum, intense, and focused concentration was required to maintain a *flow* experience (Csikszentmihalyi et al., 2018). Additionally, because of focused concentration, there was a need to merge action and awareness (Csikszentmihalyi et al., 2020).

Moreover, individuals may experience a loss of self-consciousness or sense of control over their actions (Csikszentmihalyi et al., 2018). The *flow* experience may also be characterized by distortion of temporal experiences (Csikszentmihalyi et al., 2020). Lastly, individuals in a *flow* state may experience autotelic encounters denoted by the fact that the activity being performed is achieved intrinsically which is a reinforcement for continued practice (Conradty et al., 2020).

Themes and Related Variables

This section discusses the dependent variable, math anxiety, and the independent variables, math self-efficacy and *flow* experience. Each variable is discussed in terms of its definitions, importance to the learning process, its dimensions, as well as the suggested strategies for overcoming the related problems.

Mathematics Anxiety

Everingham et al. (2017) defined mathematics anxiety as an anxious state characterised by fear of failing to achieve mathematics targets. It is an unpleasant feeling of tension, fear and insecurity that surrounds individuals when they are confident about how they should go through a task. Mathematical anxiety is characterised by various symptoms. First, it is characterised by psychological issues like anxiety, tension, discomfort, nervousness, fear, shock, and insecurity. Secondly, mathematical anxiety is characterised by palpitations, high peristaltic movements, cold perspiration in the palms, and increased blood pressure, among other symptoms. Over the years, researchers have studied the concept of mathematics anxiety from different perspectives. Arens et al. (2017) demonstrated that the affective domain of mathematics anxiety correlated directly with a learner’s ability to handle complex mathematics problems from a cognitive perspective.

Mathematics anxiety is known as a worldwide problem that remains unresolved (Sánchez-Pérez et al., 2021). Mathematics anxiety occurs broadly within different ages and educational levels including elementary, middle, and secondary schools, as well as university (Al Mutawah, 2015; Khatoon & Mahmood, 2010; Reyes, 2019; Zakaria et al., 2012). Additional factors influence student mathematics performance aside from individual factors such as self-engagement and motivation (Brezavšček et al., 2020) and cognitive factors such as self-efficacy (Olango, 2016). Because of its effects on student self-efficacy, Beilock and Willingham (2014) claimed that almost a quarter of students who study in four-year colleges and four fifths of community college students experience mathematics anxiety at moderate to high levels. Students with lower math self-efficacy tend to be less engaged (Everingham et al., 2017; Hembree, 1990; Tobias, 1993). Moreover, Csikszentmihalyi (2014) claimed that losing the interest and the enjoyment of performing mathematical challenges is one cause of mathematics anxiety. He stated that science and mathematics have an initial disadvantage of presenting too many challenges to students, who start out being anxious and then often remain in that state without ever enjoying the learning process. While the literature is replete with research on student math self-efficacy and its influence on mathematics anxiety, few studies have investigated directly the linkages between student engagement, self-efficacy, and mathematics anxiety due to the complexity of engagement as a multifaceted construct (Dowker et al., 2016; Everingham et al, 2017).

Geary et al. (2019) suggested that addressing anxiety or self-esteem among children boosts their confidence and attitude towards mathematics. Guita and Tan (2018) stated that improving student perceptions of mathematics can be done by enhancing their self-efficacy in mathematics and their overall academic success. On the contrary, Namkung et al. (2019) reported that students with low self-efficacy in mathematics combined with the anxiety of failure reduced their performance in mathematics (see also Paechter et al., 2017). From these studies, it can be deduced that addressing anxiety and self-esteem among learners plays an important role in influencing their self-efficacy, confidence, and positive attitude which are likely to improve their overall mathematics performance (Pekrun et al., 2017).

Recber, Isiksal, and Koç (2018) explained two factors influencing mathematical anxiety, (a) self-efficacy which is an individual belief that they lack the ability to work out a mathematical problem and (b) negative emotions toward mathematical problems. A study by Masitoh and Fitriyani (2018) outlined that mathematical anxiety is related to various levels of intelligence. The findings of the study were in line with the above background information for this study as it outlined that individuals without interest in mathematical lessons have higher chances of developing mathematical anxiety.

Further evidence by Arens et al. (2017) suggested that past experiences determine learner attitudes toward mathematics. Therefore, to influence their mindset toward mathematics, it is important to focus on managing the individual emotional and psychological aspects influencing their subjective experience and debunk their previously held misconceptions about mathematics. A low sense of efficacy among students negatively affects their self-belief and capabilities, creating a sense of helplessness (Guita & Tan, 2018). However, these studies did not establish how the reduction in self-belief and capabilities encourage mathematical anxiety and, therefore, poor performance in the subject among international undergraduate students.

That research was backed by Shishigu (2018), who outlined that students with mathematics anxiety were always anxious about possible failure in mathematics, that overwhelmed their psychological well-being negatively. Faced with such threats, Wang et al. (2020) recommended research be conducted on how *flow* theory can influence mathematics anxiety and improve learner self-efficacy. Arens et al. (2017) argued that researchers need to establish different techniques or strategies which could be used to promote emotional well-being caused by mathematics anxiety among learners.

Similarly, Skaalvik (2018) suggested that involving learners in the learning process through active learning approaches coupled with timely feedback from instructors improves learner self-efficacy and helps them fight mathematics anxiety (see also Ramirez et al., 2018). Research has documented that developmental mathematics learners are more anxious than other students. As an illustration, Everingham et al. (2017) established that mathematics anxiety was higher in remedial mathematics learners than among school-based learners. According to the findings, learners enrolled in remedial classes had the misconception that they were not competent enough to address different mathematical problems. When compared to others, students who had been taught new skills and had a high sense of efficacy showed improvements in their performance (Guita & Tan, 2018). However, the literature did not establish how international undergraduate students react to active involvement in mathematical classes.

Geary et al. (2019) established that mathematics anxiety is one of the primary causes of learner difficulties in passing their remedial mathematics courses. Compared to their full-time school-based counterparts, remedial classes were established to be three times more likely to have learners with mathematics anxiety compared to their counterparts not in remedial classes. The research creates a significant background for this study based on the fact that poor performance is associated with mathematical anxiety. Comparable findings were reported by Csikszentmihalyi et al. (2020) who established that mathematics anxiety was higher in remedial learners. Subaşi (2020) however, cautioned about such trends where remedial learners are characterized with increased math anxiety resulting in their inability to address different problems. Of great concern is that Qu et al. (2020) argued that improving the math self-efficacy of remedial learners through direct participation and instructor feedback could change their mindset towards mathematics and address their increased mathematics anxiety, that causes negative impacts on their psychological well-being. The study offered room for further research on how math self-efficacy and mathematical anxiety can be connected to each other.

McKim and Velez (2017) established that students in algebra classes had more mathematics anxiety than others. In a different study, Qu et al. (2020) demonstrated that students in community colleges, particularly algebra classes, have low-achieving students with high mathematics anxiety. The increased anxiety relating to their incapability of solving complex mathematical problems negatively influences their overall academic outcomes (Guita & Tan, 2018). Thus far, the articles reviewed demonstrate that mathematics anxiety among low achieving students is linked to low math self-efficacy and negative attitudes based on past experiences towards mathematics. The findings of the studies are consistent with the hypotheses of this study outlining that there is a relationship among *flow* experiences, self-efficacy, and mathematical anxiety among international students. The articles reviewed suggest that supporting learners to improve their math self-efficacy would play an essential role in restoring their positive attitude towards mathematics.

Dimensions of Mathematics Anxiety

Math anxiety can be affected by many factors. Lack of self-confidence, lack of motivation, panic, and stress are the most prominent factors; they are discussed in detail here.

Lack of Self-Confidence

Self-confidence can be viewed in a general or a specific context (Oney & Uludag, 2013). Locander and Hermann (1979) distinguished between the two concepts. They defined general self-confidence as “the extent to which an individual believes himself to be capable, significant, successful, and worthy” (p. 270); whereas, they defined specific self-confidence as “the subject's confidence with respect to the decision at hand” (p. 270). Lampert and Rosenberg (1975) perceived specific self-confidence as the self-stated degree of an individual when judging a specific context at a certain time. This means when a student exhibits self-confidence in math classes, he or she feels confident in handling math problems. These definitions demonstrate that students may have different levels of self-confidence depending on the context, for example, mathematics problem solving or using computers (Oney & Uludag, 2013).

According to Fave and Kocjan (2020), confidence in mathematics refers to the extent to which individuals expect themselves to perform in mathematics. Learners with low self-confidence will have low performance characterized by increased mathematics anxiety (Blotnicky et al., 2018). Confidence is necessary because it is linked directly to self-efficacy which determines an individual’s sense of self-worth in handling complicated situations or gaining resilience in managing such problems. A recurring consensus among scholars is that the origin of mathematics anxiety varies broadly but often correlates to negative perceptions of the ability to handle mathematics. Subaşı, (2020) reported that mathematics anxiety results from learner fear of possible failure or of handling complex mathematical problems. However, learners with strong self-confidence in handling complex mathematical problems were characterized by improved performance and a positive attitude towards mathematics (Tuominen et al., 2020). Accordingly, lack of self-confidence is perceived as a factor of math anxiety.

Lack of Motivation

Motivation can be described as an internal force that stimulates, directs, energizes, and sustains the behavior of students to meet goals (Huitt, 2011). In the learning process, we must understand the reasons behind (a) persistence toward meeting certain goals, (b) the extent of this persistence, i.e., how long it lasts, in addition to (c) the associated emotions and feelings during the process (Brophy, 2004). In this vein, the motivation to learn is identified as the tendency of a student to perceive academic activities as worthwhile and meaningful and to try to obtain academic benefits from them. From the same perspective, where meaningful and worthy values of activities are important, McCombs (1996) defines motivation to learn as:

> a natural response to learning opportunities that is enhanced by: (1) a recognition of the role of thinking and conditioned thoughts in learning and motivation to learn under a variety of conditions, including self-constructed evaluations of the meaning and relevance of a particular learning opportunity; (2) an understanding of one's natural agency and capacities for self-regulation; and (3) contextual conditions that support natural learning as well as perceptions of meaningfulness and self-determination (p. 9).

Motivation behavior depends on individual characteristics, (e.g., gender) as well as the interaction with a particular environmental characteristic (e.g., math class), as explained by the social-cognitive framework introduced by Bandura (2001, 2012).

Students have self-regulating systems to control their beliefs and fuel the process of developing motivation that drives behavior cognitively and affectively. These systems play a role in academic achievement by influencing behaviors, including class participation, study group participation, class attendance, advice seeking, question asking, and studying. Those beliefs are affected by gender and are capable of stimulating, directing, and sustaining thoughts and feelings, such as anxiety (Glynn et al., 2007).

The control-value theory of achievement represents an effective theoretical framework, explaining the vital role of emotions in the learning process (Sutter-Brandenberger et al., 2018). Student achievement is related to control-centered appraisals of competence beliefs and value-centered appraisals such as beliefs about the intrinsic/extrinsic value of a subject area (e.g., achievement outcomes). These are among the most important determinants of academic emotions such as anger and anxiety in math classes (Tulis & Fulmer, 2013). Emotions have been found to play an essential role with regard to achievement but also to motivation (Pekrun et al., 2014). Additionally, based on the control-value theory of achievement, emotions, and self-determination theory self-determined motivation was found to have impacts on negative emotions such as anxiety, boredom, and anger in the subject area of mathematics (Sutter-Brandenberger et al., 2018). Lack of self-confidence was observed empirically as a cause of math anxiety (Estonanto & Dio, 2019). A cognitive behavior therapy study proved that using motivational language was helpful in overcoming anxiety disorder, achieving 35% of improvements (Poulin et al., 2019). All these facts demonstrate that student motivation is a factor in math anxiety; lack of motivation in math classes results in experiencing anxiety when solving math problems.

Panic

In describing math anxiety, Tobias (1980) a leading researcher in this area, underlined the term panic when he defined math anxiety as the panic, paralysis, helplessness, and mental disorganization that appears among some students once they are asked to work on a mathematics problem (Tobias & Weissbrod, 1980). Ashcraft (2002) referred to fear in his definition of math anxiety and demonstrated it as "a feeling of tension, apprehension, or fear that restricts and impedes math performance" (p. 181). Panic is defined as "a sudden overwhelming fear due to a stimulus, which produces hysterical or irrational behavior and spreads quickly through a group of animals" (Lin et al., 2016, p. 157). When students experience fear of looking unintelligent in front of their classmates, they can develop negative experiences (Siebers, 2015). Math anxiety involves fear and nervousness when solving math activities (Lee, 2021). Additionally, fear of failure has been identified as a root cause of anxiety when solving math problems (Estonanto & Dio, 2019). Accordingly, panic is a factor in math anxiety.

Stress

Stress has a functional relationship between individuals and their environments (Mantzicopoulos, 1990). It is a physical response resulting in actual and measurable changes in many body-related functions and mostly appears during main life events. Stressful situations let persons perform two interdependent assessments, what is at stake and how they respond to it (D'onofrio & Klesse, 1990). Stress is anxiety or emotional tension resulting from scenarios viewed as threatening or traumatic to a person's safety, security, and self-esteem (Chandler, 1981).

As underlined by Jain and Dowson (2009), when teachers excessively emphasize on drills and routines in math classes they trigger math anxiety among students. Finlayson (2014) argued that excessive reliance on time-pressured tests, drills, and graded performance are the major contributors to children's anxiety. They, therefore, claim that the math teaching style is a key cause of math anxiety. This is because if educators focus on completing all the curriculum's topics rather than completing the learning output of the learning process, they make students feel anxious towards mathematics. From another perspective, Estonanto and Dio (2019) identified pressure from parents and peers as reasons for students' anxiety toward math. Accordingly, all types of stress, from parents, teachers, or the time-restricted tests, are predictors and major factors in producing math anxiety.

Mathematics Self-Efficacy

In the educational context, self-efficacy is useful. The concept relates to personal factors in the learning process and is based on the social cognitive theory of learning founded by Bandura et al. (1999). He defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). From the same perspective, the concept is defined as a person's belief about being able to do or reach an aim successfully during a certain task. Therefore, the concept of self-efficacy refers to differences between students in terms of how they think, act, and feel (Zivlak & Stojanac, 2019). Shishigu (2018) defined mathematics self-efficacy as a "learner's conviction that they can competently address specific tasks" (p. 4). According to Pekrun et al. (2017), mathematics self-efficacy is 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 mathematical problem" (p. 262). Accordingly, students with a higher degree of self-efficacy set higher aims and choose high-level tasks (Zivlak & Stojanac, 2019). Self-efficacy beliefs are situation-specific because persons hold different beliefs in different situations (Hodges, 2008). In math classes, math self-efficacy implies that students who do not believe that they can master lesson content, or even a certain course in its entirety, are not very likely to take action, nor to achieve satisfactory results (Zivlak & Stojanac, 2019). At its worst, low math self-efficacy negatively influences students to the extent that they avoid mathematics-related careers (Huang et al., 2019). Accordingly, it is obvious that math self-efficacy has a great role in math achievement. Despite the various definitions of the concept by different researchers, this study adopts the definition by Bandura, which described the concept as the beliefs in one's personal capabilities to organize and execute required actions to achieve a particular goal.

Previous researchers have investigated the concept of mathematics self-efficacy and anxiety and its influence on student overall performance. For instance, Federici et al. (2018) investigated risk factors for low mathematics self-efficacy among high school students and established that experience and performance in mathematics significantly contributed to low student self-efficacy. Other studies investigated the concept of low self-efficacy and its influence on academic improvement (Gabriel et al., 2020; Jamieson et al., 2020).

Available literature shows that the number of students failing a developmental mathematics course has increased. A study reported in 2019 established that nearly two-thirds of students enrolled in developmental mathematics courses were unable to graduate in a timely manner (Kesici & Bindak, 2019). One factor contributing to high failure rates among developmental students is low self-efficacy issues and mathematics anxiety. The high number of students failing to pass developmental mathematics implies that they are likely to have career problems in the future (Khoule et al., 2017).

As outlined in the first chapter, self-efficacy is perceived to be related to *flow* and mathematics anxiety. A low sense of self-efficacy coupled with high mathematics anxiety could lead learners to have negative conceptions of mathematics. The implication is that learners will have negative perceptions regarding their capability to handle complex mathematical problems that would lower their mathematics self-efficacy (Liu et al., 2020). Wang et al. (2020) established that mathematics self-efficacy helps learners increase their self-esteem in handling complex mathematical problems. In turn, students are more likely to boost their performance and overall perceptions regarding the required skills needed to address complex mathematical issues. Conversely, learners with low self-efficacy have low self-esteem and less confidence to address complex mathematical problems, hence poor performance. This literature can be directly related to the international undergraduate students who are perceived to be portraying the characteristics of low self-efficacy with low performance in mathematics.

Research has demonstrated that self-concept or self-efficacy predicts learner mathematics anxiety in developmental mathematics. Regarding developmental mathematics, studies have demonstrated that developmental students are characterized by low self-efficacy compared to other students. Gabriel et al. (2020) surveyed first-year college students to explore the differences between students enrolled in developmental mathematics courses and those in calculus courses. The study findings suggested that students who were enrolled in developmental mathematics reported lower mathematics self-efficacy compared to those who did calculus. Masitoh and Fitriyani (2018) established that mathematics achievement is the most significant source of self-efficacy because developmental mathematics students are less likely to have a previous history in mathematics than those enrolled in calculus.

Kiili et al. (2018) defined self-efficacy as an individual's self-confidence relating to the ability to accomplish specific tasks. Learners who have a positive attitude toward mathematics will have increased joy and success in handling complex problems. Fave and Kocjan (2020) established an indirect relationship between mathematics achievement and the attitudes of learners towards it. Kiili et al. (2018) found that a positive attitude toward mathematics increases mathematics self-efficacy and learner capability to perform better in their classrooms. Therefore, scholars have concurred that frequent learning of mathematics can improve student math self-efficacy (Rachels et al., 2018). Improved self-efficacy has the capability of changing the negative attitude that learners have towards mathematics. Fave and Kocjan (2020) argued that instructors and other stakeholders in the education system must endeavour to address issues relating to mathematics self-efficacy through different strategies that will improve learners' attainment in mathematics.

Self-efficacy has been linked to a reduced achievement gap among students. According to Fave and Kocjan (2020), learners who have strong self-efficacy in mathematics find it easier to compete with their peers than those who have low self-efficacy. Kiili et al. (2018) investigated the mathematics self-efficacy of 712 participants in the United States. According to the findings, participants who had high self-efficacy reported improved overall performance over those with low self-efficacy in mathematics. The researchers concluded that mathematics self-efficacy would affect student overall performance and their graduation rates. The conclusions were based on the fact that poor performance in mathematics, characterized by low self-efficacy, can delay graduation among learners if they fail to obtain the required graduation points.

Dimensions of Self-Efficacy

This section describes and discusses the dimensions of self-efficacy, including self-confidence, sense of accomplishment, good qualities and abilities, the examination process, and self-evaluation.

Throughout the literature, self-efficacy is connected to numerous personal factors that direct positive outcomes (Jenson et al., 2011). Successful students are more resilient when faced with challenges, more motivated to work toward goals, more likely to continue in their studies and show greater self-determination. To succeed, students not only need skills and knowledge but also a sense of efficacy to employ their skills, and engage in learning, and access support (Bandura, 1994). 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). This definition refers to personal sense of confidence in abilities that relate to goal setting and success (Bandura et al., 1999). Thus, self-confidence in mathematics classes can shape mathematics self-efficacy.

According to Bandura (2012), students’ sense of self-efficacy is influenced by mastery experiences, vicarious experiences, social persuasion, and self-management of physiological reactions. Past experiences that show positive outcomes support confidence and willingness to keep up the effort when faced with challenges (Schunk & Pajares, 2009). Mastery experiences refer to a sense of accomplishment and success when a student encounters challenges. Mastery experiences are linked to resilience, perseverance, and reduced stress imposed by daunting tasks. Additionally, confidence can be increased or decreased according to the emotional reactions. Moods of tension, stress, and depression physically and psychologically influences negatively on performance (Schunk & Pajares, 2009). Self-efficacy is perceived in the literature as a moderator between cognition and performance (Rugutt et al., 2013). Self-efficacy is not a static personal state and self-efficacy beliefs are not rigid and they can be altered over time (Cervone & Peake, 1986). Thus, performance and a sense of accomplishment shape self-efficacy in the mathematics context.

Vicarious experiences refer to observing others succeed and consequently feeling an increased sense in one’s own ability to similarly succeed (Schunk & Pajares, 2009). When a person sees someone like him/herself succeed, he/she in turn can feel capable of mastering comparable tasks. Conversely, seeing a peer fail can reduce a person’s sense of self-efficacy (Jenson et al., 2011).

Social persuasion impacts both self-confidence and the student’s self-evaluation and how students perceive their personal capabilities. Teacher, parent, and peer encouragements influence the student’s self-confidence. As soon as a student is convinced that s/he is capable (self-evaluation) then s/he in all likelihood will continue to achieve a greater effort, increasing their self-efficacy. Thus, self-evaluation is a dimension of self-efficacy. In the area of social persuasion, students may interpret their grades in mathematics as an indicator of how their personal abilities are judged by teachers. The verbal exchange between students and teachers shapes self-efficacy because students look at those positive or negative exchanges as judgments. From the physiological perspective, in self-efficacy, students link their feelings during a certain mathematic assignment with how they evaluate themselves (Jenson et al., 2011).

How students decode their experiences (examination process) in solving mathematics problems shapes their self-efficacy. Students often relate high grades to content mastery and thus experience an upsurge in delight over their learning experiences as they escalate content mastery (Jenson et al., 2011). The quality of challenging assignments (examination process) is shown to influence the development of students as learners, particularly in the domain of self-efficacy (Jenson et al., 2011). When students feel satisfied by finishing a challenging mathematics assignment, their own self-efficacy is influenced (Hutchison et al., 2006). Thus, examination process can shape mathematics self-efficacy.

Self-Efficacy and Math Anxiety

The connection between math anxiety and math self-efficacy has been discussed both theoretically (e.g. Ashcraft, 2002) and empirically (Huang et al., 2019; Macmull & Ashkenazi, 2019). This relationship between math self-efficacy and math anxiety has been studied from a bi-directional perspective. On the one hand, a number of studies have investigated how math self-efficacy predicts math anxiety. For example, Macmull and Ashkenazi (2019) found that self-efficacy exerted a negative effect on math anxiety, and this effect was greater in females compared to males. Zhou et al. (2020) documented an influence of math self-efficacy on math anxiety but to a small extent. Arji et al. (2019) ensured that an increase in math self-efficacy decreases math anxiety levels. On the other hand, other researchers studied the inverse relation. Bandura et al. (1999) perceived anxiety as an affective or physiological source of self-efficacy, noting that increasing anxiety lowers self-efficacy. İbrahimoğlu (2018) observed a strong positive connection between anxiety and self-efficacy.

Additionally, some researchers studied the reciprocal relationship. For example, Huang et al. (2019) studied the bi-directional relationship between math anxiety and math self-efficacy for both boys and girls. They found that math self-efficacy predicted math anxiety for both genders, but they could not find s reverse relationship. They found that math self-efficacy was likely to reduce boys' math anxiety, but it exerts no effect on girls' anxiety. Rozgonjuk et al. (2020) reported that math self-efficacy influences math anxiety negatively. The influence was greater for female students. The above articulation demonstrates a relationship between self-efficacy and math anxiety, but more research is required to assess whether a reciprocal (bi-directional) relationship exists and, if so, how this relationship is related to gender.

Feedback as a Strategy to Overcome Low Mathematics Self-Efficacy

The concern about the relationship between math self-efficacy and mathematics anxiety as outlined in Chapter 1 prompts the need to establish how the challenge can be addressed. Consequently, this section outlines how previous researchers have coined various strategies for addressing self-efficacy challenges in mathematics. According to Wang et al. (2020), feedback is defined as the amount and value of information instructors provide students with relating to their performance and academic goals. As described by Paechter et al. (2017), effective feedback does not entail judgment; instead, feedback informs students of their actions' effect on their performance goal. Differently, Pekrun et al. (2017) argue that feedback aims to articulate to learners what they understand and the possible areas where extra effort is required to demonstrate their proficiency; feedback also demonstrates instructor willingness to use different strategies to support improvement.

There are different areas on which instructors may provide feedback to learners. For instance, Tuominen et al. (2020) argued that instructors could provide feedback about learner success on a task. Feedback is of utmost importance because “such feedback will include an assessment of how students have achieved a given job” (Jamieson et al., 2020, p. 27) and “it will also entail what was done correctly, what should be done correctly, and what aspects need to be incorporated to achieve the desired performance targets” (Skagerlund et al., 2019, p. 23).

The second aspect in which instructors can give feedback is the process used by students. The purpose of feedback is to enhance student reflective thinking relating to their learning process (Khoule et al., 2017). This type of feedback grants learners the chance to self-correct their mistakes and build on them to become proficient because they point out not only the errors made by the students but also the reasons behind those errors and how the students can manage to avoid such errors in the future.

Feedback has different tenets. First, Qu et al. (2020) noted that feedback must be tied to learner learning targets and success criteria. Second, the feedback provided must be evidence-based and devoid of personal feelings. Instructors must ensure they give feedback to learners without prejudice or personal misconception about learners (Ching, 2017). Instead, the feedback provided must address evidence-based problems relating to difficulties a student has and possible strategies to manage them. Third, the feedback provided must inform learners about their status relative to the criteria used to gauge their success. Fourth, feedback provided by instructors to students must be actionable (Jamieson et al., 2020). The implication is that the feedback should be detailed enough to offer learners information that can be used to address different problems identified or take necessary actions to address possible concerns raised by instructors (Blotnicky et al., 2018). Feedback is not a one-time process, it must be a continuous practice designed to assist students realize their performance goals (Khoule et al., 2017).

Feedback in mathematics becomes an essential tool that instructors can use to support self-efficacy among learners. One of the benefits of using feedback in mathematics is to improve the positive attitude among learners towards mathematics, thereby shifting their attitudes toward mathematics positively (Tuominen et al., 2020). McKim and Velez (2017) established that the use of immediate feedback on students' mathematical problems provided them with the needed support to address areas of weaknesses in their studies and gain proficiency in mathematics. Feedback in mathematics encourages learners to use effort to explain failure and self-efficacy as a tool to fight low self-esteem (Blotnicky et al., 2018). Instructors perceive that self-efficacy among learners can be achieved through constant feedback from learners.

Instructors can employ several methods to improve their students’ balance of skills and handling of challenges while at the same time promoting the students’ self-efficacy. According to Prabawanto (2018), students with difficulties solving a mathematical problem will shy away from asking for help and will retreat into their silent confusion. As a result, the students’ self-efficacy will reduce substantially. To avoid such a scenario, Prabawanto (2018) recommends that instructors group the students in mixed groups with strong and weak students. The strong students will tutor the more vulnerable students, thereby giving the weaker students more knowledge about solving mathematical problems. Concurrently, the stronger students were able to cement their skills and knowledge. The students were able to strike a balance of skills, and more of them will have the confidence to tackle challenging mathematics problems. The result of the entire process is a boost in all groups of student self-efficacy, both strong and weak.

Mathematics students need to strike a balance between hard skills and soft skills. The hard skills include the actual knowledge needed to solve math-related problems. In contrast, soft skills include explaining certain concepts to their colleagues in an easier way for them to understand. According to Akin (2017), a future school leader must assume a leading role in a learning environment. For mathematics students, taking up the role of tutoring weaker students improves their leadership profile. The ripple effect of this is increased confidence in their abilities to solve mathematical problems, thereby improving their self-efficacy (Blotnicky et al., 2018).

Facing challenges and overcoming them during mathematics learning is an excellent way of improving student self-efficacy. Challenges can include the teacher giving out assignments that require critical evaluation before being solved. Such assignments can be given to the students in groups with varied skillsets and strengths. Students can then pool their knowledge and come up with solutions; this pooling will help “weaker students to tap into the stronger students' knowledge mathematically” (Blotnicky et al., 2018, p. 13). In the end, the more vulnerable students will develop greater self-efficacy due to the confidence boost they received from their more substantial counterparts.

Investigators have studied feedback to determine the different types of feedback and their role in goal clarity and performance. Ardi et al. (2019) maintained that verbal persuasion, which could be in the form of praise or criticism, could support learner self-efficacy in different ways. Blotnicky et al. (2018) conducted a qualitative study to investigate the relationship between feedback and student performance. The results suggested that students who received frequent feedback from their instructors on areas that required further improvement improved their beliefs towards mathematics (Khoule et al., 2017). Positive beliefs in their ability to address mathematical problems over time through support and feedback allowed students to change their attitude and perceptions towards mathematics, thereby improving their self-efficacy.

An analysis conducted by McKim and Velez (2017) suggested there is a direct relationship between feedback and self-efficacy. Researchers argued that self-efficacy could be learned or improved by helping learners build trust in themselves and their capacity to handle complex problems (Guo et al., 2020). By supporting them through feedback, learners are in a position to make decisions supported with guidance from instructors (Tuominen et al., 2020). This is because guidance through feedback allows learners to identify challenging areas, areas which need more effort, or areas which need consultations with their instructors to address challenging issues related to mathematics (Khoule et al., 2017).

Providing feedback to students is one of the best ways through which learners can improve their self-efficacy. The primary goal of feedback is to help learners improve their skills by highlighting areas that need improvement or clarification. Studies have suggested that learners who are provided timely feedback tend to have enhanced self-efficacy because they get nurtured in improving their skills over time (Guo et al., 2020). Feedback, as explained by Ardi et al. (2019), allows learners to understand what is required for them to be successful, how it should be done, when it should be done, and who should do it.

Additionally, feedback may clarify strategies that learners should undertake to improve their performance in specific areas. This may include recommendations to seek further help as well as the required skills (Qu et al., 2020). Positive feedback shapes individual beliefs in their competencies to become better, thereby improving their self-efficacy. Based on the analysis conducted, it can be concluded that self-efficacy is directly influenced by feedback. The analysis suggested that learners who obtain timely feedback from their instructors are more likely to initiate strategies that can be used to overcome weakness identified in each area and avoid spiraling it to different stages (Blotnicky et al., 2018), resulting in personal dissatisfaction and a low sense of personal efficacy.

Mathematics *Flow* Experience

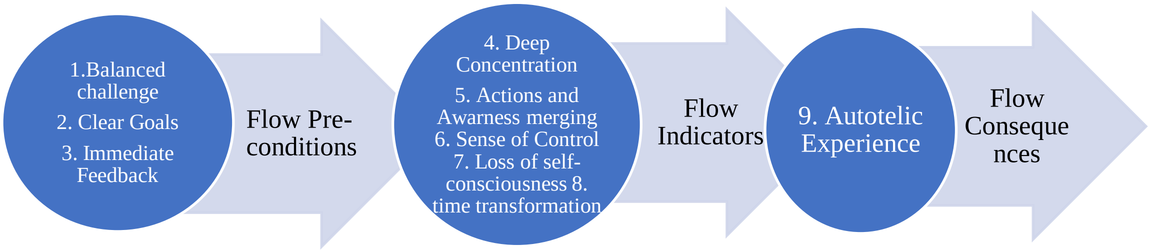
Academic *flow*, abilities, interests, and psychological conditions are all factors of mathematics student success (Herawati et al., 2021). Academic *flow* is a concept that describes the behavior of students when they are interested in, concentrated on, and passionate about doing an activity (Csikszentmihalyi & Csikszentmihalyi, 1992). Academically, *flow* experience has been researched for more than four decades. In everyday language, statements such as "I’ve been in a *flow*, " or " I’ve been in the channel" are usually used to describe the state of *flow* in various situations, for example, in mathematics learning (Barthelmäs & Keller, 2021). Accordingly, academic *flow* is a significant aspect that a student needs especially in the learning process. By experiencing *flow*, students will open themselves to the received information and understand the subject studied (Csikszentmihalyi & Larson, 2014). In mathematics classes, academic *flow* is an aspect of the students' personality that has an impact on their mathematical abilities development (Golnabi, 2017). Therefore, as a personality factor, academic *flow* has an influence on student anxiety and achievement and is related to motivation as well as self-efficacy (Joo et al., 2015). This means students experiencing academic *flow*, for example in mathematics, demonstrate active involvement in math activities, making them unconscious of the place or time, showing no lazy behavior (Yuwanto, 2018). It means that they work perfectly and are highly engaged in the classroom (Ljubin-Golub et al., 2018). Therefore, students with *flow* experience are usually motivated in the classroom (Nurita et al., 2022). Academic *flow* has been shown to be related to mathematics anxiety and self-efficacy (Golnabi, 2017; Herawati et al., 2021). In short, academic *flow* is a vital student attribute that distinguishes students from one another in the learning process. There are a number of factors and dimensions that help academic *flow* to emerge. These dimensions are discussed below.

Dimensions of *Flow*

Flow is composed of nine dimensions including challenge-skill balance, immediate feedback, clear goals, deep concentration, complete sense of control, action-awareness merging, autotelic experience, freedom from being time bound, and elimination of self-consciousness. These categories of *flow* dimensions are based on Csikszentmihalyi’s Nine Components (Csikszentminalyi & Csikszentminalyi, 1988) and appear in Figure 3.

Figure 3

Categories of Flow Dimensions Based on Csikszentmihalyi's (1988) Nine Components



For students to experience *flow*, pre-existing conditions must be met including (a) balance between the challenge presented and skills of the students, (b) clear goals, and (c) immediate feedback, that create a suitable learning environment for these students. Then comes the indicating components signaling that students are experiencing *flow*. These components include (a) deep concentration, (b) actions and awareness merging, (c) sense of control, (d) loss of self-consciousness, and (e) time transformation while solving the problem. Finally, once the students go through all these experiences, they experience the autotelic experience, the final consequence of all the previous components of the *flow* experience.

Attainment of Challenge/Skill Balance

One component of *flow* theory has been used extensively to investigate learning motivation: the challenge/skill balance. This construct plays an important role in helping individuals to understand their optimal experiences (Skaalvik, 2018). There can be different components of an optimal experience based on *flow* theory (Yildizli, 2020). Firstly, the perceived challenge or opportunities of a given action, linked to a particular risk involving an activity, should interact with the perceived skills of the individual performing a specific task (Tuominen et al., 2020). Second, challenges and abilities should be moderated to a high level to allow challenges to “stretch but do not over merge existing skills” (Kesici & Bindak, 2019, p53). The implication was that activities demanding low skills with low challenges may be considered enjoyable but conducive to apathy (Csikszentmihalyi et al., 2018).

Conversely, anxiety may be experienced when challenges exceed perceived skills. Despite this centrality of challenge skill balance as advocated by *flow* theory, limited research has explored empirically how these constructs influence self-efficacy levels for students learning mathematics (Huang et al., 2019). The study focus was to integrate challenge/skill balance variables as suggested by *flow* theory to assess it’s contribution to student self-efficacy in mathematics as explained by teachers (Khoule et al., 2017).

In every classroom setting, the teacher must know about most of the students' abilities. Such knowledge was necessary in the event that a particular student needs special attention or extra work (Akin, 2017). Actions to create self-efficacy among mathematics learners in a classroom can be group action or individual action (Prabawanto, 2018). For group activities, a teacher can give out tasks to a group of students to discuss and come up with the right solutions. The advantage of using group action is that students with greater abilities can tutor students with weaker abilities in a more comfortable environment. During the process, the student with greater abilities will have a better understanding of mathematical concepts, thereby increasing their self-efficacy. Similarly, weaker students will get someone on their level who is able to walk them through the mathematical concepts patiently, increasing their chances of grasping knowledge. In the long term, the weaker students will develop greater self-efficacy.

During the early stages of assigning problems to be solved in groups, the teacher could go around the classroom and help where necessary. The teacher could also provide insight and let the students finish their work (Prabawanto, 2018). With time, the groups can be reduced in number to a point where each student can solve most of the mathematics problems independently. At such a point, the teacher would have played a key role in improving student self-efficacy (Akin, 2017). Self-efficacy were achieved because the students will have started to develop some level of confidence and courage in their abilities to solve most of the problems (Abuhamdeh, 2021).

Similarly, the teacher and students can create awareness of possible ways of improving student self-efficacy. Teachers can develop training strategies such as personal experience, observation of others, and verbal persuasion. Personal experience will help the students understand ways to overcome challenges they experience (Abuhamdeh, 2021). Students can observe other students doing well in mathematics and emulate their practices to create higher self-efficacy. Teachers can use verbal persuasion to motivate and encourage their students to do even more practice, which will significantly improve their mathematical skills and their self-efficacy by extension (Akin, 2017).

Giving students problems or challenges that are way above their skill level heightens their anxiety, meaning they cannot experience *flow* and self-efficacy. They doubt their skills, they risk the failure which results in extreme anxiousness and disrupts the *flow*. If they see a math problem that is beyond their skills, the students do not even try to do it and hence fail to feel self-efficacy or experience *flow* in their performance. Furthermore, failure to balance the challenge and skills creates a mismatch, and studies show that an imbalance in challenge and skills disturbs the emotional states and can result in anxiety and stress if the problem is extremely challenging or boredom in case it is too easy for the student (d’Entremont & Voillot, 2021).

Immediate Feedback

In the educational realm, Vygotsky’s (1978) zone of proximal development describes what happens in the *flow* moment when students move up their skills to match high challenging tasks in an activity; providing immediate feedback and clear goals allows students to peak at the highest level of skill to finish the task.

Immediate feedback is an important preconditional characteristic of *flow* that allows students to double check their performance; when they become sure of their performance instead of second-guessing themselves, their self-efficacy increases, ultimately decreasing their anxiety levels. This immediate feedback can be in any form including a solved example of the real problem, hints, or tips to solve the problem, etc. Research conducted on assisting students with mathematics difficulties revealed that 4 out of 6 studies that had immediate corrective feedback showed student improvement on word problems and operation skills measurement. Feedback was considered a crucial component of *flow* in which students received feedback from internal sources (i.e., mind and body) and external sources (i.e., teachers and partners) that guided them during the experience until they could perceived that they were on the right path to reach their goals. The feedback should be clear and accurate with instructional scaffolding (Csikszentmihalyi, 1990; Meyer & Smithenry, 2014).

Clear Goals

Goal clarity refers to the degree to which an individual can tell the nature of the goals being pursued, including the standards and measures that are likely to be used to gauge their performance (Ramirez et al., 2018). Goal clarity contributes to the experience of *flow* by allowing learners to assess the extent to which they are nearer to their goals (Federici et al., 2018). Equally, goal clarity enabled learners to focus on initiating strategies that can be used to support their learning process. This may include having the required information to gather the required resources and time management to execute certain tasks (Rameli et al., 2018). As expressed by Sağlam and Toğrol (2018), clear goals help create an automatic response to eventually solve the problem if the focus maintains the status quo toward the attainment of the set goals. Clarity of goals informs learners promptly about strategies to undertake when faced with a challenge. Wang et al. (2020) argued that goal clarity creates a sense of control among learners by allowing them to feel part of the system and take the necessary measures to avoid losing control.

Flow theory assumes that clarity of goal provides a clear direction and focus. This implies that learner self-efficacy could be determined by the extent to which mathematics goals and focus for each milestone are clear. Having clear direction allows learners to focus on a smaller milestone that will ultimately contribute to the larger success. Clear goals help learners prioritize their energy on the milestones important for their success (Federici et al., 2018). Golnabi (2017) argued that clear goals could allow students to develop a strong sense of personal satisfaction. Setting goals and developing strategies to achieve them create a strong sense of personal satisfaction that would motivate learners to achieve specific goals (Rameli et al., 2018). Personal fulfilment through goal clarity increases learner confidence and the self-efficacy level required for learning mathematics.

Guo et al. (2020) maintained that goal clarity allows individuals to set realistic time frames for accomplishing specific goals. Learning mathematics is considered challenging, particularly by learners with limited experience handling challenging problems. To improve their self-efficacy, teachers need to help them set clear goals that will improve time management skills that will allow them to accomplish a particular milestone. Clarity of goals enables learners to develop a clear understanding of their teachers' expectations and themselves. Understanding the expectations allows individuals to initiate strategies and set goals and priorities that identify them with the set expectations (Rawlings et al., 2020).

Masitoh and Fitriyani (2018) investigated the relationship between goal setting and mathematics achievement. A sample of 213 students in high school were recruited to take part in the study. Participants were asked to rank the benefits of goal setting and their mathematics achievements. Based on the study findings, the researchers found that student’s success in mathematics was determined by the nature of goals they set (Masitoh & Fitriyani, 2018). Learners who had clear goals increased their performance compared to those who did not have clear mathematics goals. Goal strategy allows learners to set achievable targets which is important in realizing their expectations and linking such expectations to their capabilities (Federici et al., 2018).

Similar thoughts were reported by Rawlings et al. (2020) who found that learners who had clear goals in mathematics improved their scores because they could easily track their performance over time. It is important to emphasize that clarity of goals among learners makes it easy for them to achieve milestones successfully (Guo et al., 2020). Successful attainment of milestones creates internal satisfaction among learners which is important in improving their efficacy. Compared to learners who did not have clear goals in mathematics, Rameli et al. (2018) established that students who had a clear alignment of goals and the expectations attached to them, improved their self-efficacy when each milestone was successfully achieved. Self-efficacy, as explained by Akin (2017) is linked to the extent to which learners perceive milestone achievements as constituting overall success in mathematics.

Periodic goal attainment provides learners with the hope that they are performing well and have the capacity to build on their current performance to be successful. In sum, the articles reviewed thus far demonstrate that goal setting and clarity give learners control of their learning process, which directly impacts their capacity and competency to perform well (Ardi et al., 2019). Studies show that goal setting creates clear expectations for learners and their strategies to realize their goals (Guo et al., 2020). This helps to develop internal motivation for learners to continue learning mathematics as they positively shape their beliefs and self-efficacy towards mathematics (Rawlings et al., 2020). Goal clarity supports learners to initiate corrective measures to address unprecedented outcomes in the learning process. The implication was that when learners are aware of their goals, deadlines, and expectations, they are more likely to be committed to a given cause of action until the successful phase (Masitoh & Fitriyani, 2018).

Clear goals, one of the elements in the *flow* preconditions category, not only give a clear view of the problem to the student but also leave less window for ambiguity about the requirements of the problem. Naturally, students feel anxious when they don’t know what is expected from them. Sides and Cuevas (2020) conducted an 8-week-long study to find the impact of goal setting on motivation, self-efficacy, and math achievement among elementary grade students. There was increased performance on mathematical multiplication facts for the students who had clear goals. Goals can be set by the teachers or the students themselves, but it is evident that having a clear set of goals enhances self-efficacy hence reducing math anxiety in class.

Deep Concentration

Martin and Jackson (2008) described deep concentration as being in the “present moment” (p. 8), in that someone is concentrating deeply on the activity to the extent there is no attention left over for any other thoughts. Chen et al. (2000) ensured that “In the Web environment, this phenomenon is the most frequent dimension mentioned by subjects” (p. 271). Shernoff et al. (2003) stated that students can enter a deeper level of engagement where they can enjoy working on an intellectual task whenever they feel satisfaction and accomplishment.

To enjoy something and to fully invest in it, it is vital to have deep concentration while performing that task. Without effortless and deep concentration, the students fail to understand the problem and cannot enjoy solving it, hence they don’t experience *flow*. The concentration can be lost either because of extreme math anxiety or even as a result of external distractions in their surroundings. When a student is in deep concentration, his thoughts about solutions, intentions to solve the mathematics problems presented to him, and his feelings of self-efficacy are all focused on one goal, which is mathematics. At this stage, the student feels *flow*, and his self-efficacy increases along with a reduction in math anxiety levels.

Sense of Control

Flow is a continuous process and to experience *flow,* any kind of fear or hindrance means that the process was disrupted. One must feel in control to beat the anxiety. If the student feels no control over the problem presented and that eventually failure will occur, math anxiety was experienced, even higher than earlier because the fear will contribute to the anxiety. Freeing the student from this burden of failure and other factors that seem controlling to the student will open the doors for *flow*; the student were able to feel increased self-efficacy with the reduction in anxiety. Research studies demonstrate this pattern of control and *flow*. Taylor et al (2006) found that frequent *flow* is positively or directly related with autonomy and internal locus of control.

Action-Awareness Merging

Merging of actions and awareness is an indicator that the student is experiencing *flow*. It kicks the students out of their self-doubt and self-consciousness phase, and they become fully engaged in solving the problem assigned to them. When students have awareness of the problem presented, they merge it with their actions, making the achievement of *flow* an automatic process which then reduces the anxiety; the students feel self-efficient. d’Entremont and Voillot (2021) showed that when students were engaged in activities of their own choice and had an element of creativity, they showed improved *flow* by merging action and awareness.

Autotelic Experience

The last element of *flow* theory is the consequence of experiencing *flow*, enabling students to view their engagement and effort towards the problem as something rewarding, instead focusing on how the problem ended. One example of the last characteristic is when a student is rewarded points for each step done during the attempt to solve the problem, even if the final answer is wrong. The student can consider each step an achievement even if they failed to get the correct final answer for the problem.

All these elements drive students to keep experiencing *flow* and self-efficacy; with the evidence collected through several research studies, it can be concluded that with the help of these elements and continuous *flow*, students are finally able to overcome their math anxiety. A study conducted on the autotelic experience of Japanese college students found that Japanese students who experienced *flow* regularly were more likely to show higher self-esteem and lower anxiety. They used active coping strategies more often and used passive coping strategies less often as compared to the students who have fewer autotelic experience episodes (Asakawa, 2009).

Freedom from Being Time Bound

It has been observed that one can't keep track of time when invested fully in a task (Csikszentmihalyi, 1990). If students must experience *flow* and self-efficacy to reduce their anxiety levels, they must be free from time restraints. Students who experience *flow* often believe that the time has passed quicker than they expected, that is because they were deep into the problem; the experience was so enjoyable and mentally stimulating that they did not feel bored and did not even have time to feel math anxiety. Another interesting view on this characteristic is that sometimes students experiencing *flow* think that the time has been prolonged. The problem they were solving kept them so engaged in detail that minutes seemed to be stretched into hours. This indicator shows the transformation of time experienced during *flow* where hours seem like minutes and minutes can feel like hours (Csikszentmihalyi, 1990).

Eliminating Self-Consciousness

Freedom from fear of failure and elimination of self-consciousness are closely knit indicators of *flow*. According to Csikszentmihalyi (1990), this indicator means students have successfully invested into the math problem to the extent that they are no longer self-conscious and worried about their surroundings. He even calls it one of the most important features of people who get to experience *flow* even during adversity. Such people have intrinsic motivation amid external surroundings; events cannot disturb their non-self-conscious individualism (Csikszentmihalyi, 1990). This deep engagement and elimination of self-consciousness allows the students to enjoy the problem and the process of finding the solution so much that the students almost forget about their own existence.

Hypotheses Development: Relationship Between *Flow* Experience, Mathematics Self-Efficacy and Mathematics Anxiety

This section explains how previous studies have addressed the relationships between *flow* experience and math anxiety; between math self-efficacy and math anxiety; and between *flow* experience and math self-efficacy.

***Flow* Experience and Math Anxiety**

Scholars have studied *flow* theory as an application of student engagement to improve student mathematical learning experience (Allan, 2015; D’Entremont et al., 2021; Golnabi, 2017; Herawati, et al., 2020). Csikszentmihalyi (1997) claimed that creating a safe and enjoyable environment where students enjoy performing a challenging activity would reduce mathematics anxiety, because when a mental task is more difficult, it is harder to concentrate on it. However, when people enjoy what they are doing and are motivated, they find it easier to focus their minds even when an objective observer sees great difficulties (Zollars, 2018) .

Schiepe-Tiska (2013) outlined that *flow* required a balance of challenges and skills for individual students. *Flow* was experienced when individual minds or bodies were stretched to their limits voluntarily. In such cases, both challenge and skill-level are moderately high, enabling the experience of *flow*. Conversely, a mismatch of balance can result in emotional states such as stress and anxiety, particularly when the challenge is higher. When a challenge-to-skill balance existed when solving a problem, the student experienced *flow*. Therefore, the original *flow* channel model suggested there would be a high probability of *flow* occurrence when challenge levels matched skill levels. The match could be low, medium, or high.

Flow needs a balance between individual skill level and the expected challenge. When the challenge was too demanding, students became frustrated and developed math anxiety because of their low self-efficacy and limited skills to perform the specific math problems (Csikszentmihalyi et al., 2020). Action-awareness merging referred to the state where individuals (students) were completely absorbed in the task at hand, thus reducing math anxiety and improving self-efficacy (Csikszentmihalyi et al., 2020). Students with clear goals and expectations experienced reduced math anxiety and improved their self-efficacy given their awareness of what needed to be done at a particular time (Moneta & Csikszentmihalyi, 1996). Unambiguous feedback in math allowed students to adjust their reactions to meet the current demands, improving their self-efficacy and reducing math anxiety (Csikszentmihalyi et al., 2020). Finally, concentration on the task at hand involved students having high levels of concentration and attention, excluding any unnecessary distractions that could contribute to math anxiety and low self-efficacy (Moneta & Csikszentmihalyi, 1996).

According to Moneta and Csikszentmihalyi (1996), *flow* experiences were achieved when individuals did math activities instead of listening to explanations. The significance of student choice was linked with the control individuals experienced when achieving a *flow* state. Being in control was vital to student experiences of mathematical *flow* in the learning environment. Therefore, interventions need to be designed to optimize the choices and controls of the students. A balance between control and demand was vital for balancing challenges and skills, suggesting that increases in challenge need to be accompanied by increases in latitude in decision-making among students. Students with a high sense of self-control in math had low math anxiety and increased self-efficacy. Loss of self-consciousness was a state in which an individual was completely absorbed in an activity which they were enjoying, such as math, thus reducing math anxiety and improving self-efficacy (Csikszentmihalyi et al., 2020).

The construct of transformation of time referred to a distorted sense of time. Math anxiety among students was created when they felt their time was being wasted, thereby compromising their self-efficacy (Conradty et al., 2020). Finally, autotelic experience presumed that *flow* was an intrinsically rewarding activity. Students with autotelic experiences were more likely to be motivated in math, thus reducing math anxiety and improving their self-efficacy (Csikszentmihalyi et al., 2020). However, these studies did not establish what learning activities would enhance *flow* characteristics among international undergraduate students in the United States. *Flow* experiences originated from participation in working out math activities at the expense of listening to explanations. The significance of student choice was linked to control in the achievement of *flow* state.

Csikszentmihalyi et al. (2020) summarized the factors relating to *flow* experience in a group of nine elements: (a) challenge-skill balance; (b) action-awareness merging; (c) clear goals; (d) unambiguous feedback; (e) total concentration on the task at hand; (f) sense of control; (g) loss of self-consciousness; (h) transformation of time; and (i) autotelic experience. Each of these were discussed in the context of math anxiety in terms of challenge-skills balance.

Based on the above articulation, it was hypothesized that:

H1: There was a relationship between *flow* experience and mathematics anxiety.

Math Self-Efficacy and Math Anxiety

Researchers have investigated the relationship between self-efficacy and mathematics anxiety in different settings. In various grades, Hong et al. (2017) explored learning activities linked to student experiences and their perceived self-efficacy, concluding that students with low self-efficacy in mathematics had low academic performance when compared to those with high self-efficacy.

Subaşı (2020) integrated *flow* theory into the mathematics classroom. Researchers conducted longitudinal research among students talented in mathematics. They established that those who experienced *flow* in the first half of their courses reported improved performance in their second half. Other studies investigated the *flow* of mathematics classrooms and found that perceived challenges in addressing mathematics problems negatively correlated with self-efficacy (Csikszentmihalyi et al., 2018; Guo et al., 2020). A possible explanation was that individuals who have constant difficulties or poor past experiences in mathematics continued to experience such issues in their future. Subaşı (2020) established that the *flow* of ideas and experiences played a significant role in supporting learners to attain their academic goals.

Achievement of peak performance was defined as the state when a student experienced *flow* and felt self-efficacy which, as a response, reduced the math anxiety experienced. To enable a student to experience *flow*, the nine elements play a critical role. For example, clear goals, the third of the nine elements, not only gave a clear view of the problem to the student, but also left more opportunity for creativity or ambiguity. Naturally, students felt anxious when they were uncertain about what was expected from them. Similarly, immediate feedback, another characteristic of *flow*, allowed students to double check their performance; when they became sure of their performance instead of second guessing themselves, their self-efficacy increased, ultimately decreasing their anxiety levels. This immediate feedback could be in any form such as a solved example of the real problem, hints, or tips to solve the problem.

The first element of *flow* was the balance between challenges and skills. Giving students problems or challenges that were way above their skill level heightened their anxiety and they could not experience *flow* or self-efficacy. They doubted their skills, they risked failure which resulted in extreme anxiousness and disrupted *flow*. *Flow* was defined as a phase of in-depth concentration when the student was not affected by distractions either internal or external. Merging of actions and awareness, another element of *flow* theory, kicked students out of their self-doubt and self-conscious phase; they became fully engaged in solving the problem assigned to them. Likewise, characteristics such as excluding distractions, freeing students from the fear of failure, eliminating their self-consciousness, and freedom from being time bound enabled them to view their engagement and effort to solve the problem as something rewarding. One example of this characteristic was a student who was rewarded points for each step done to solve the problem, even if the answer was wrong. All these elements assisted students to continue to experience *flow* and hence self-efficacy. With the help of these elements and continuous *flow*, students can be able finally to overcome their math anxiety.

As pointed out in the first chapter of this study, in the long run *flow* characteristics affect self-efficacy, math anxiety, and the overall performance of learners. The relationships as outlined in the research questions prompted the need to review literature on how *flow* related to self-efficacy and math anxiety. According to Raymond Lavoie et al. (2021), *flow* was not a unidimensional experience as some historic studies have considered it. In *flow*, through the different dimensions, students can achieve the peak of their academic performance. Studies revealing the multidimensional existence of *flow* included Nascent's work; according to him, there were two dimensions of the *flow* experience, i.e., absorption and fluency (Lavoie et al., 2021). Achievement of peak performance was the state when a student experienced *flow* and felt self-efficacy which, as a response, reduced the math anxiety experienced. To enable students to experience *flow*, the nine elements falling between these two dimensions of *flow* played a critical role. The dimensions of *flow* were divided into three categories, (a) *flow* preconditions, which need to be met before experiencing peak performance; (b) *flow* indicators where the students show indications of experiencing *flow*, and (c) *flow* consequences which show the aftermath of the peak performance.

Based on the above articulation, it was hypothesized that:

H2: There was a relationship between mathematics self-efficacy and mathematics anxiety.

***Flow* Experience and Math Self-Efficacy**

The literature established theoretical connections between self-efficacy and *flow* experiences. Regarding academic self-efficacy, Csikszentmihalyi et al. (2018) argued that self-efficacy entailed a slate of judgments relating to individual capacity to perform a given activity rather than personal qualities. Tuominen et al. (2020) noted that this form of characterizing academic self-efficacy correlated with the state of *flow* in which the perceived needs of a given activity became a key predecessor to *flow*. The implication was that, for *flow* to be realized, an assessment was needed to determine that the perceived challenges and skills required to perform a given activity were balanced. The balance between the perceived challenges and the skills needed to perform a given task determined a student’s self-efficacy. Yildizli (2020) established that perceived mastery experiences were important sources of mathematics self-efficacy in learners. Those “who feel that they have mastered skills are successful in challenging different assignments to improve their self-efficacy" (Subaşı, 2020, p. 329).

Another conceptual link between *flow* and mathematics self-efficacy was the concept known as locus of control, referring to individual perceptions of whether they had control over the key factors required to determine their success in each activity. As an illustration, Csikszentmihalyi et al. (2018) investigated the role of locus of control in mathematics self-efficacy. The findings suggested a statistically significant relationship between self-efficacy and locus of control. Locus of control moderated the correlations among mathematics self-efficacy, feedback, and emotional arousal (Guo et al., 2020). In a similar study, Rawlings et al. (2020) found that individuals with a strong internal locus of control were three times more likely to enter the *flow* state, and achieve challenge/skill balance, which allowed them to assess their competencies over time. Additional research explored the relationship between self-efficacy and *flow* experiences in different settings.

Subaşı (2020) studied learning activities linked directly to student experience quality with varying levels of self-efficacy. Researchers recruited 130 students, divided into two groups. The first group comprised learners with high self-efficacy; the second group of learners had low self-efficacy (Conradty et al., 2020). At the end of the study, self-efficacy was linked to locus of control. Their conclusions were based on the observation that learners who perceived having greater control of their learning process had better skills and ability for setting their goals and attaining them at their own pace (Hong et al., 2017).

Based on the above articulation, it was hypothesized that:

H3: There was a relationship between mathematics self-efficacy and *flow* experience.

Gender Differences Among International Undergraduate Students in *Flow* Experience

The third research question in the study was concerned with gender differences among international undergraduate students in math anxiety and *flow* experiences. The literature review in this section offered a foundation for the connection among gender differences, *flow* experiences, and math anxiety among international undergraduate students. Very few studies have explored *flow* experience in international students; this number drops even further when it comes to exploring the existence of differences among international undergraduate student *flow* experiences. Gender difference in class performance and *flow* exists which is evident from the study where Halpern et al. (2007) found that males performed better in class especially when visual-spatial abilities were tested. These results were consistent with the performance differences on mathematics and science standards. This review will explore further where there are differences in *flow* state as well as whether the differences in mathematics exam results were because of cognitive skills only.

Gender differences in mathematics performance do exist, which has been demonstrated in several studies. The difference is prominent even at the elementary level. Males have better concepts and self-efficacy in math class as compared to females. A detailed study including 897 students in the 5th and 6th years of education revealed that girls showed less positivity about mathematics and were less motivated as compared to the opposite gender. Moreover, anxiety levels in girls were higher as compared to boys

(Rodriguez et al., 2020). However, *flow* state was not studied. The questions that need to be addressed is whether these gender differences persist to the undergraduate level. Is there any *flow* state difference between the genders? Because studies show that overall academic performance of both genders remains the same, why is there a difference in mathematics exam results? Another interesting possibility is that female international students are more vulnerable when they are not in their homeland as compared to males. So, is it possible that surroundings, peer pressure, cultural distance, and an overall unknown environment for females adds to their anxiety, impacting *flow*, and hence their self-efficacy. It is believed by many that men and women have different roles in society. Psychologically speaking, women have highly sensitive senses and are good at the cognitive aspects of their surroundings. These characteristics make them sensitive to the cultural distance. Research has shown that international female students displayed reduced cultural adaptation after going abroad and that this influences their academic performance at university (Hu & Cheung, 2021). The current study sought to find evidence in favor of or against this view by observing gender differences in *flow* experience. All these studies along with the current one, will create a base to further expand the data about the performance difference among individuals belonging to different genders and to relate the *flow* state in different genders with their self-efficacy, anxiety, motivation, and academic performance.

Gender Differences in Math Anxiety

To examine the relationship between mathematics anxiety and mathematics performance among undergraduate students in Iran, a detailed study was conducted by Pourmoslemi, Erfani, and Firoozfar, investigating the effects of gender and field of study on mathematics anxiety. The findings were significant for the current research objective. Using a sample of 275 undergrad students (58.9% females, 41.1% males), from various disciplines, mathematics anxiety and related variables were recorded and analyzed using the Revised Mathematics Anxiety Rating Scale (RMARS), the Abbreviated Mathematics Anxiety Scale (AMAS), one-way ANOVA and Statistical Procedures for Social Sciences (SPSS 11.5) (Pourmoslemi et al., 2013). Total mathematics anxiety was further subdivided into learning mathematics anxiety and evaluation mathematics anxiety.

Generally, higher mathematics anxiety levels related to lower academic performance. Mathematics anxiety was found to be independent of the field of study being taught and tested but was affected by gender. In the two subscales, mathematics anxiety during learning was low and independent of the gender of the students, while anxiety in examination scenarios was higher with females experiencing significantly higher anxiety levels than males. Previous studies concerning gender and mathematics anxiety gave varying results; some researchers attributed performance to self-confidence, while others concluded that gender had an important role to play. This research demonstrated that the relationship of gender with mathematics anxiety and hence with performance was clear and considerable. The presence of mathematical anxiety depended on multiple variables; further investigation was required to pinpoint the causes of this difference and how different variables contributed adversely to mathematical anxiety in females compared to males. Only then can remedial measures be suggested to students, especially females, resulting in better performance.

Summary

This chapter discussed mathematics anxiety, causes of mathematics anxiety, mathematics self-efficacy, factors shaping mathematics self-efficacy, *flow* experience, and various relationships among these variables; specifically, the relationships between self-efficacy and math anxiety, between *flow* experience and self-efficacy, and between *flow* experience and math anxiety. Math anxiety can be shaped through lack of self-confidence, lack of motivation, panic, and stress. Math self-efficacy can be shaped through self-confidence, sense of accomplishment, self-evaluation, and regular tests and examination to check the progress of the students. Throughout the literature the relationship between math anxiety and self-efficacy was observed as reciprocal, where each of them influences the other. *Flow* experience is composed of nine elements: challenge-skill balance, immediate feedback, clear goals, deep concentration, complete sense of control, action-awareness merging, autotelic experience, freedom from being time bound, and elimination of self-consciousness. The dimensions of *flow* are divided into three categories. *Flow* preconditions need to be met before experiencing peak performance. Next comes the *flow* indicators where the students show indications of experiencing *flow*; finally, *flow* consequences show the aftermath of peak performance. *Flow* experience with all its dimensions influences self-efficacy in mathematics classes. Moreover, gender plays a role in determining math anxiety, math self-efficacy, and *flow* experience.

CHAPTER 3

METHODOLOGY

Introduction

This chapter begins with a restatement of the purpose of the study and the research questions, followed by a description of the quantitative correlational research method used and the research design. Six sections comprise the chapter: (a) restatement of the problem and research questions, (b) research design, (c) study population and sample selection, (d) data resources and instruments, (e) reliability and validity of the study, and (f) data collection and analysis.

The purpose of this quantitative correlational study was to investigate the relationships between (a) *flow* and mathematics anxiety, (b) mathematics self-efficacy and mathematics anxiety, (c) academic *flow* and mathematics self-efficacy, and (d) the role of mathematics self-efficacy as a mediator between academic *flow* and student mathematics anxiety.

Research Questions

The following research questions were addressed in this study:

RQ1: What levels of mathematics anxiety did international undergraduate students report?

RQ2: To what extent did international undergraduate students experience characteristics of *flow*, when doing mathematical problems?

RQ3: Were there gender differences among international undergraduate students in math anxiety and *flow* experience?

RQ4: To what extent was mathematics anxiety related to *flow* and mathematics self-efficacy in international undergraduate students?

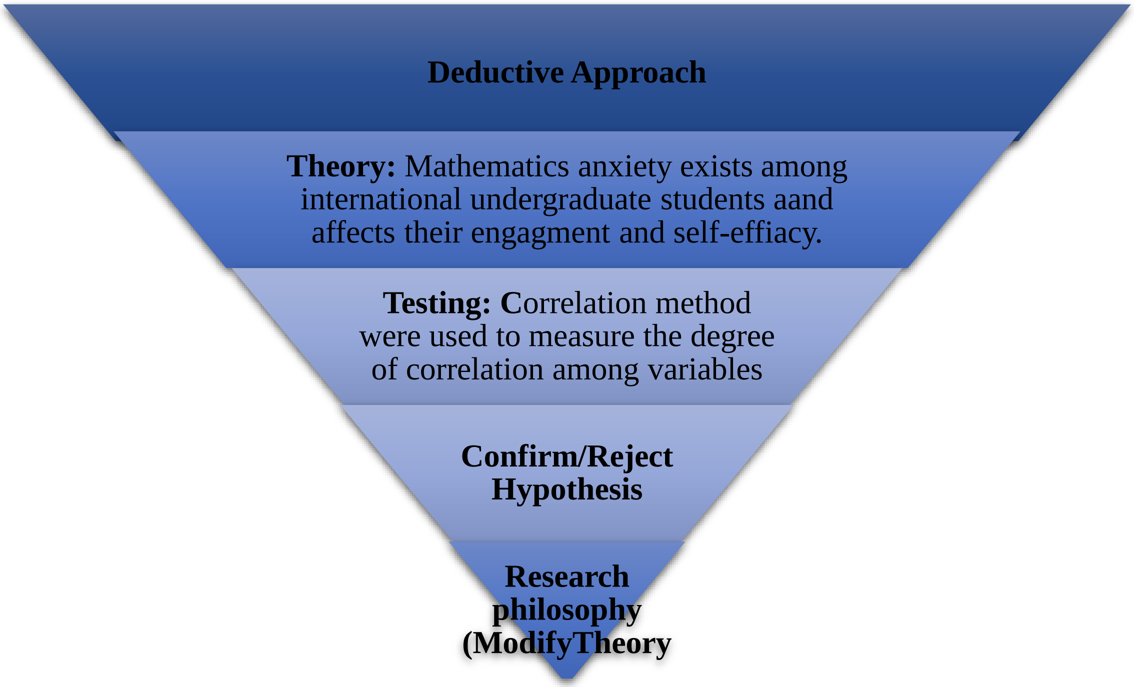
Research Strategy

The research strategy used a deductive or top-down approach to test the hypotheses based on existing theory; the study was designed to test the theory and develop generalizations to contribute to existing theory and fill the gap in the literature (Wilson, 2014). Moving from generalization (theory) to prediction (hypotheses), the study investigated and explored relationships among *flow* experience, self-efficacy, and mathematics anxiety among international undergraduate students.

Bandura & Walters (1977) stated that mathematics anxiety is mediated by the relationship between *flow* experience and self-efficacy; *flow* experience increases self-efficacy which in turn decreases math anxiety. Thus, the correlation method is a good fit for the observed data. Figure 4 illustrates the research strategy process followed.

Figure 4

Research Strategy Process



Research Design

The main purpose of this study was to investigate relationships among *flow* experience, mathematics self-efficacy, and mathematics anxiety among international undergraduate students; therefore, this study combined a quantitative approach and descriptive method based on the research questions. An explanatory quantitative approach using a survey method was employed to explore how *flow* experience and math self-efficacy impacted student math anxiety. According to Leedy and Ormrod (2001) a quantitative approach should be used when studies “seek explanations and predictions that will generate to other persons and places. The intent is to establish, confirm, or validate relationships and to develop generalizations that contribute to theory” (p. 102).

Descriptive statistics described the demographic information of students regarding their majors, gender, and residence. The Statistical Package for Social Sciences (SPSS) version 24.0 was used to calculate and analyze the survey data. SPSS AMOS was used for structural equation modeling (SEM) as a multivariate statistical analysis approach to analyze the structural relationships between variables. Due to the nature of the questions, the degree of correlation among variables was measured. Creswell and Poth (2017) stated, “A correlation is a statistical test to determine the tendency or pattern for two (or more) variables or two sets of data to vary consistently” (p. 338).

An explanatory design was used because the intention was to investigate relationships among *flow* experience, self-efficacy, and mathematics anxiety, and to address how the variables of *flow* and self-efficacy influenced mathematics anxiety. Creswell and Poth (2017) declared that, in the explanatory method, “the researcher is interested in the extent to which two variables (or more) co-vary, that is, where changes in one variable are reflected in changes in the other” (p. 340).

Due to the nature of the research questions posed, descriptive statistics and inferential statistics were utilized to answer the research questions. Structural equation modeling (SEM), a multivariate statistical technique, was employed to analyze structural relationships by examining linear causal relationships among variables while accounting for measurement error, similar to but more powerful than regression analysis. Additionally, structural validity might be assessed by examining model fit indices such as the root mean squared error of approximation (RMSEA), the Comparative Fit Index (CFI), and the Tucker-Lewis Index (Hu & Bentler, 1999).

Population and Sample

In the fall of 2018, a total of 16.6 million undergraduate students were enrolled in post-secondary institutions in the United States—56% female (9.4 million students), and 44% male (7.2 million students) (Hussar et al., 2020). Of these students, 8.7 million were White, 3.4 million were Hispanic, 2.1 million were Black, 1.1 million were Asian, 0.6 million were of two or more races, 0.1 million were American Indian/Alaska Native, and 0.6 million were nonresident aliens. In this study the target population was international undergraduate students. For the academic year 2018/19 around 1,095,299 international students were enrolled in the United States, although the number dropped for following years because of travel restrictions due to the Covid-19 pandemic (Duffin, 2021).

The sample selected consisted of male and female international undergraduate students. While some studies investigated math anxiety among college students by nationality and majors (Hamza & Helal, 2013; Rummel et al., 2016), and others considered *flow* and mathematics self-efficacy based on gender differences (Engeser & Rheinberg, 2008; Golnabi, 2017; Radu & Seifert, 2011; Tandon, 2016), no single study was found addressing these three variables within the international undergraduate student population. Selecting this sample allowed the researcher to address this unexplored area in the literature including the lack of research about *flow*, mathematics self-efficacy, and math anxiety among international students.

Convenience sampling (a type of non-probability sampling) was used to select participants, based on their availability and willingness to participate. To decide the sample size, the sample-to-item ratio was used according to the number of questionnaire items in a study, where 5-to-1 is the minimum W ratio (Memon et al., 2020). The sample size was measured utilizing the ratio of 10-to-1 as suggested by Kline (2011); making the projected minimum sample size 390 participants, 39 items were used in the questionnaire. However, 614 questionnaires were collected, and 503 valid responses were suitable for statistical analysis. The remaining 111 were invalid because some of the responses were incomplete. They had a large percentage of missing answers, not just for one or two questions.

Instrumentation

The survey was designed to measure three variables: math anxiety, mathematics self-efficacy, and *flow*. The survey was comprised of three parts: a demographic survey including student age, gender, and current geographic region; the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (May 2009); and the Core *Flow* Scale (Martin & Jackson, 2008) (Appendix A, B, C respectively). The MSEAQ measured the independent variables of math self-efficacy and math anxiety and was a 29-item tool using a five-point Likert scale from 1 (never), through 5 (usually).

Mathematics Self-Efficacy and Anxiety Questionnaire

For measuring mathematics anxiety (dependent variable) and mathematics self-efficacy (independent variable), the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) developed by May (2009) was used (see Table 1). MSEAQ is a combined scale measuring both anxiety and mathematics self-efficacy. Fourteen items measure self-efficacy (SE); 15 items measure anxiety (Anx). 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).

Table 1

The Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ)

Item
1. I feel confident enough to ask questions in my mathematics class. (SE)
2. I get tense when I prepare for a mathematics test. (Anx)
3. I get nervous when I have to use mathematics outside of school. (Anx)
4. I believe I can do well on a mathematics test. (SE)
5. I worry that I will not be able to use mathematics in my future career when needed. (Anx)
6. I worry that I will not be able to get a good grade in my mathematics course. (Anx)
7. I believe I can complete all of the assignments in a mathematics course. (SE)
8. I worry that I will not be able to do well on mathematics tests. (Anx)
9. I believe I am the kind of person who is good at mathematics. (SE)
10. I believe I were able to use mathematics in my future career when needed. (SE)
11. I feel stressed when listening to mathematics instructors in class. (Anx)
12. I believe I can understand the content in a mathematics course. (SE)
13. I believe I can get an “A” when I am in a mathematics course. (SE)
14. I get nervous when asking questions in class. (Anx)
15. Working on mathematics homework is stressful for me. (Anx)
16. I believe I can learn well in a mathematics course. (SE)
17. I worry that I do not know enough mathematics to do well in future mathematics courses. (Anx)
18. I worry that I will not be able to complete every assignment in a mathematics course. (Anx)
19. I feel confident when taking a mathematics test. (SE)
20. I believe I am the type of person who can do mathematics. (SE)
21. I feel that I were able to do well in future mathematics courses. (SE)
22. I worry I will not be able to understand the mathematics. (Anx)
23. I believe I can do the mathematics in a mathematics course. (SE)
24. I worry that I will not be able to get an “A” in my mathematics course. (Anx)
25. I worry that I will not be able to learn well in my mathematics course. (Anx)
26. I get nervous when taking a mathematics test. (Anx)
27. I am afraid to give an incorrect answer during my mathematics class. (Anx)
28. I believe I can think like a mathematician. (SE)
29. I feel confident when using mathematics outside of school. (SE)

* SE = Self-efficacy, Anx = Anxiety

Everingham et al. (2017) defined mathematics anxiety as an anxious state characterised by fear of failing to achieve mathematics targets. It is an unpleasant feeling of tension, fear and insecurity that surrounds individuals when they are confident about how they should go through a task. Math anxiety can be affected by many factors. Lack of self-confidence, lack of motivation, panic, and stress are the most prominent factors; accordingly, they are used to measure mathematics anxiety. Mathematics self-efficacy is 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 mathematical problem” (p. 262). Mathematics self-efficacy can be measured through self-confidence, sense of accomplishment, good qualities and abilities, the examination process, and self-evaluation.

May (2009) measured the reliability of the MSEAQ, obtaining a Cronbach’s coefficient alpha of .96 which was considered very good, showing consistency throughout the instrument. Moreover, May (2009) tested the validity of the MSEAQ and found that all items about math anxiety were correlated with the total math anxiety score. Additionally, all the math self-efficacy items were correlated to the total math self-efficacy score

Core Flow Scale

The Core *Flow* Scale developed by Martin and Jackson (2008) was used to measure core *flow* (an independent variable). The Core *Flow* Scale focused on *flow* experience from an individual perspective, capturing the subjective experience. The Core *Flow* Scale can be used as a research instrument for studying *flow* and the factors associated with *flow*; across a variety of settings, such as work, sport, hobbies, and school; as a research tool for measuring the effects of interventions; as a stimulus for discussion in performance, training, and workshop settings; and as a practitioner tool when working with a student to evaluate their potential to experience *flow* or to develop their skills for increasing *flow*. The scale consists of 10 items measured on a five-point Likert scale, ranging from 1 (strongly) to 5 (strongly disagree). The items, their meaning, and the dimension measured appear in Table 2.

Table 2

Core Flow Items and Dimensions Measured

Core *Flow* Item	Dimension of *Flow*
I am “totally involved.”	Challenge-Skill balance
It feels like “everything clicks.”	Immediate feedback
I am “tuned in” to what I am doing.	Clear goals
I am “in the zone.”	Deep concentration
I feel “in control.”	Complete sense of control
I am “switched on.”	Action-awareness merging
I feel like “I am in the *flow*” of things.	Autotelic experience
It feels like “nothing else matters.”	Freedom from being time bound
I am “in the grove.”	Elimination of self-consciousness
I am “totally focused” on what I am doing.	Clear goals

The Core *Flow* Scale measured *flow* from the perspective of the person who experienced it. Students answered the questions according to what happened to them when they were in *flow*; researchers measure and analyze *flow* with the assistance of these questions. In the words of Martin and Jackson (2008) this scale measures “core” *flow* and is comprised of a 10-item scale aimed at assessing the core experiential characteristics of the *flow* experience” (p. 142). The concept and goal of the Core *Flow* Scale was to determine the optimal *flow* experience of the subject, including *inter alia*, which means “in the zone.” When students are “in the zone,” they feel as though they are totally focused, and everything is clicking, which soon results in solving the problem. The scale was composed of ten items (questions) for measuring the nine dimensions of core *flow*. Only one dimension was measured using two questions: the “clear goal” dimension (I am “tuned in” to what I am doing, *and* I am “totally focused” on what I am doing).

Martin and Jackson (2008) explained in detail how they tested the reliability and validity of the Core *Flow* Scale. The Core *Flow* Scale was found to be reliable and approximately normally distributed. The validity of the *flow* construct was tested in a variety of domains such as work, sports, music, and school. Confirmatory factor analysis (CFA) showed an acceptable fit of the hypothesized models to the data.

Reliability refers to test-retest reliability and the consistency of the results of the instrument over time (Sürücü & Maslakçı, 2020). To assess the internal consistency of the instruments, the alpha coefficient method was used.

Validity refers to “the degree to which a test or measuring instrument actually measures what it purports to measure or how well a test or a meaning instrument fulfils its function” (Oluwatayo & Adebule, 2012, p. 391). To assess the validity of the instrument, construct validity was utilized to determine whether the sentences in the items of the instruments represented the phenomenon intended to be measured. I used CFA to test construct validity for the instruments. According to Sürücü and Maslakçı (2020) “In CFA, the primary purpose is to test the accuracy of the previously validated scale or model” (p. 2700).

Procedure

Before collecting the data, the researcher obtained approval from the Andrews University Institutional Review Board (IRB) (Appendix D). For collecting data QuestionPro was used which is a powerful online survey platform designed to help researchers distribute their surveys quickly and easily. After contacting QuestionPro by email, the researcher asked them to distribute the survey to international undergraduates enrolled in developmental math courses.

QuestionPro utilized their proprietary panel, which includes consumer, B2B, and custom niche panels that are managed and recruited by QuestionPro Audience, to provide the sample. Additionally, they utilized various media channels such as affiliate marketers, online banner advertisements, social media, and other methods to reach undergraduate students in the United States. Typically, QuestionPro administers the sample through only one source, but they use multiple recruitment tactics to target hard-to-reach audiences. This includes strategies such as industry affiliation access, list purchase, social media, offline, and mobile recruitment to target low incidence populations. Once they have identified the target population, their team develops a sampling plan to randomly invite respondents who are best qualified to participate in the survey based on the outlined specifications. Invitations are then deployed randomly to the target population, including mobile respondents who fit the criteria. Adjustments are made as necessary to ensure that the entire population is accurately represented.

QuestionPro Audience maintains an average of 250 profile data points on each member, covering various aspects such as demographic, sociographic, purchasing decisions, household, job title, and specialties. Members are encouraged to complete their profiles at the time of registration and throughout their membership, and profile data is also collected and updated from each survey. This information is then stored in the panel database and used to ensure the information is up to date. Members who opted to join the panel are informed that they will be invited to participate in occasional surveys that are conducted solely for market research purposes.

As compensation for their participation, members may receive incentives such as cash, gift cards, or points that can be redeemed for cash. All invitations from QuestionPro Audience are sent via email or push notification for mobile users and follow the same standard template to eliminate respondent bias. The invitations include basic information such as the date/time of the survey, the incentive being offered, and other panelist information, while revealing very little about the survey topic to prevent any advantages or biases in the survey-taking experience.

QuestionPro Audience offers various incentive opportunities for respondents, primarily through a "point" system that rewards respondents upon completion of a survey or when they meet specific conditions such as survey length, complexity, or quotas set for the project. Points can be redeemed for gift cards or cash, depending on the redemption level and if the panel member has fulfilled all requirements. For qualitative projects or those requiring longer participation, such as IHUT, respondents may receive incentives in the form of keeping the product being tested or earning a large sum of cash in the form of a company check. Low incidence or specialties typically result in higher survey incentives.

Participants were provided with an informed consent form (Appendix E) containing an (a) explanation of the purpose of the study and the significance of their cooperation, (b) assurances of their right to withdraw without penalty, and (c) a description of how their data and information would be held secure and confidential, accessible only to the researcher and her committee members. Prospective participants were invited to participate in the study by an email invitation sent directly from QuestionPro. QuestionPro was instructed to deliver 390 responses from only international undergraduate students over 18 years old in the United States. Only international undergraduate students over 18 years old from the United States were allowed to take part in the study. Within the email, participants were asked to click the QuestionPro link to access the informed consent form as well as the survey instruments. After every participant had completed the online survey, data were retrieved from QuestionPro for analysis. Additionally, QuestionPro offered a real-time analysis based on the survey answers.

Analysis of the Data

SPSS and IBM SPSS AMOS were used for statistical analysis. The research aimed to investigate measure *flow* experience, mathematics self-efficacy, and students' mathematics anxiety.

Creating a Data File

A data file in Excel and SPSS was created using the data downloaded from QuestionPro software.

Screening the Data

Before commencing data analysis, the data were cleaned by examining the dataset for missing data (Field, 2018). After collecting 614 questionnaires, only 503 responses were complete; incomplete questionnaires were excluded. Categorical variables, such as gender, were assigned numerical values. Frequency and percentage summaries were used to measure categorical variables, while measures of central tendencies of means, standard deviations, and minimum and maximum values were conducted for continuous variables.

Both descriptive and inferential statistics were used to address the four research questions presented earlier. RQ1 and RQ2 utilized descriptive statistics to report overall mean math anxiety and *flow* characteristics; the mean scores of all math anxiety and *flow* characteristics were examined to measure which ones were experienced by most subjects.

For RQ3, an independent samples t-test was computed to determine whether there was a difference between the mean scores of male and female international undergraduate students in math anxiety, using a significance level of $p = 0.05$. Further, SEM was conducted to answer RQ4, using only complete datasets with no missing values.

Developing the Model Specification

The data were cleaned; the hypothesized model was developed by IBM SPSS Amos (path diagram). Ovals or circles represented latent variables, while rectangles or squares represented measured variables. Residuals are always unobserved, so they were represented by ovals or circles. The correlations and covariances were represented by bidirectional arrows, representing relationships without explicitly defined causal directions. The software SPSS AMOS was used to test the proposed model. First, the data file was linked to AMOS. Next, the model was created in AMOS with the pertinent variables moved to each “rectangle.” Once the model was created, the options/methods to be used in the analysis were specified. Maximum Likelihood was used.

SEM, with the help of AMOS software, was used to test the proposed research model. SEM is a powerful multivariate technique used widely to test latent and observed variables together (Hair et al., 2017; Hair, 2009; Hair et al., 2019; Kline, 2011). This study used Anderson and Gerbing’s (1988) two-step approach to testing the SEM model. Under this approach, a researcher first designs a measurement model and tests its psychometric properties (e.g., convergent and discriminant validity) using CFA. If there are no validity issues in the measurement model, then the researcher converts the measurement model into an SEM model and tests it.

The validity of the structural models was assessed by examining model fit indexes. Criteria for overall good fit of a model used included the Normed Chi-Square (Chi-square [CMIN]/Degree of Freedom [DF]), at less than 3; the Comparative Fit Index (CFI), greater than 0.95; the Goodness of Fit Index (GFI) should be greater than 0.95; the Adjusted Goodness of Fit Index (AGFI), greater than 0.80, the Standardized Root Mean Square Residual (SRMR) should be less than 0.09, the Root Mean Square Error of Approximation (RMSEA), less than 0.05; and the Probability of Close Fit (PCLOSE) should be greater than 0.05. Additionally, the *p*-values for each predictor were examined to determine significance. If the *p*-value was less than or equal to .05, the predictor was significant. Table 3 summarizes these values

Table 3

Model Fit Indices

Indices	Acceptable Value/range
Normal Chi-Square [CMIN]/Degree of Freedom [DF])	< 3
Comparative Fit Index (CFI)	> 0.95
Goodness of Fit Index (GFI)	> 0.95
Adjusted Goodness of Fit Index (AGFI).	>0.80
Standardized Root Mean Square Residual (SRMR)	<0.09
Root Mean Square Error of Approximation (RMSEA)	<0.05
Probability of Close Fit (PCLOSE)	>0.05

Ethical Considerations

The Belmont Report (U.S. Department of Health and Human Services, 1979) describes the ethical considerations researchers must address. Researchers must protect participants and adhere to respect for persons, autonomy, justice, and beneficence. This study employed purposive, nonprobability sampling, and the data collected did not include any personally identifying information. The data collected did not include names or IP addresses of the participants. The data were downloaded to a secure, password-protected personal computer. The ethical considerations identified in the Belmont Report were important for the current study.

The first ethical consideration is respect for persons (U.S. Department of Health and Human Services, 1979). The researcher adhered to the respect of persons by ensuring that no personally identifiable information was collected. The second ethical consideration identified in the Belmont Report was autonomy. The researcher conformed by ensuring that individuals participated in the study voluntarily without being coerced.

The third ethical consideration was protection for vulnerable participants. The researcher ensured that no participants were minors by using an informed consent form clearly describing the inclusion criteria. The fourth ethical consideration was beneficence; the researcher safeguarded the welfare of participants by obtaining IRB approvals for the study. The IRB approval indicated that other scholars had reviewed the study, determining there was little risk to participants. The fifth ethical consideration mentioned in the Belmont Report was justice. The researcher ensured justice by guaranteeing that society would benefit from the results of the project. The sixth ethical consideration was the protection of human participants. The participants were informed about the risks and benefits of the project through the informed consent form. All participants were required to read and agree to the information in the informed consent form that contained clear descriptions of the purpose, possible risks, and benefits of participating in the study. Adhering to the Belmont Report required that researchers provide participants with an informed consent form using accurate language, explaining the purpose and procedures of the project, identifying the risks and benefits associated with the project, and guaranteeing that participants could choose to withdraw at any time.

The researcher ensured that participants’ private information would not be compromised; their names were not collected. Instead, each respondent was identified by an anonymous identification number. Additionally, Internet Protocol (IP) addresses for the participants were not collected. The collected data were stored and encrypted on a password-protected computer where only the researcher has access to the data for five years. The data will be permanently destroyed after five years by deleting the files from the computer and shredding any paper copies of the raw data.

To maintain confidentiality and privacy of the shared information, the data collection was completed using QuestionPro software; the data collection was protected by a secure server, to protect respondent anonymity. The software was HIPPA compliant which further ensured the security of the participants and their answers. The researcher and her dissertation committee were the only individuals who had access to the survey data.

Summary

This chapter provided a comprehensive description of the quantitative correlational research design of the study. Complete usable surveys were received from 503 international undergraduate student participants who were recruited via QuestionPro to address the four research questions. All analyses were conducted using SPSS. Statistical significance was assessed at the 5% level.

The results and findings from the data analyses will be presented in Chapter 4, along with tables and graphics demonstrating the descriptive results and inferences regarding the underlying connections among the study variables. Conclusions and interpretation of the findings are provided in Chapter 5, along with study limitations, recommendations for future studies, and implications for positive social change.

CHAPTER 4

RESULTS

Introduction

This study investigated the relationships among *flow* experience, mathematics self-efficacy, and mathematics anxiety among international undergraduate students in a developmental mathematics course. This study attempted to answer the following four research questions:

RQ1: What levels of mathematics anxiety did international undergraduate students report?

RQ2: To what extent did international undergraduate students experience characteristics of *flow*, when doing mathematical problems?

RQ3: Were there gender differences among international undergraduate students in math anxiety and *flow* experience?

RQ4: To what extent was mathematics anxiety related to *flow* and mathematics self-efficacy?

As discussed in the previous chapter, a questionnaire was developed, using tool identified from the literature review, to measure *flow* experience, mathematics self-efficacy, and student mathematics anxiety. Demographic information was also collected. This chapter explains how the collected data were analyzed and presents the findings. Microsoft Excel, IBM SPSS, and AMOS software were used to analyze the collected data. First, this chapter presents participant demographic information in a summarized form. Later, the statistical analyses used to answer the research questions are described.

Demographics Data Analysis

A total of 614 participants participated in the study. For data screening, criteria were established to accept or not accept responses for the data analysis stage; all incomplete responses (e.g., responses with many missing values) and/or those that did not fit the study requirements were not considered. Most participants provided complete answers; however, some stopped in the middle of the submission process, leaving many missing values. While 614 responses were received, 111 (18%) were incomplete; thus 503 (82%) responses were complete and qualified for data analysis. Among these 503 participants, 451 were between 18 and 24 years, 367 were female (89.66%), and 136 were male (27.04%). Table 4 presents an overview of age and gender distribution.

Table 4

Sample Distribution by Age and Gender

Variables	*N*	%
Age		
18-24	451	89.66
25-34	52	10.34
Total	503	100

Gender		
Female	367	72.96
Male	136	27.04
Total	503	100

The United States has always been attractive to international students, offering a wide range of degrees and courses acceptable all around the world. While fewer have come during the past two to three years because of the pandemic, a total of 948,519 international students enrolled in the United States during the 2021/22 academic year (Duffin, 2023). Of the international students enrolled in 2021, 44% were female and 56% were male (International Students Studying in the United States: Trends and Impacts, n.d.). The exact number of international students enrolled in math courses is unclear.

In terms of ethnicity, 155 (30.82%) participants were Hispanic or Latino, 120 (23.86%) were multiracial, 94 (18.69%) were Asian, 39 (7.75%) were Blacks, not African American, and 11 (2.19%) were native Hawaiian or other Pacific islanders. The remaining 84 (16.7%) were white non-Americans (see Table 5). More than 50% of the participants resided in California, New York, Texas, Florida, Georgia, Illinois, and New Jersey (see Table 6 and Figure 5).

Table 5

Distribution of Respondents by Ethnicity Background

Ethnicity Background	n	%
Hispanic or Latino	155	30.82
Multiracial	120	23.86
Asian	94	18.69
Black, Not African American	39	7.7
Native Hawaiian or Other Pacific Islander	11	2.19
Other (white non-American)	84	16.70
Total	503	100

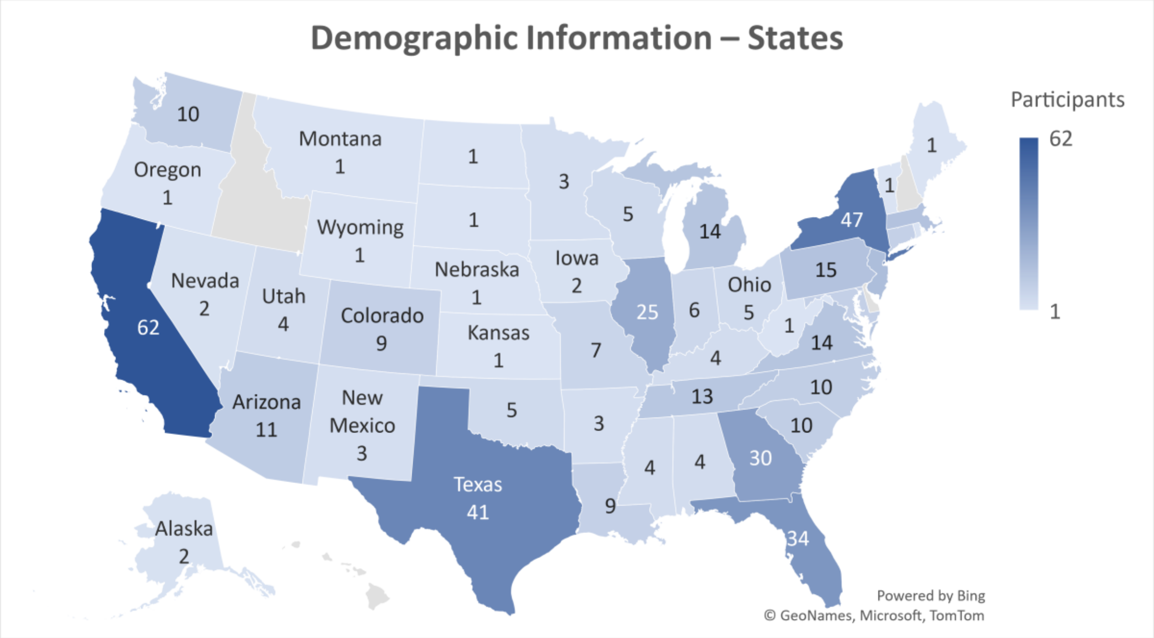
Table 6

Sample Distribution by State of Residence

State	*N*	%	State	*N*	%
CA	62	12.30	WI	5	1.0
NY	47	9.30	AL	4	.80
TX	41	8.20	KY	4	.80
FL	34	6.80	MS	4	.80
GA	30	6.00	UT	4	.80
IL	25	5.00	AR	3	.60
NJ	17	3.40	MN	3	.60
MA	15	3.00	NM	3	.60
PA	15	3.00	AK	2	.40
MI	14	2.80	DC	2	.40
VA	14	2.80	IA	2	.40
TN	13	2.60	NV	2	.40
AZ	11	2.20	KS	1	.20
NC	10	2.00	ME	1	.20
SC	10	2.00	MT	1	.20
WA	10	2.00	ND	1	.20
CO	9	1.80	NE	1	.20
CT	9	1.80	OR	1	.20
LA	9	1.80	RI	1	.20
MD	9	1.80	SD	1	.20
MO	7	1.40	VT	1	.20
IN	6	1.20	WV	1	.20
OH	5	1.00	WY	1	.20
OK	5	1.0	No response	27	5.40
Total			503		100%

Figure 5

Distribution of Respondents by State of Residence



Descriptive Statistics

After assessing participant demographic information, descriptive statistics (means, standard deviations, and Cronbach's alpha values) were computed to understand the data distribution and evaluate the reliability of the scales used to measure *flow* experience, math self-efficacy, and student mathematics anxiety. The mean and standard deviation of *flow* experience (*M* = 3.25, *SD* = 0.95) showed that most of the responses fell in the "disagree," "neutral," and "agree" range. The mean and standard deviation of math self-efficacy (*M* = 3.23, *SD* = 0.90) and mathematics anxiety (*M* = 3.12, *SD* = 0.87) showed that most of the responses fell in the "seldom," "sometimes," and "often" range. Similarly, on the subscale level analysis, the means and standard deviation values of self-efficacy subscales: accomplishment (*M* = 3.24, *SD* = 1.04), good qualities and ability (*M* = 3.43, *SD* = 0.95), self-confidence (*M* = 3.10, *SD* = 0.95), examination process (*M* = 3.28, *SD* = 1.08), and self-evaluation (*M* = 3.10, *SD* = 0.96) showed that most of the responses fell in the “seldom,” “sometimes,” and “often” range. Likewise, the means and standard deviation values of mathematics anxiety subscales: stressed (*M* = 3.22, *SD* = 0.98), panic or confused (*M* = 3.21, *SD* = 0.90), lack of motivation (*M* = 3.06, *SD* = 1.02), lack of confidence (*M* = 3.00, *SD* = 0.95) showed that most of the responses fell on “seldom,” “sometimes,” and “often.”

Skewness is a measure of the degree of asymmetry of a probability distribution. A distribution will be considered approximately symmetric if the skewness values fall in between -0.5 and 0.5. The results showed that the skewness values of *flow* experience, math self-efficacy, students mathematics anxiety, and the subscales of math self-efficacy and students mathematics anxiety fall between -0.5 and 0.5, meaning all the distributions are approximately symmetric (Table 7).

Cronbach’s alpha is a statistic commonly used in research to assess the reliability or internal consistency of a scale. It is a measure of how well the individual items in the scale measure the same underlying construct. Cronbach’s alpha provides a coefficient that ranges from 0 to 1, with higher values indicating greater reliability. A value of 0 indicates no reliability, while a value of 1 indicates perfect reliability. Cronbach (1951) stated that a scale would only be regarded as reliable if its alpha coefficient value was equal to or greater than 0.70. In this study, all three main scales and subscales met Cronbach’s criteria.

Table 7

Descriptive Statistics and Reliability Estimates for Instruments and Subscales (n = 503)

Scales and Subscales	Items	*M*	*SD*	Skewness	Cronbach's α
Flow Experience	10	3.25	0.95	-0.25	0.94
Math Self-Efficacy	14	3.23	0.90	-0.12	0.94
Sense of accomplishment	3	3.24	1.04	-0.11	0.83
Good qualities and ability	3	3.43	0.95	-0.28	0.73
Self-confidence	3	3.10	0.95	-0.02	0.71
Examination process	2	3.28	1.08	-0.25	0.75
Self-evaluation	3	3.10	0.96	-0.05	0.77
Mathematics Anxiety	15	3.12	0.87	-0.08	0.93
Stressed	5	3.22	0.98	-0.07	0.82
Panic or confused	3	3.21	0.90	-0.17	0.82
Lack of motivation	4	3.06	1.02	0.00	0.70
Lack of confidence	3	3.00	0.95	0.00	0.74

For the *flow* scale the alpha value was 0.94, the self-efficacy alpha value was 0.94, and the mathematics anxiety value was 0.93. Similarly, on the subscale of self-efficacy, the sense of accomplishment alpha value was 0.83, the good qualities and ability alpha value was 0.73, the self-confidence alpha value was 0.71, the examination process alpha value was 0.75, and the self-evaluation alpha value was 0.77. On the subscale of mathematics anxiety, the stressed alpha value was 0.82, panic or confused alpha value was 0.82, lack of motivation alpha value was 0.70, and lack of confidence alpha value was 0.74. As no issues were identified in the descriptive statistics analysis (such as central tendency, variability, and shape of the distribution) of the study, further statistical analyses could be conducted to answer the research questions. Table 8 shows an overview of the descriptive statistics.

Research Questions

Mathematics Anxiety

The first research question was: What levels of mathematics anxiety did international undergraduate students report? Based on the descriptive analysis of overall mathematics anxiety, most participants felt anxious sometimes while solving math problems ($M = 3.12$, $SD = 0.87$). Most participants sometimes felt stressed ($M = 3.22$, $SD = 0.98$), confused ($M = 3.21$, $SD = 0.90$), less motivated ($M = 3.06$, $SD = 1.02$), and less confident ($M = 3.00$, $SD = 0.95$) while solving mathematics problems. Table 8 shows these analysis results for math anxiety. To further understand math anxiety, an items-wise descriptive statistics analysis of each dimension was conducted, revealing that the participants reported more anxiety feelings while solving mathematics problems on Item 27 “I am afraid to give an incorrect answer during my mathematics class” ($M = 3.41$, $SD = 1.22$), Item 2 “I get tense when I prepare for a mathematics test” ($M = 3.50$, $SD = 1.23$), Item 6 “I worry that I will not be able to get a good grade in my mathematics course” ($M = 3.47$, $SD = 1.18$). Students reported low anxiety feelings while solving mathematics problems for Item 18 “I worry that I will not be able to complete every assignment in a mathematics course” ($M = 2.86$, $SD = 1.23$) and Item 5 “I worry that I will not be able to use mathematics in my future career when needed” ($M = 2.80$, $SD = 1.33$). Tables 9, 10, 11, and 12 and Figures 6, 7, 8, and 9 show the item-wise descriptive statistics of the dimensions (i.e., stressed, panic or confused, lack of motivation, and lack of confidence, respectively).

Table 8

Descriptive Statistics for Mathematics Anxiety

Variables	*N*	*M*	*SD*	Skewness
Mathematics Anxiety	503	3.12	0.87	-0.075
Stressed	503	3.22	0.98	-0.068
Panic or confused	503	3.21	0.90	-0.166
Lack of motivation	503	3.06	1.02	0.001
Lack of confidence	503	3.00	0.95	0.002

Table 9

Descriptive Statistics for Stressed Statements of Mathematics Anxiety

Construct Statements	*N*	*M*	*SD*	Often/Usually %	Sometimes %	Seldom/Never %
27. I am afraid to give an incorrect answer during my mathematics class.	503	3.41	1.22	49.9	27.7	22.4
15. Working on mathematics homework is stressful for me.	503	3.20	1.20	37.6	35.3	27.1
11. I feel stressed when listening to mathematics instructors in class.	503	3.07	1.22	36.0	31.2	32.8

Note: Percent shows “Often” and “Usually” responses.

Figure 6

Distribution of Responses to Stressed Statements of Mathematics Anxiety

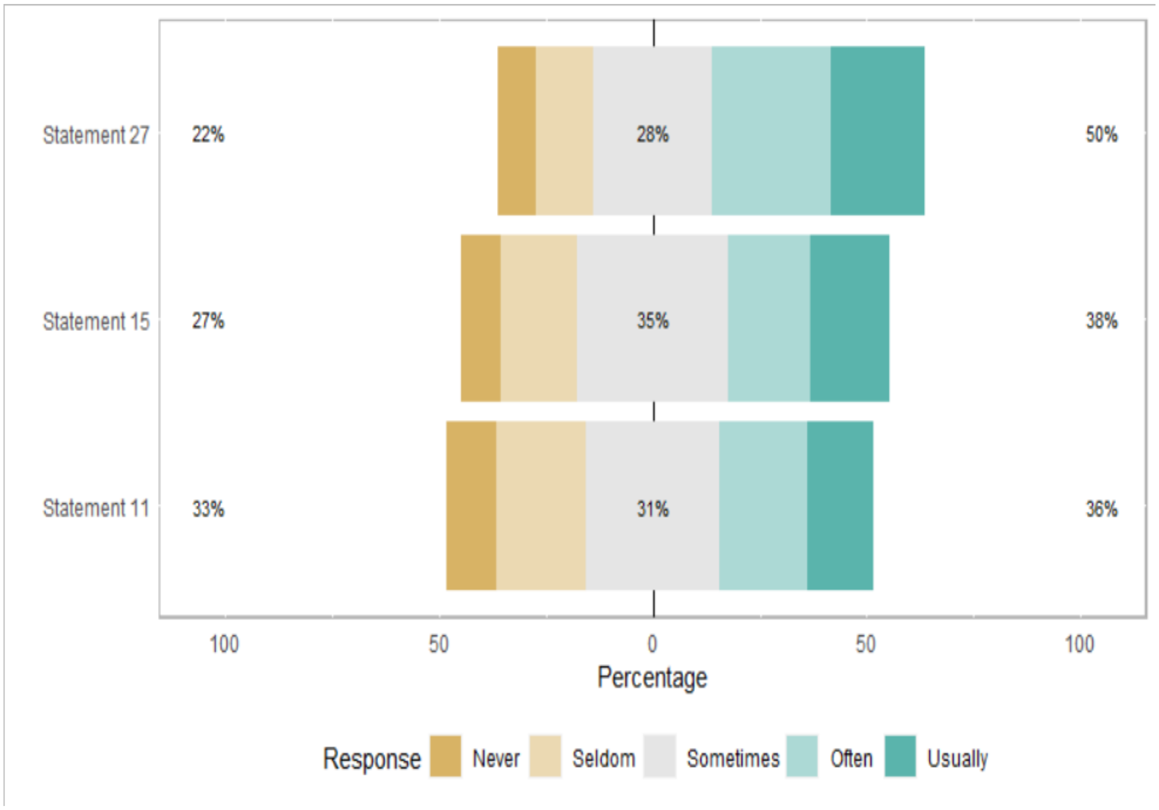


Table 10

Descriptive Statistics for Panic or Confused Statements of Mathematics Anxiety

Construct Statements	*N*	*M*	*SD*	Often/Usually %	Sometimes %	Seldom/Never %
2. I get tense when I prepare for a mathematics test.	503	3.50	1.23	53.3	26.1	20.6
26. I get nervous when taking a mathematics test.	503	3.47	1.18	48.2	32.6	19.2
14. I get nervous when asking questions in class.	503	3.17	1.27	39.2	31.2	29.6
3. I get nervous when I have to use mathematics outside of school.	503	2.73	1.34	27.9	27.1	44.9

Note: Percent shows “Often” and “Usually” responses.

Figure 7

Distribution of Responses to Panic or Confused Statements of Mathematics Anxiety

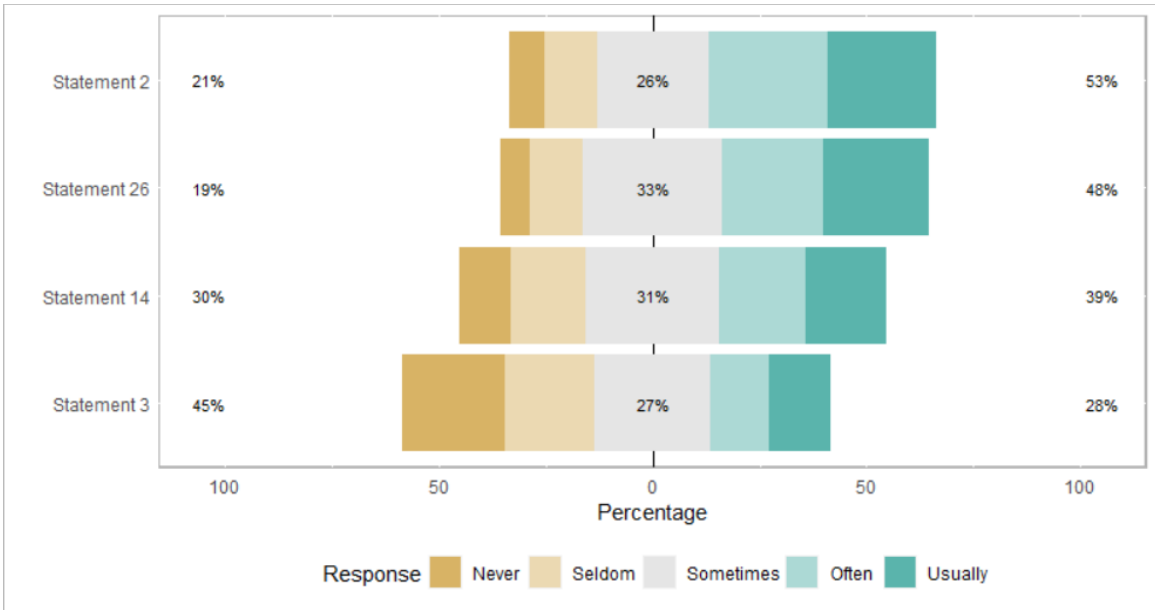


Table 11

Descriptive Statistics for Lack of Motivation Statements of Mathematics Anxiety

Construct Statements	*N*	*M*	*SD*	Often/Usually %	Sometimes %	Seldom/Never %
24. I worry that I will not be able to get an "A" in my mathematics course.	503	3.19	1.26	41.4	28.1	30.5
25. I worry that I will not be able to learn well in my mathematics course.	503	3.01	1.20	33.7	32.9	33.3
22. I worry I will not be able to understand the mathematics.	503	3.00	1.16	32.2	33.8	34.0

Note: Percent shows "Often" and "Usually" responses.

Figure 8

Distribution of Responses to Motivation Statements of Mathematics Anxiety

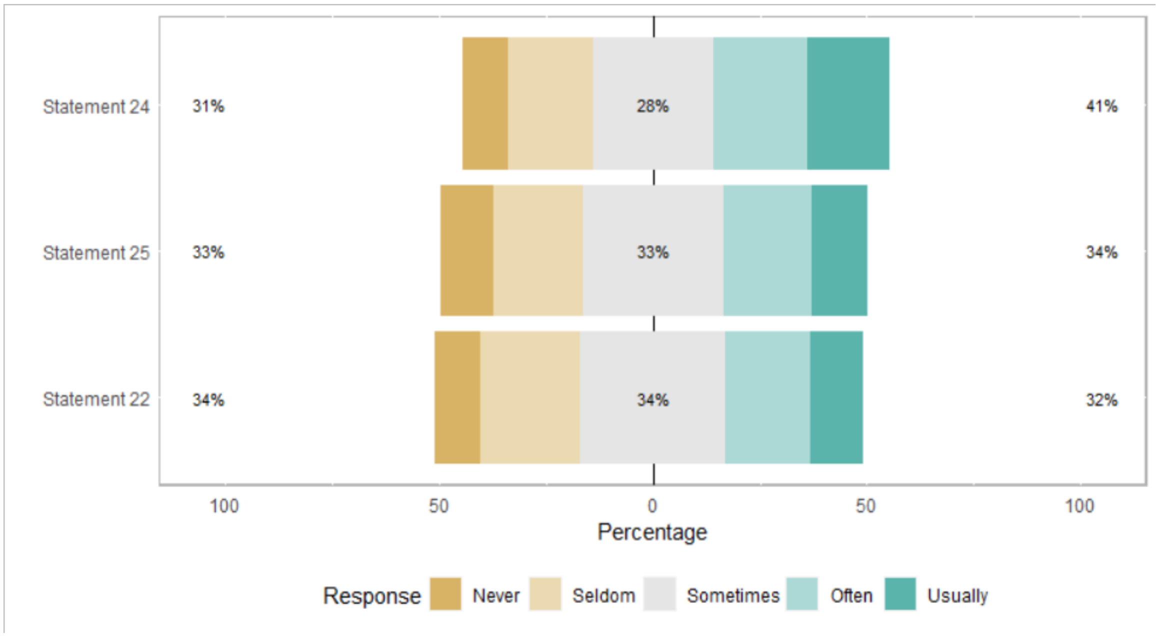


Table 12

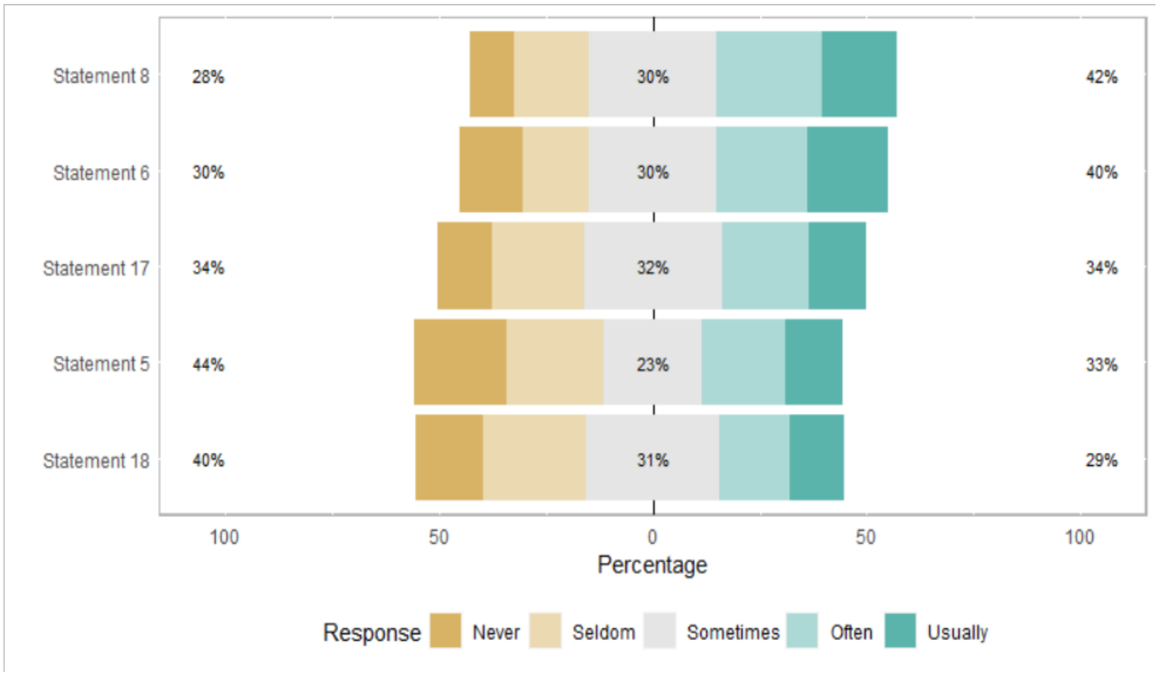
Descriptive Statistics for Lack of Confidence Statements of Mathematics Anxiety

Construct Statements	*N*	*M*	*SD*	Often/Usually %	Sometimes %	Seldom/Never %
8. I worry that I will not be able to do well on mathematics tests.	503	3.22	1.22	42.2	30.0	27.8
6. I worry that I will not be able to get a good grade in my mathematics course.	503	3.14	1.30	40.0	29.8	30.2
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	503	3.01	1.21	33.7	32.1	34.1
18. I worry that I will not be able to complete every assignment in a mathematics course.	503	2.86	1.23	29.1	31.1	39.8
5. I worry that I will not be able to use mathematics in my future career when needed.	503	2.80	1.33	32.8	23.0	44.2

Note: Percent shows "Often" and "Usually" responses.

Figure 9

Distribution of Responses to Lack of Confidence Statements of Mathematics Anxiety



Flow Experience

The second research question was: To what extent did international undergraduate students experience characteristics of *flow* theory, as measured by the *Flow* Scale when doing mathematical problems? Table 13 (p. 103) reports the overall mean score of each *flow* variable of the participants. Based on the descriptive statistics analysis of overall *flow* experience, the participants experienced low to moderate characteristics of *flow* experience while solving mathematics problems (*M* = 3.25, *SD* = 0.95.) To further understand *flow* experience, item-wise descriptive statistical analyses were conducted. The result showed individual differences in responses regarding each of the *flow* characteristics while solving mathematics problems. That is *flow* characteristics were experienced with different levels: the highest item was the challenge-skill balance (a pre-condition of *flow*), where 56.5% of the participant agreed/strongly agreed that there was a balance of challenge and skill (*M* = 3.50, *SD* = 1.14). The second highest item was clear goals (a pre-condition of *flow),* where 56.5% of student agreed/ strongly agreed that they experience clear goals (*M* = 3.48, *SD* = 1.11). The subsequent highest item was focusing (an indicator of *flow),* where 47.5% of the student agreed/ strongly agreed that they are focusing (*M* = 3.30, *SD* = 1.17).

On the other hand, the two indicators of *flow* were represented as less moderate or neutral among the students. For sense of control (an indicator of *flow)* 43.1% of students agreed/strongly agreed they were experiencing a sense of control (*M* = 3.19, *SD* = 1.20). The subsequent item was feedback (an indicator of *flow*) where 41.6% of the participants agreed/ strongly agreed that they experienced feedback (*M* = 3.15, *SD* = 1.18).

The lowest level was observed at Item 8, freedom from being time-bound (a *flow* indicator) where only 28.2% of the participants agreed/ strongly agreed that they feel freedom from being time-bound while solving mathematics problems (*M* = 2.27, *SD* = 1.23). See Figure 10 and Table 13 where items are arranged in descending order in terms of the percentage of agree/ strongly agree.

Table 13

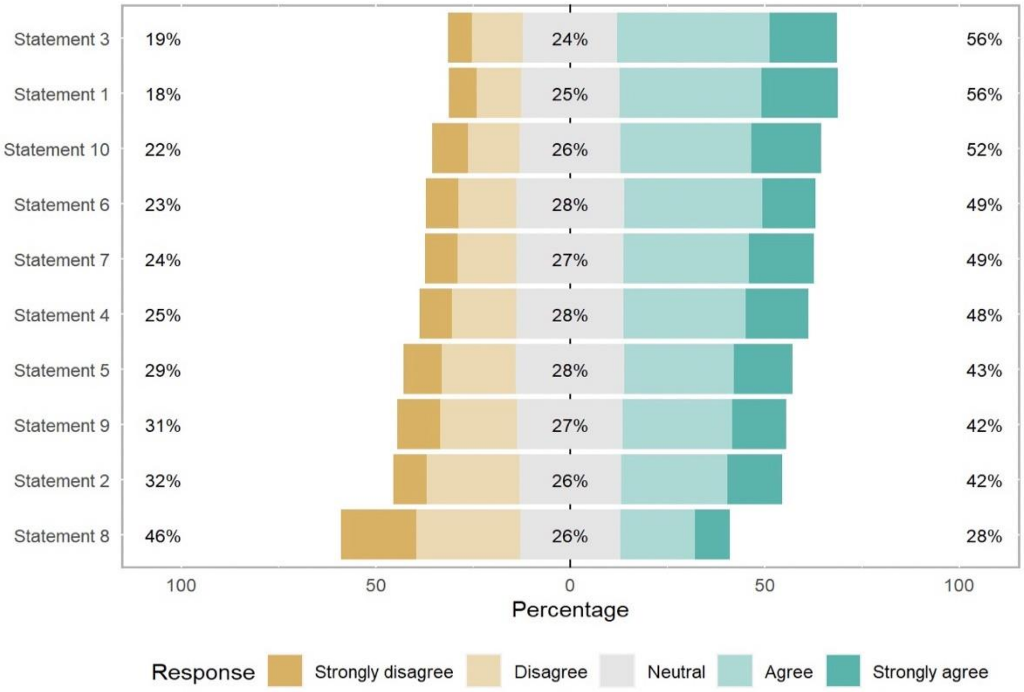
Descriptive Statistics for the Flow Experience Statements and Dimensions(n = 503)

Construct Statements	*M*	*SD*	Agree/Strongly agree %	Neutral %	Disagree/Strongly disagree %
3. I am “tuned in” to what I am doing. Clear goals	3.48	1.11	56.5	24.3	19.3
1. I am “totally involved.” Challenge-skill balance	3.50	1.14	56.3	25.2	18.5
10. I am “totally focused” on what I am doing. Clear goals	3.38	1.19	51.7	25.8	22.5
6. I am “switched on.” Action-awareness merging	3.31	1.13	49.1	27.8	23.1
7. It feels like I am “in the *flow*” of things. Autotelic experience	3.33	1.17	48.9	27.4	23.7
4. I am “Am in the zone.” Deep concentration	3.30	1.17	47.5	27.6	24.9
5. I feel “in control.” Complete sense of control	3.19	1.20	43.1	28.0	28.8
9. I am “in the groove.” Elimination of self-consciousness	3.14	1.21	41.9	27.2	30.8
2. It feels like “everything clicks.” Immediate feedback	3.15	1.18	41.6	26.0	32.4
8. It feels like “nothing else matters” Freedom from being time-bound	2.72	1.23	28.2	25.6	46.1

Note: (1-SD, 2-D, 3-Not sure, 4, A, 5-SA) Percent shows “Agree” and “Strongly Agree” responses.

Figure 10

Distribution of Responses to Flow Experience Statements



Gender Differences

This study's third research question was: Were there gender differences among undergraduate international students in math anxiety and *flow* experience? An independent sample t-test was used to answer this research question. The assumptions before applying an independent sample t-test are a scale of measurement, random sampling, normality of data distribution, adequacy of sample size, and equality of variance in standard deviation. This data fulfilled all the assumptions for the hypothesis tests (normality of data distribution and equality of variance in standard deviation) except the adequacy of sample size from a gender perspective. As discussed in the descriptive statistics analysis, out of 503 participants, 136 were male, 367 were female, three were other, and one preferred not to disclose. The overview of the collected data show that the data is normally distributed and there is equality of variance in the standard deviations; therefore, this study can use independent samples t-test to gain insights into gender differences. The results of the t-test for gender differences among international undergraduate students in math anxiety and *flow* experiences are explained as follows.

Gender Differences in Math Anxiety

Application of an independent samples t-test on mathematics anxiety showed that although both females and males felt moderately anxious when solving math problems, females (M = 3.16, SD = 0.89) felt more mathematics anxiety than males (M = 2.99, SD= 0.78) while solving mathematics problems; this difference was statistically significant $t(501) = -1.95$, $p = 0.05$ with a large effect size ($d = 0.86$). Interpretation of the contradiction in this result, between a small difference in means and a large effect size, needs to be explained. A difference of only 0.17 (3.16 - 2.99) in *flow* experience between females and males seemed negligible and did not truly show whether the female group was different from the male group. However, the difference was statistically significant ($p = .05$). The statistical significance alone could be misleading because sample size influences significance. Increasing sample size increases the likelihood of finding a statistically significant effect, no matter how small the effect truly is in the real world. Therefore, adding a measure of practical significance shows how promising this difference is from a practical consideration. The effect size reflects that practical significance. The main value of the effect size was to compute how much of the variability of one group was determined by the variability of the other group regardless of the sample size.

When mathematics anxiety dimensions were analyzed using the independent sample t-test, females felt more stressed (*M* = 3.28, *SD* = 0.99), were more panicked (*M* = 3.28, *SD* = 0.91), were more likely to lose confidence (*M* = 3.04, *SD* = 0.99), and were less motivated (*M* = 3.12, *SD* = 1.07) while solving mathematics problems as compared to males, who felt less stressed (*M* = 3.09, *SD* = 0.96, *t*(501) = -1.95, *p* = 0.05; *d* = 0.98), less panicked (*M* = 3.05, *SD* = 0.87, *t*(501) = -2.46, *p* = 0.01, *d* = 0.90), were less likely to lose confidence (*M* = 2.92, *SD* = 0.83, *t*(501) = -1.40, *p* = 0.16.) and were more motivated (*M* = 2.94, *SD* = 0.89, *t*(501) = -1.91, *p* = 0.06, *d* = 1.02). All these differences were statistically significant with a large effect size, except that the difference in lack of confidence was not significant (*t*(501) = -1.40, *p* = 0.16). Tables 14 and 15 show the results of the independent t-test for gender differences in mathematics anxiety and *flow* experience; see also Figure 11.

Table 14

Gender Differences in Mathematics Anxiety

Construct	Gender	*N*	*M*	*SD*	Levene's test		t-test			
					F	p	t	df	p	ES(d)
Lack of Confidence	Male	136	2.92	0.83	6.34	0.01	-1.40	284.39	0.16	0.95
	Female	367	3.04	0.99						
Lack of Motivation	Male	136	2.94	0.89	8.03	0.01	-1.91	288.16	0.06	1.02
	Female	367	3.12	1.07						
Panic or confused	Male	136	3.05	0.87	2.11	0.15	-2.46	501.00	0.01	0.90
	Female	367	3.28	0.91						
Stressed	Male	136	3.09	0.96	0.00	0.95	-1.95	501.00	0.05	0.98
	Female	367	3.28	0.99						
Overall Mathematics Anxiety	Male	136	2.99	0.78	3.70	0.06	-1.95	501.00	0.05	0.86
	Female	367	3.16	0.89						

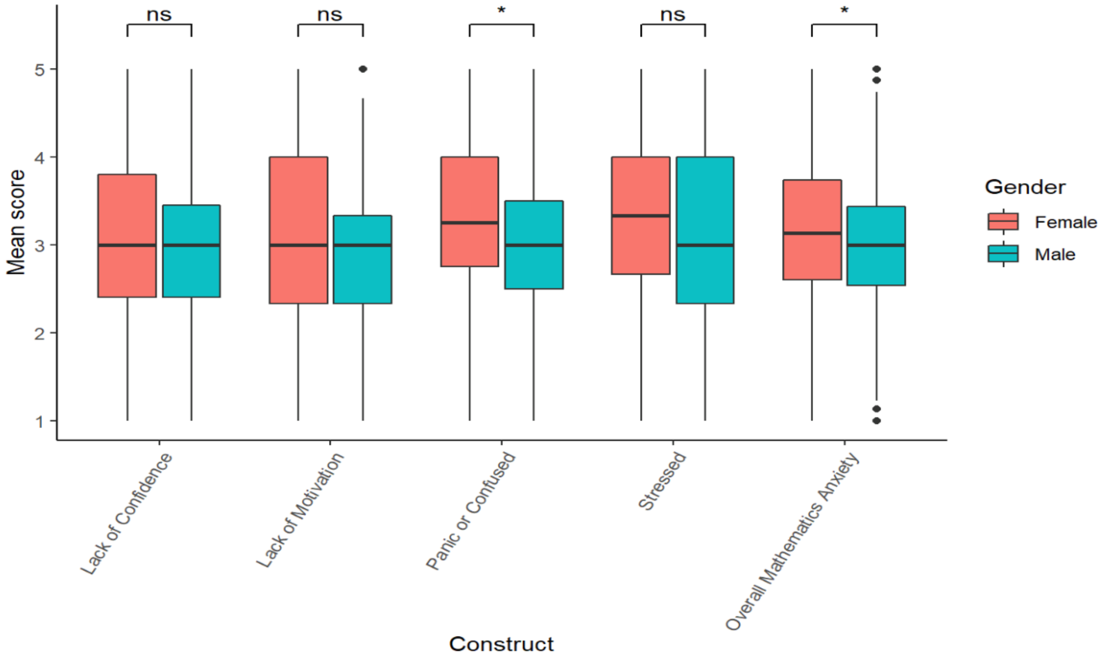
Table 15

Gender Differences in Flow Experience

Construct	Gender	*N*	*M*	*SD*	Levene's test		t-test			
					F	*p*	*t*	*df*	*p*	ES(d)
Flow Experience	Male	136	3.39	0.87	1.87	0.17	2.04	501.00	0.04	0.95
	Female	367	3.20	0.97						

Figure 11

Distribution of Gender Differences in Types of Mathematics Anxiety



Flow Experience–Gender Differences

The application of an independent sample *t*-test on *flow* experience data showed that males (*M* = 3.39, *SD* = 0.87) experienced more *flow* experience than females (*M* = 3.20, *SD* = 0.97) while solving mathematical problems; this difference was statistically significant, *t* (501) = 2.04, *p* = 0.04, with a large effect size (*d* = 0.95). Both groups, males and females still experienced *flow* moderately. When *flow* experience construct items were analysed using an independent sample *t*-test, all results were similar to the overall *flow* experience *t*-test results except Item 1 of the *flow* scale, where females (*M* = 3.51, *SD* = 1.13) felt more *flow* experience than males (*M* = 3.49, *SD* = 1.19) while solving mathematical problems; however, this difference was not statistically significant (*t*(501) = -0.21, *p* = 0.83). Table 16 shows the results from applying the independent sample *t*-test to *flow* experience results.

As articulated above, mathematics anxiety and *flow* experience were analyzed from a gender differences perspective. The gender-based comparison showed that females (*M* = 3.16, *SD* = 0.89) felt more mathematics anxiety than males (*M* = 2.99, *SD* = 0.78), and females (*M* = 3.20, *SD* = 0.97) had less *flow* experience while solving mathematical problems compared to males (*M* = 3.39, *SD* = 0.87).

Table 16

Gender Differences in Items of Flow

Construct	Gender	N	Mean	SD	F	Sig.	t	df	Sig.
FL1	Male	136	3.49	1.19	0.58	0.45	-0.21	501.00	0.83
	Female	367	3.51	1.13					
FL2	Male	136	3.30	1.07	3.50	0.06	1.79	501.00	0.08
	Female	367	3.09	1.22					
FL3	Male	136	3.57	1.04	2.10	0.15	1.02	501.00	0.31
	Female	367	3.45	1.13					
FL4	Male	136	3.43	1.15	0.00	0.97	1.52	501.00	0.13
	Female	367	3.26	1.17					
FL5	Male	136	3.52	1.14	0.01	0.91	3.78	501.00	<.001
	Female	367	3.07	1.20					
FL6	Male	136	3.58	1.04	4.09	0.04	3.43	266.16	<.001
	Female	367	3.21	1.15					
FL7	Male	136	3.43	1.09	3.02	0.08	1.16	501.00	0.25
	Female	367	3.30	1.20					
FL8	Male	136	2.85	1.17	2.50	0.12	1.52	501.00	0.13
	Female	367	2.66	1.25					
FL9	Male	136	3.31	1.26	2.63	0.11	1.90	501.00	0.06
	Female	367	3.08	1.18					
FL10	Male	136	3.44	1.16	0.55	0.46	0.68	501.00	0.50
	Female	367	3.36	1.20					
Overall FL	Male	136	3.39	0.87	1.87	0.17	2.04	501.00	0.04
	Female	367	3.20	0.97					

Relationships Among Mathematics Anxiety, *Flow* Experiences, and Mathematics Self-Efficacy

The fourth research question was: To what extent was mathematics anxiety related to *flow* theory characteristics and mathematics self-efficacy? In the previous chapter, the research model proposed that *flow* experience impacts math- self-efficacy and mathematics anxiety, and math-self-efficacy impacts mathematics anxiety. The study used structural equation modelling technique (SEM) with the help of AMOS software to test the research model. SEM is a powerful multivariate technique used widely to test latent and observed variables together (Hair, 2009; Hair et al., 2017; Hair et al., 2019; Kline, 2011).

Measurement Model

This study used Anderson and Gerbing's (1988) two-step approach for testing the SEM model. Under this approach, a researcher designs a measurement model and tests its psychometric properties (e.g., convergent and discriminant validity), using CFA. If there are no validity issues in the measurement model, the next step is to convert the measurement model into an SEM model and test it. Following this approach, the researcher drew and tested a measurement model in AMOS. Figure 12 shows the initial measurement model. Before checking the convergent and discriminant validity, assessing the goodness of fit for the model was critical. The criteria for the goodness of fit were suggested by Hair et al. (2006), Hooper et al. (2008), Hu and Bentler (1999), and Kenny (2012) who stated that the Normed Chi-Square (Chi-square [CMIN]/Degree of Freedom [DF]) should be less than 3, the Comparative Fit Index (CFI) should be greater than 0.95, the Goodness of Fit Index (GFI) should be greater than 0.90, the Adjusted Goodness of

Fit Index (AGFI) should be greater than 0.80, the Standardized Root Mean Square Residual (SRMSR) should be less than 0.09, and the Root Mean Square Error of Approximation (RMSEA) should be less than 0.05 for a good model fit. Testing of the measurement model by these criteria demonstrated good fit, with fit indices of Chi-square = 439.911, *DF* = 149, Normed Chi-square = 2.952, CFI = 0.962, GFI = 0.911, AGFI = 0.887, SRMR = 0.050, and RMSEA = 0.062. All fit indices met the thresholds; therefore, the measurement model could be tested for composite reliability and convergent and discriminant validity. Figure 13 shows the original measurement model. Table 17 shows the model fit indices, their thresholds, and model fit indices achieved for the measurement model in a summarized form.

Figure 12

Measurement Model I

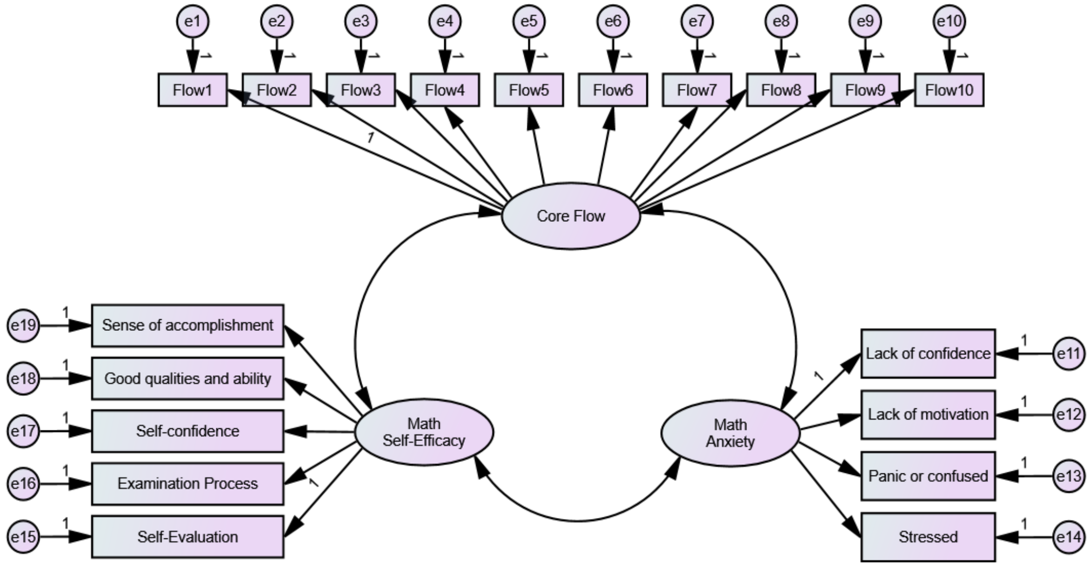


Figure 13

Measurement Model II

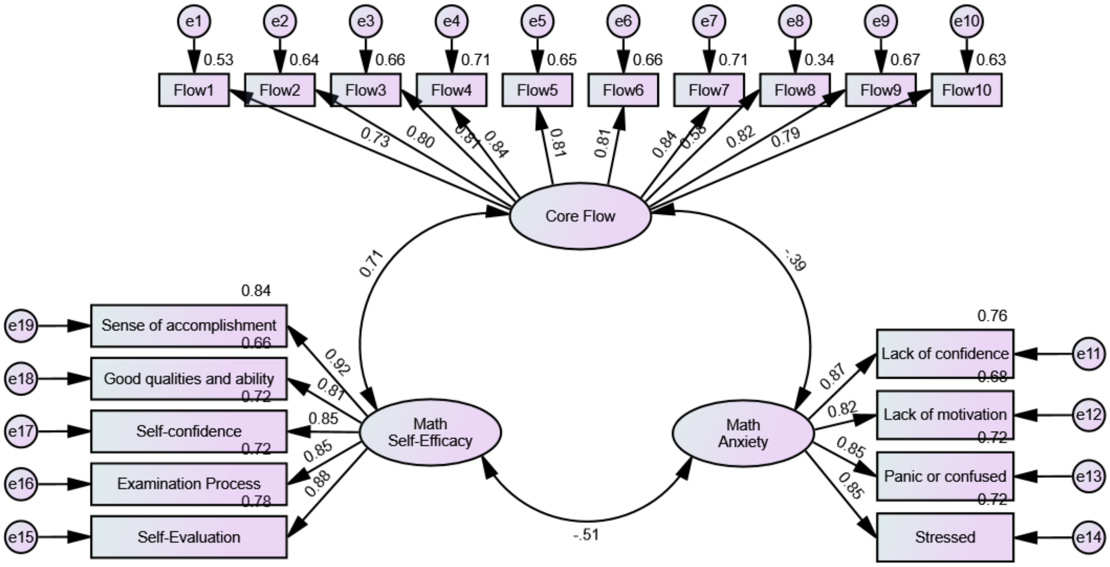


Table 17

Model Fit Indices, Thresholds Achieved for the Measurement Model

Measures	Threshold	Measurement Model
Normed Chi-Square	< 3 Good; < 5 sometimes permissible	2.952
CFI	> 0.95 Great; > 0.90 traditional; > 0.80 sometimes permissible	0.962
GFI	> 0.90	0.911
AGFI	> 0.80	0.887
SRMR	< 0.09	0.050
RMSEA	< 0.05; 0.05 – 0.10 moderate	0.062

Guidelines provided by Hair et al. (2006), Hancock and Mueller (2001), and Malhotra and Dash (2011) were used to calculate and assess the composite reliability (CR) and convergent and discriminant validity. As per these authors, CR is defined as the degree to which the group of constructs represented in the model relates to a certain latent variable. A good construct should have a 0.70 or higher CR value, showing that all the construct items measure the same construct consistently. This was true for these study results. As Table 18 shows, all factor loading values for all the constructs were greater than 0.70. As Table 19 shows, all CR values for all the constructs were greater than 0.70.

Table 18

Factor Loadings for Flow Experience, Mathematics Self-Efficacy, and Mathematics Anxiety

Variables	No. of Indicators	Factor Loadings
Flow Experience	10	0.727, 0.802, 0.811, 0.840, 0.806, 0.814, 0.843, 0.584, 0.820, 0.794
Mathematics Self-Efficacy	5	0.884, 0.849, 0.849, 0.815, 0.916
Mathematics Anxiety	4	0.873, 0.822, 0.846, 0.848

Table 19

Psychometric Properties for Flow Experience, Mathematics Self-Efficacy, and Mathematics Anxiety

	CR	AVE	MSV	MaxH	*Flow* Experience	Math Self-Efficacy	Mathematics Anxiety
Flow Experience	0.942	0.620	0.503	0.947	0.788		
Math Self-Efficacy	0.936	0.745	0.503	0.941	0.709	0.863	
Mathematics Anxiety	0.911	0.718	0.257	0.912	-0.388	-0.507	0.847

Convergent validity assesses the degree to which different measures of the same construct are correlated. On the other hand, discriminant validity focuses on determining the lack of relationships between constructs that theoretically should not be related to one another. Hair et al. (2006), Hancock and Mueller (2001), and Malhotra and Dash (2011) proposed criteria to test the convergent and discriminant validity of a model. Before explaining the criteria to test the convergent and discriminant validity, the terms average variance extracted (AVE), maximal reliability (MaxH), and maximum shared variance (MSV) must be understood. The AVE measured the amount of variance captured by a construct concerning the amount of variance due to measurement error. In comparison, MaxH was another form of reliability, like CR, to check that the constructs represented in the model related to a given latent variable; MSV showed the maximum variance shared by two constructs. To establish the convergent validity of a model, the CR of the factors should be greater than 0.70, the AVE should be greater than 0.50, the MaxH should be greater than 0.80, and factor loadings should be greater than 0.7. Additionally, to establish the discriminant validity of a model, factor MSVs should be less than the AVE, and the square root of AVE should be greater than the inter-construct correlations. Tables 18 and 19 show measured values of factor loadings, AVE, square root of AVE, MaxH, MSV, CR, and correlations between the constructs (i.e., psychometric properties) to assess the measurement model's validity. These tables clearly show that CR is greater than 0.70, AVE is greater than 0.50, MaxH is greater than 0.80, and factor loadings are greater than 0.70. Thus, there were no convergent validity issues in this measurement model; all the items and dimensions converged with their related constructs. These tables showed that MSV was less than AVE, and the square root of AVE (i.e., shown on the diagonal of the table in **bold** form) was greater than the inter-construct correlations. The findings showed no discriminant validity issues in this measurement model; therefore, all the constructs were unique and did not overlap with each other. The measurement model could be converted to a structural model to test relationships among factors.

Structural Equation Model

After performing CFA and checking the convergent and discriminant validity, the measurement model was converted into a structural model, and the proposed relationships were tested. Figure 14 (p. 117) shows the structural model. Before assessing the proposed relationship, the structural model GFIs were tested as the measurement model indices were. The fit indices of the structural model were Chi-square = 439.911, *DF* = 149, Normed Chi-square = 2.952, CFI = 0.962, GFI = 0.911, AGFI = 0.887, SRMR = 0.050, RMSEA = 0.062, and PCLOSE = 0.001. These GFIs of the structural model are the same as the measurement model. It is expected because this study just replaced covariant relationships with direct relationships during the conversion of the measurement model to the structural model; no new relationship is included or excluded. All the GFIs met the model fitness criteria; therefore, the structural model could be trusted to assess the proposed relationships. The model estimates showed that *flow* experience had a strong, positive, and significant impact on self-efficacy (Unstandardized β = 0.727, Standardized β = 0.709, p < 0.001). Thus, student *flow* experiences enhanced their mathematics self-efficacy greatly. However, *flow* experience had a very weak, negative, and insignificant impact on mathematics anxiety (Unstandardized β = -0.058, Standardized β = -0.058, p > 0.1). It showed a very little indirect relationship between *flow* experience and mathematics anxiety. In addition, self-efficacy had a moderate to a strong, negative, and significant impact on mathematics anxiety (Unstandardized β = -0.455 Standardized β = -0.466, p < 0.001), showing that student mathematics self-efficacy decreases their mathematics anxiety. Table 20 summarizes the regression weights.

Table 20

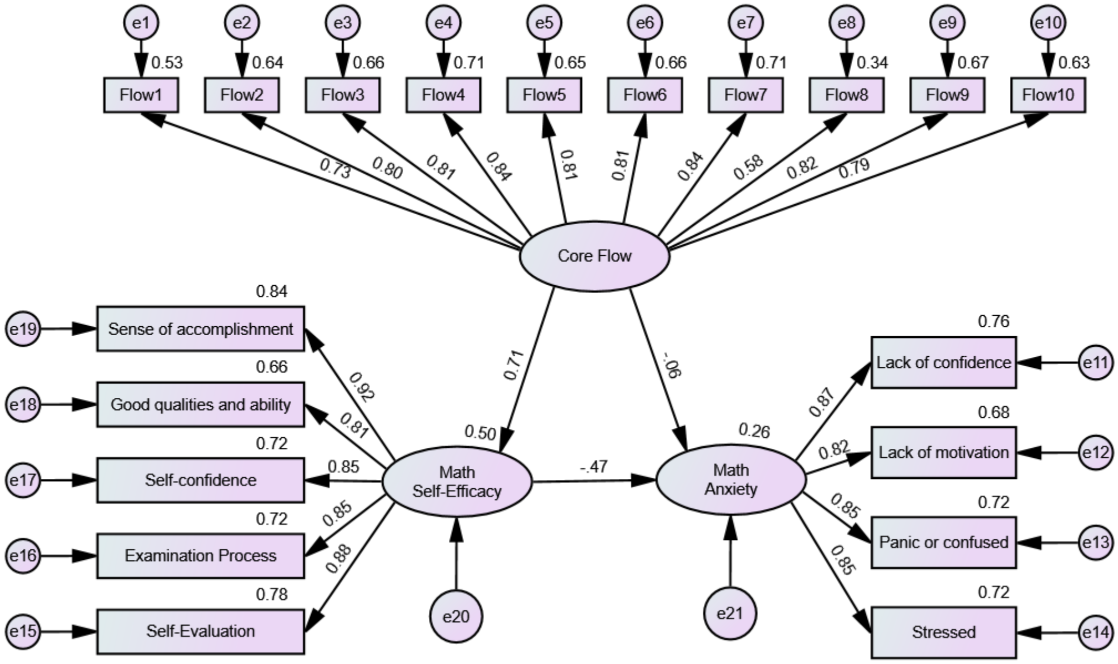
Regression Weights for Relationships Among Flow Experience, Mathematics Self-Efficacy, and Mathematics Anxiety

Relationships	Unstandardized β	Standardized β	*Standard Error*	Critical Ratio	*P*
Flow Experience → Mathematics Self-Efficacy	0.727	0.709	0.050	14.578	***
Mathematics Self-Efficacy → Mathematics Anxiety	-0.455	-0.466	0.064	-7.131	***
Flow Experience → Mathematics Anxiety	-0.058	-0.058	0.064	-0.907	ns

Note: ns = not significant, *** = p <0.001.

Figure 14

Structural Model



After assessing the direct impact of *flow* experience on math self-efficacy and mathematics anxiety and of math self-efficacy on mathematics anxiety, summarized in Table 21 (p. 119), further evaluation of the model took place, (a) whether *flow* experience impacted mathematics anxiety via math self-efficacy (i.e., math self-efficacy mediated between *flow* experience and mathematics anxiety), and (b) whether math self-efficacy fully or partially mediated the relationship, as displayed in Table 22 (p. 119). The mediation analysis guidelines provided by Baron and Kenny (1986), Hayes (2008), and Kenny (2014) were used. Per Kenny (2014), two types of meditation exist (i.e., partial and full meditation). He presented a four-step approach to understanding these concepts.

Mediation was called partial mediation (a) if the independent variable had a significant effect on both the dependent variable and the mediator variable, (b) if the mediator variable had a significant effect on the dependent variable, and (c) the independent variable also had a significant indirect effect on the dependent variable via the mediator variable. On the other hand, if the effect of the independent variable on the dependent variable when including the mediator variable in the model becomes zero, a full mediation exists (i.e., the mediator variable fully mediates between the independent variable and the dependent variable). The SEM analysis was rerun with a bias-corrected bootstrapping method and performed bootstrapping 5000 times at a 90% confidence interval to test the mediating role of self-efficacy between *flow* experience and mathematics anxiety. It is common practice to use a confidence level of 90% instead of the more traditional 95% level while doing SEM analysis. It is because bootstrapping produces more accurate and reliable results than traditional methods. Tables 21 and 22 show the calculated direct and indirect effects. The results show that *flow* experience had a significant direct effect on math self-efficacy (Unstandardized $\beta = 0.727$, Standardized $\beta = 0.709$, $p < 0.01$) and an insignificant direct effect on mathematics anxiety (Unstandardized $\beta = -0.058$, Standardized $\beta = -0.058$, $p > 0.1$). Math self-efficacy significantly affected mathematics anxiety (Unstandardized $\beta = -0.455$, Standardized $\beta = -0.466$, $p < 0.01$). In addition, *flow* experience had a moderate but significant negative indirect effect on mathematics anxiety via math self-efficacy (Unstandardized $\beta = -0.331$, Standardized $\beta = -0.330$, $p < 0.05$). The significance of all the effects except the direct effect between *flow* experience and mathematics anxiety showed that math self-efficacy fully mediates the relationship between *flow* experience and math anxiety.

Table 21

Direct Effects Among Flow Experience, Mathematics Self-Efficacy, and Mathematics Anxiety

Relationships	Unstandardized β	Standardized β	*P*
Flow Experience → Mathematics Self-Efficacy	0.727	0.709	**
Mathematics Self-Efficacy → Mathematics Anxiety	-0.455	-0.466	**
Flow Experience → Mathematics Anxiety	-0.058	-0.058	ns

Note: ns = not significant, ** $p < 0.01$.

Table 22

Indirect Effects Among Flow Experience, Mathematics Self-Efficacy, and Mathematics Anxiety

Relationships	Unstandardized β	Standardized β	*P*	BCCI	
				Lower	Upper
Flow Experience → Mathematics Self-Efficacy → Mathematics Anxiety	-0.331	-0.330	**	-0.445	-0.239

Note: ** $p < 0.01$.

Summary of Findings

This study aimed to investigate the relationships among *flow* experience, math self-efficacy, and mathematics anxiety among international undergraduate students enrolled in developmental math courses and to explore the relationship between *flow* experience and mathematics self-efficacy on student mathematics anxiety. In this regard, four research questions were asked, and data was gathered accordingly. This chapter discussed the analysis, interpreted the collected data, and attempted to answer the research questions individually. Based on the results, this study found that the sample of international undergraduate students felt low to moderate levels of both math self-efficacy and math anxiety while solving mathematics problems, in addition, the results confirmed that students also felt low to moderate levels of *flow* experience while solving mathematics problems.

Moreover, comparison analyses based on gender showed that female students felt slightly more of a low to moderate level of mathematics anxiety than male students; this difference was significant. However, male students experienced significantly lower to moderate levels of *flow* than female students while solving mathematical problems. The female student perspective had an inverse proportionate relation to the male student perspective on mathematics anxiety and *flow* experience. For example, female students felt more of a low to moderate level of mathematics anxiety than male students. Still, at the same time, female students experienced less of a low to moderate level of *flow* than males while solving mathematical problems.

Furthermore, student *flow* experiences strongly impacted and increased their mathematics self-efficacy. Similarly, mathematics anxiety decreased when students felt more mathematics self-efficacy. However, mathematics self-efficacy played a more substantial role in reducing mathematics anxiety than did *flow* experiences. Additionally, the results showed that *flow* experience negatively influences math anxiety (i.e., the higher the *flow* experience, the less the anxiety). However, in the presence of math self-efficacy, the effect of *flow* experience becomes insignificant (i.e., math self-efficacy fully mediates the influence of *flow* experience on math anxiety).

CHAPTER 5

SUMMARY, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This chapter summarizes the current study about the relationships between *flow*, mathematics self-efficacy, and mathematics anxiety among international undergraduate students in the United States. The summary discusses the study purpose, research problem, literature review, significance of the study, and brief review of the hypotheses and methodology. The results of the study are reported with the limitations impacting the study. Finally, there are implications and recommendations for future research.

Summary

Research Problem

Despite several research studies explaining math anxiety and academic performance, the research on math anxiety, mathematics self-efficacy, and *flow* experience in developmental math classes, specifically among international undergraduate students, was still insufficient. In the past, researchers investigated mathematics self-efficacy and math anxiety to understand the risk factors of poor achievement in students enrolled in developmental math courses (Paechter et al., 2017). However, the number of students failing developmental mathematics doubled over a five-year period, raising concerns about how this situation got out of hand (Everingham et al., 2017). In response to these concerns, this study addressed connections among math anxiety, math self-efficacy, and *flow* experience. The goal was to understand the psychological state of these students which may help educationists create strategies to improve student academic performance and decrease their math anxiety.

Purpose of the Study

The purpose of this study was to investigate the relationships between *flow*, mathematics self-efficacy, and mathematics anxiety among international undergraduate students enrolled in developmental math classes. A hypothesized model was created and used to comprehend the relationships among these variables. In addressing the study purpose, a survey was used to collect data and the data was analyzed for comparison with the hypothesized model. Researchers in the past have investigated mathematics self-efficacy and math anxiety to understand the risk factors of poor math achievement (Paechter et al., 2017). However, the number of students failing developmental mathematics doubled over a five-year period, raising concerns of how this situation developed (Everingham et al., 2017). Therefore, the purposes of this quantitative correlational study were to investigate (a) the gender differences in math anxiety and *flow* experience, (b) the relationship between academic *flow* and mathematics anxiety, (c) the relationship between mathematics self-efficacy and mathematics anxiety, (d) the relationship between academic *flow* and mathematics self-efficacy, and (e) the role of mathematics self-efficacy as a mediator between *flow* and mathematics anxiety. In addressing these objectives, the study reduced the research gap and improved understanding of factors contributing to the increasing number of learners who fail developmental mathematics courses, particularly among international students in the United States.

Significance of the Study

The major significance of this study was its uniqueness in addressing these three variables (i.e., mathematics anxiety, *flow* experience, and mathematics self-efficacy) among international undergraduate students in the United States and provided information about the impact of *flow* and mathematics self-efficacy on reducing math anxiety among these students. The results of this research can help to improve student math self-efficacy for enhanced academic performance and be helpful for educationists in informing teaching strategies that improve mathematics self-efficacy among undergraduate students. Finally, these results were significant in forming the foundation for future research on ways for reducing academic achievement gaps between high and low math achievers due to their anxiety.

Research Design

This study used a quantitative approach in an effort to quantify the relationships among variables. For data collection a demographic survey, the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (May, 2009), and the Core *Flow* Scale (Martin & Jackson, 2008) were used. Inferential statistics were used to analyze the data collected, which was further analyzed through SEM analysis.

Theoretical and Conceptual Framework

Flow theory was the framework for the current study. Csikszentmihalyi (1990) defined *flow* as a state of mental absorption where an individual's ability was matched to the current demand. He found that people experienced the feeling of being "in control" and were highly focused with full awareness of their actions when they experienced *flow*. This study explored the relationships among *flow* experience and its impact on mathematics self-efficacy and reduced mathematics anxiety among undergraduate international students enrolled in developmental math courses.

The framework provided a theoretical basis for explaining the relationships among *flow*, math self-efficacy, and math anxiety, demonstrating that math anxiety was a dependent variable influenced by both *flow* and math self-efficacy. During the *flow* experience, math anxiety decreases resulting in an increase in student math self-efficacy. When math self-efficacy increases, the higher confidence arising from math self-efficacy helps to reduce anxiety among students.

Limitations

The study faced some limitations ranging from the sample size to generalizability. A limited number of students was used for the study. Moreover, since the students were international, their math education varied. There was no information about their educational development especially math skills developed in their country, therefore that would be considered a limitation as well. A sample of 503 international undergraduate students was not representative of the entire international student population in the United States. Since the study was voluntary, the responses of participants could include deception which could impact the validity and reliability of the data collected. The results of this study relied on analysis of a non-probability sample or a convenience sample selected according to the researcher’s subjective judgment. This hindered generalization of results. Additionally, for testing gender differences, some assumptions were made before applying an independent sample t-test. These assumptions included a scale of measurement, random sampling, normality of data distribution, adequacy of sample size, and equality of variance in standard deviation.

A review of the literature provided details about math anxiety, math self-efficacy, and *flow* experience, and explored the relationships among them, creating a foundation for the study. To build a strong theoretical framework, an extensive literature review was conducted on mathematics anxiety; four causes of mathematics anxiety were identified (a) lack of motivation, (b) lack of self-confidence, (c) lack of mathematics self-efficacy, and (d) panic and stress. Factors of mathematics self-efficacy were identified and discussed, including self-confidence, sense of accomplishment, qualities and abilities self-evaluation, and examination process.

Flow is composed of nine dimensions: (a) challenge-skill balance, (b) immediate feedback, (c) clear goals, (d) deep concentration, (e) complete sense of control, (f) action-awareness merging, (g) autotelic experience, (h) freedom from being time-bound, and (i) elimination of self-consciousness. These categories of *flow* dimensions were based on Csikszentmihalyi's Nine Components (1990). The studies reviewed referred explicitly or implicitly to the relationship between math self-efficacy and math anxiety, and the relationships between *flow* experience, math self-efficacy, and mathematics anxiety.

Theoretical Framework

The current study was based largely on *flow* theory, which focused on autotelic or intrinsically unintended practices (Csikszentmihalyi et al., 2020) and was comprised of the nine elements mentioned above.

Themes and Related Variables

Math anxiety was defined as an anxious state experienced by students during mathematics classes or when doing math homework. As a result of this anxiety, students tend to fail to understand and resolve the math problems presented to them. Math anxiety could be caused by limited classroom support, limited experience in mathematics, and low self-confidence. Fave and Kocjan (2020) stated that mathematics anxiety had an inverse relationship with positive perceptions toward mathematics, which means that if students had self-confidence and a positive attitude towards mathematics, they would experience lower math anxiety (Conradty et al., 2020).

The variable math self-efficacy was defined by Pekrun et al. (2017) as “an assessment of a person’s self-confidence in his abilities to understand and successfully perform to resolve mathematical problems” (p. 262). Low math self-efficacy combined with high math anxiety resulted in failure of students to find a solution to the math problem presented to them; whereas high math self-efficacy boosted confidence and reduced levels of anxiety, which ultimately helped students find a solution to the problem. Previous researchers found that instructor failure to address (a) the individual needs of students, (b) the learning styles of students, and (c) the classroom environment played a role in developing math self-efficacy among students. According to Skaalvik (2018), instructors failing to guide students about solving complicated problems and failing to provide feedback also caused low math self-efficacy. Some strategies have been suggested to address self-efficacy in mathematics. Per Tuominen et al. (2020), giving feedback to students was an important strategy, providing an instant assessment of student performance (Jamieson et al., 2021). Keeping a balance of hard and soft skills and giving assignments to groups of students with different strengths were additional strategies suggested for increasing mathematics self-efficacy.

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

Previous studies established a relationship between self-efficacy and *flow*. Yildizli (2020) found that the perception of mastery experience was the key to developing self-efficacy among students (Subaşı, 2020). Rawlings et al. (2020) discovered that students with a high level of internal locus of control were almost three times more likely to experience a *flow* state. Another study found that student experiences while solving mathematical problems impacted their self-efficacy (Conradty et al., 2020). According to Hong et al. (2017), students with low self-efficacy displayed reduced academic performance.

Flow was defined as the state where students were at the height of their academic performance and felt self-efficacy. As a result of math self-efficacy and *flow* experience, math anxiety decreased. As mentioned above, the *flow* was defined with nine elements that facilitated the experience. According to Csikszentmihalyi (1990), during *flow*, time seemed either stretched or shortened. Minutes seemed like hours and hours like minutes to students (Csikszentmihalyi, 1990). Other studies showed a direct relationship between *flow* and internal locus of control (Taylor et al., 2006).

Gender Differences in *Flow* Experience Among Undergraduate International Students

Flow experiences tended to vary across gender (Habe et al., 2019; Habe & Tement, 2016) There was a lack of studies discussing *flow* experience among international students and there were extremely few studies addressing *flow* experiences in the light of gender differences.

In explaining the relationship between leisure involvement and *flow* experiences during extreme activities, Chang (2017) found that leisure involvement had a stronger effect on the *flow* experience of males compared to females, establishing that self-expression and lifestyle centrality influenced *flow* experience in females. Yang and Quadir (2018) established that female students were likely to report higher gaming *flow* compared to their male counterparts. These findings indicated that there could be a difference in *flow* experience between the genders; there was a need for more studies to explore this difference.

Gender differences in mathematics performance were well established (Felson & Trudeau, 1991; Rodríguez et al., 2020), but gender differences in experiencing *flow* involved contradictions. On the one side, Bonaiuto et al. (2016) argued that *flow* was reported regardless of gender; Csikszentmihalyi (2009) declared that "*flow* is reported in essentially the same words by men and women" (p. 4). Tse et al. (2022) reported marginal relationships between age and *flow* experience with no significant moderating effects of gender, race, or education. From the same perspective, most studies demonstrated no differences in *flow* experience between males and females (Bonaiuto et al., 2016; Kee & Wang, 2008; Russell, 2001). As argued by Bryce and Haworth (2002), the experience of *flow* occurred more at work than in leisure; gender differences appeared in activities causing an increase in *flow*. Other studies showed differences in *flow* experience related to gender (Habe et al., 2019; Habe & Tement, 2016). A higher score of *flow* was reported for male athletes than females (Habe et al., 2019; Murcia et al., 2008). Gender differences in *flow* experience were expected in the current study because women are inclined to experience positive emotional states in a more concentrated and intense way than men (Fujita et al., 1991). Therefore, there was a need for further investigation to explore differences between the genders.

Methodology

To achieve the objectives, the current study utilized a quantitative approach. A demographics survey, the Core *Flow* Scale, and the Mathematics Self-efficacy and Anxiety Questionnaire (MSEAQ) were used to measure (a) core *flow* experience, (b) math self-efficacy, and (c) mathematics anxiety in participants. Inferential statistics and SEM analyses were conducted on the data collected.

Summary of Demographic Data

Valid responses included 503 questionnaires from undergraduate international students. The majority (451) were 18-24 years old, while only 52 were 25-34 years old. More than two thirds of the participants were female (367) and less than one-third (136) were male. Participants were from various ethnic/racial backgrounds: Hispanic or Latino ethnic (30.80%), multiracial (23.90%), Asian (18.70%), Black/Not African American (7.80%), Native Hawaiian or Other Pacific Islander (2.20%), and other (16.70%). More than 50% of the participants were from California, New York, Texas, Florida, Georgia, Illinois, and New Jersey.

Summary of Findings

There was a moderate feeling of stress (M = 3.22, SD = 0.98), confusion (M = 3.21, SD = 0.90), lack of motivation (M = 3.06, SD = 1.02), and lack of confidence (M = 3.00, SD = 0.95) among participants while solving mathematics problems.

Second, the descriptive statistics results from the Core *Flow* Scale indicated that, although international students' responses tended to be neutral (*M* = 3.25, *SD* = 0.95) participants still reported individual differences in experiencing each of the *flow* characteristics. Further, all *flow* dimensions recorded a moderate level of *flow* experience, except for Item 8 ("nothing else matters") which represents the freedom from being in a time-bound dimension. However, results indicated some of the *flow* characteristics were experienced more than others. For example, the dimensions of challenge skill balance (*M* = 3.50, *SD* = 1.14) and clear goals (*M* = 3.48, *SD* = 1.11) were most experienced characteristics in which 56.3% of participants agreed/ strongly agreed that their skills match the required task and 56.5 % of the participants agreed/ strongly agreed that they felt that the goals of the task were clear. On the other hand, the dimensions of time distortion (*M* = 2.72, *SD* = 1.23) and feedback (*M* = 3.15, *SD* = 1.18) were experienced less in which 28.2% of the participants agreed/ strongly agreed that they did not lose tracking of time and 41.6 % of the participants agreed/strongly agreed that they did not receive immediate feedback while they were working on the task.

Third, the application of an independent sample t-test on math anxiety showed that females (*M* = 3.16, *SD* = 0.89) felt more mathematics anxiety than males (*M* = 2.99, *SD* = 0.78) while solving mathematics problems; this difference was statistically significant (*t* (501) = -1.95, *p* = 0.05) with a large effect size (*d* = 0.86). The application of an independent sample t-test on *flow* experience data showed that males (*M* = 3.39, *SD* = 0.87) experienced more *flow* experience than females (*M* = 3.20, *SD* = 0.97) while solving mathematical problems; this difference was statistically significant, *t* (501) = 2.04, *p* = 0.04, with a large effect size (*d* = 0.95).

Fourth, the results of tested relationships were (a) *flow* experience had a strong, positive, and significant impact on self-efficacy (Unstandardized β = 0.727, Standardized β = 0.709, $p < 0.001$), (b) self-efficacy had a moderate to strong, negative, and significant impact on mathematics anxiety (Unstandardized β = -0.455, Standardized β = -0.466, $p < 0.001$), (c) *flow* experience was negatively related to math anxiety (r = -0.39) (d) *flow* experience had a weak, negative, and insignificant impact on mathematics anxiety (Unstandardized β = -0.058 Standardized β = -0.058, $p > 0.1$), and (e) *flow* experience had a moderate but significant negative indirect effect on mathematics anxiety via self-efficacy (Unstandardized β = -0.081, Standardized β = -0.078, $p < 0.05$).

Discussion

The results of the study demonstrated the levels of math anxiety, math self-efficacy and *flow* experience of undergraduate international students enrolled in developmental math courses in the United States. No single study was found to address these variables for this student population. The results showed four relationships: (a) the influence of mathematics self-efficacy on math anxiety, (b) the influence of *flow* experience on math anxiety, and (c) the influence of *flow* experience on mathematics self-efficacy, and (d) the influence of *flow* experience on math anxiety through math self-efficacy as a mediator.

Results indicated that most international undergraduate students in the sample felt anxious while solving mathematics problems (*M* = 3.18, *SD* = 0.87), and most of them have moderate levels of both math self-efficacy (*M* = 3.23, *SD* = 0.90) and *flow* (*M* = 3.25, *SD* = 0.95). Additionally, females (*M* = 3.16, *SD* = 0.89) felt more mathematics anxiety than males (*M* = 2.99, *SD* = 0.78) while solving mathematics problems.

Moreover, when students had higher mathematics self-efficacy, their mathematics anxiety decreased. *Flow* experience negatively affected math anxiety through self-efficacy as a mediator. *Flow* experience affected self-efficacy positively.

Math anxiety was still an unresolved problem and a negative experience affecting adult lives and career choices. Although some studies documented factors influencing mathematics anxiety, such as *flow* experience and self-efficacy, at the college level (Engeser & Rheinberg, 2008; Golnabi, 2017; Radu & Seifert, 2011) no single study was found to address these three variables within undergraduate international students. The results replied to the current study's research questions sufficiently in terms of the level of math anxiety, *flow* experience, and math self-efficacy among international undergraduate students, demonstrating the effect of gender on math anxiety and *flow* experience, and illustrating the relationships among the three variables.

Overall Math Anxiety Among Participants

In the current study, most of the international undergraduate students sampled sometimes felt anxious while solving mathematics problems. The prevalence of math anxiety in the United States has been underlined throughout the literature. Ramirez et al. (2018) stated that almost 80% of U.S. college students experienced math anxiety when performing mathematics problems, which affected their academic performance and created physiological disturbances. Beilock (2019) revealed that most students in the United States (93%) experienced a level of math anxiety in math classes. Moreover, the top-performing students in math in the United States in general were ranked lower than average when compared to other countries (Richards, 2020). Math anxiety has long been perceived as a key player for low achievement in math (Barroso et al., 2021), avoidance of math-related tasks, increased worries about math failure, and an upsurge in cortisol response when performing math tasks (Ramirez et al., 2013). Therefore, understanding the prevalence and level of math anxiety was important for the development of mathematics teaching processes. In addition, the United States had 914,095 international students during the 2020/21 academic year (Duffin, 2021), but usually the voices of international students are left out of conversations about their experience as students (Heng, 2019); thus, studying math anxiety in this group was important in efforts to boost student success.

The overall mathematics anxiety recorded (*M* = 3.12, *SD* = 0.87), shows a moderate level of math anxiety. This result shows that the participants sometimes felt anxious while solving mathematics problems. Similarly, all the math anxiety dimensions revealed a similar pattern. The participants sometimes felt stressed (*M* = 3.22, *SD* = 0.98), confused (*M* = 3.21, *SD* = 0.90), less motivated (*M* = 3.06, *SD* = 1.02), and less confident (*M* = 3.00, *SD* = 0.95) while solving mathematics problems. Thus, participants sometimes experience a lack of self-confidence, lack of motivation, panic and stress when solving math problems. Lack of self-confidence was found to be a source of math anxiety and low performance by Blotnicky et al. (2018), while strong self-confidence in handling complex mathematical problems was a cause of improved performance and a positive attitude towards mathematics as described by Tuominen et al. (2020). Lack of motivation was also found by these researchers to be a source of math anxiety. Sutter-Brandenberger et al. (2018) claimed that the theories of (a) control-value of achievement and (b) self-determination perceived self-determined motivation to be influencers of negative emotions such as anxiety. Estonanto and Dio (2019) found that lack of motivation was a cause of math anxiety. One cognitive behavior therapy study found that using motivational language was helpful in overcoming anxiety disorder; participants achieved 35% improvement (Poulin et al., 2019).

Fear or panic has been reported as a source of math anxiety. Mutodi and Ngirande (2014) reported that mathematics anxiety resulted from learner fear of possible failure or of handling complex mathematical problems. Siebers (2015) demonstrated that when students experienced a fear of looking unintelligent in front of their classmates, they could develop negative experiences. Estonanto and Dio (2019) identified fear of failure as a root cause of anxiety when solving math problems.

In the literature, all types of stress or pressure, from parents, teachers, or time-restricted tests were reported as predictors of math anxiety. Jain and Dowson (2009) contended that math anxiety may be triggered among students when there is persistent use of drills and routines in math classes. Finlayson (2014) observed that excessive reliance on time-pressured tests, drills, and graded performance caused student anxiety. Estonanto and Dio (2019) identified pressure from parents and peers as reasons for student anxiety toward math. Accordingly, understanding the roles of lack of self-confidence, lack of motivation, and panic and stress as causes of math anxiety could be helpful in controlling math anxiety during math classes. Teachers need to use motivational language and focus on the learning output, not just on completing all the curriculum topics. These strategies could help students gain more confidence towards mathematics.

The Level of *Flow* Experience

The current study measured the overall *flow* experience among international undergraduate students while doing math problems. Participants experienced *flow* while solving mathematics problems moderately (*M* = 3.25, *SD* = 0.95). referring to the Likert scale scores, if a score of 3 was obtained, it meant "neutral," that is, a status of "not fully experiencing *flow*" and at the same time "not totally lacking *flow*." Thus, it is an in-between status. Therefore, mean of 3.25 showed that participants had a status of experiencing *flow* at a higher rate than feeling a lack of *flow*.

Remarkably, each *flow* experience item exceeded 3 except for Item 8, freedom from being time-bound, which was less than 3. The students reported differences in experiencing each of the *flow* characteristics. The balance of challenge and skills (a pre-condition of *flow)* was the strongest characteristic of *flow* experienced. This is because Item 1, "I am totally involved " which represents the challenge-skill balance dimension showed the highest mean (*M* = 3.50, *SD* = 1.14) When there is a balance between skills and the challenges of a task, participants pass the neutral state and start experiencing more *flow* while solving math problems. Those who agreed and strongly agreed to Item 1 represent between 41% to 57% of participants. The next strongest *flow* characteristic is clear goals (a pre-condition of *flow*) which is indicated by Item 3 and Item 10 with a mean of (*M* = 3.48, and *M* = 3.38) respectively.

The least influential *flow* characteristic is the freedom from being time-bound. Item 8 "It feels like 'nothing else matters'" representing the freedom from being time-bound dimension (a *flow* indicator), showed the smallest mean (*M* = 2.72, *SD* = 1.23). More than a quarter of the participants (28.2 %) agreed and strongly agreed with Item 8.

In fact, when students are interested in, concentrated, and passionate about doing a math activity, they experienced *flow* (Csikszentmihalyi & Csikszentmihalyi, 1992). *Flow* experience has been researched for some time, and has been expressed by statements such as "I've been in a *flow*" or "I've been in the channel" (Barthelmäs & Keller, 2021). Understanding the overall level of *flow* experience is a significant aspect of math learning. The role of *flow* has been described differently by different researchers. Experiencing *flow* permits students to open themselves to the received information and understand the underlying math activity (Csikszentmihalyi & Larson, 2014). Experiencing *flow* also permits students to be actively involved in math activities, making them unconscious of the time or place, showing no lazy behavior (Yuwanto, 2018). In *flow*, students work perfectly and are highly engaged in the classroom (Ljubin-Golub et al., 2018). *Flow* experience helps student motivation in the classroom (Nurita et al., 2022).

The findings of the current study agreed with Abduljabbar's (2021) results, who found evidence that primary students in the United States experienced *flow* during online learning classes, in varied degrees. While this study found that most of the students experienced *flow* moderately in all nine dimensions, Abduljabbar identified six prominent dimensions (balance of skills and challenges, clear goals, immediate feedback, focused attention, a sense of control, and presence) as the most prevalent of the nine *flow* characteristics.

The Overall Level of Math Self-Efficacy

The overall level of math self-efficacy in this sample exceeded the average score at 3.25. Accordingly, most of the participating students had moderate levels of mathematics self-efficacy. Similarly, all of the subscale values of self-efficacy exceeded the average score for (a) sense of accomplishment, (b) ability, (c) self-confidence, (d) examination process, and (e) self-evaluation. These results were consistent with previous studies. Both Wu (2016) and Usher and Pajares (2009) reported that mathematics self-efficacy for students in the United States was above the average level. The findings of the current study were consistent with past studies on the influence of math self-efficacy on student math achievement.

Gender Differences in Math Anxiety

This study identified gender differences in terms of math anxiety and *flow* experience. Significant gender differences were observed; females felt more mathematics anxiety ($M = 3.16$, $SD = 0.89$) than males ($M = 2.99$, $SD = 0.78$), and females experienced less *flow* ($M = 3.20$, $SD = 0.97$) while solving complex mathematical problems when compared to males ($M = 3.39$, $SD = 0.87$). Very few studies have explored math anxiety and *flow* experience among international students; this number drops even further when exploring the existence of gender differences among undergraduate international students. The findings of this study established significant differences in *flow* experience between female and male undergraduate international students. The male students were likely to record higher *flow* experiences when compared to their female counterparts. These findings were consistent with other studies that established gender differences in *flow* experience.

The relationship between math anxiety and gender in the learning process has been discussed from two perspectives. First, many studies documented that females have greater levels of math anxiety than males. Devine et al. (2012) found that math anxiety was higher for females among British secondary school students. Rodríguez et al. (2020) noted that girls showed less positivity about mathematics and were less motivated by education as compared to males in the 5th and 6th grades; they reported the anxiety level in girls was higher as compared to boys. Xie et al. (2019) observed that females exceeded males in experiencing math anxiety. Second, only a few studies have rejected the existence of gender differences in math anxiety (Birgin et al., 2010; Erturan & Jansen, 2015; Frary & Ling, 1983). Gender differences can be explained psychologically. Women have highly sensitive senses and are good at the cognitive aspects of their surroundings. These characteristics make them sensitive to cultural distance. International female students displayed reduced cultural adaptation and social adjustments after going abroad; this influenced their academic performance at universities (Khan et al., 2020; Li et al., 2010; Mok et al., 2021).These differences may explain the gender differences found among international students in this study.

Gender Differences in *Flow* Experience

The current study showed significant gender differences, to the benefit of males. This result is consistent with Bryce and Haworth (2002), who noticed gender differences in *flow* experience. Studies by Habe et al. (2019) and Habe and Tement (2016) reported gender differences in *flow* experience; similarly, Habe et al. (2019) and Murcia et al. (2008) observed a higher score of *flow* in male athletes. Some scholars did not observe gender differences in *flow*. For example, Bonaiuto et al. (2016) and Tse et al. (2022)

argued that *flow* is reported at high levels regardless of gender and observed no significant moderating effect of gender. Similarly, Kee and Wang (2008), and Russell (2001) demonstrated no differences in *flow* experience between males and females.

The Proposed Model Relationships

In this study, SEM revealed several relationships. First, *flow* experience affected math self-efficacy positively. When international students felt involved and interested in a mathematical problem, their self-efficacy escalated and vice versa. This relationship has been discussed in the literature from two viewpoints. From the first perspective, Csikszentmihalyi et al. (2018) reported a strong relationship between locus of control (as an indication of *flow*) and self-efficacy. Similarly, Rawlings et al. (2020) found that individuals with a strong internal locus of control were three times more likely to enter the *flow* state and achieve challenge/skill balance, which supported their competencies over time. From the opposite perspective, Guo et al. (2020) found that self-efficacy has an influence on locus of control. Similarly, Inkinen et al. (2014) asserted that the availability of resources and capacity to fulfil a task allowed students to experience *flow*. In a comparative study, Martin et al. (2021) noted that those students with low anxiety and elevated self-efficacy experienced more *flow* than those with average anxiety and average self-efficacy.

Second, math self-efficacy had a significant negative effect on math anxiety. This suggests that math anxiety among international students can be reduced by supporting and increasing math self-efficacy, which can be experienced through a sense of accomplishment and mastery experience, self-confidence, self-evaluation, and examination process. This relationship had a remarkable body of knowledge in the literature, with varying results. Rozgonjuk et al. (2020) reported that math self-efficacy had a negative and very high influence on math anxiety. Huang et al. (2019) studied this bi-directional relationship and found that math self-efficacy was likely to reduce male math anxiety, but exerted no effect on female anxiety; they found that math anxiety significantly predicted math self-efficacy in both girls and boys. Similarly, Bandura et al. (1999) perceived anxiety as an affective or physiological source of self-efficacy and noted that increasing anxiety lowers self-efficacy. In addition, İbrahimoğlu (2018) observed a strong positive connection between anxiety and self-efficacy.

Finally, if we look at the bi-variant correlation between *flow* and math anxiety the path coefficient (standardized) between *flow* experience and math anxiety is significant at -.39 (p<.01). Therefore, if math-self efficacy is removed, *flow* influences math anxiety. So, the less engaged students are, the more math anxiety they have. The more engaged, the less their math anxiety level. Math self-efficacy fully mediates the influence of *flow* experience on math anxiety.

Thus, *flow* is inversely related to math anxiety. In the existence of math self-efficacy as a predictor of math anxiety, the effect of *flow* on math anxiety is negligible. However, *flow* experience had a moderate negative effect on math anxiety through math self-efficacy and thus, math self-efficacy fully mediated the relationship between *flow* experience and math anxiety. This result complied with what Martin et al. (2021) argued, pointing out that anxiety escalated as required resources and capacity exceeded one’s ability, which ultimately affected *flow* negatively. The results of the current study showed that *flow* had a minimal negative influence on math anxiety. Mao et al. (2020) reported that *flow* experience had a negative influence on anxiety. Mao et al. (2020) also found that academic self-efficacy represented a full mediator between *flow* and anxiety, as confirmed by the results of the current study as well.

Conclusions

The current study underlined the importance of *flow* theory when studying anxiety in mathematics classes and consideration of math self-efficacy as a mediator variable. A model was proposed, tested, and validated. The model evaluated (a) the direct relationship between *flow* experience and math anxiety, and (b) the relationships between math anxiety with math self-efficacy and between *flow* experience and math self-efficacy.

The empirical findings of the current study suggested that many international undergraduate students in the United States experience high levels of anxiety while solving mathematics problems in developmental math courses. Most students seemed to have a moderate level of math self-efficacy and *flow* experience while solving mathematics problems. Additionally, females felt more mathematics anxiety than males. Students with higher math self-efficacy had a lower level of mathematics anxiety. Math self-efficacy slightly influenced and decreased math anxiety. *Flow* experience negatively affected math anxiety through math self-efficacy as a mediator. *Flow* experience positively affected math self-efficacy.

Future studies could be conducted to assess these variables and these relationships; such studies should be based on a mixed methods design, collecting qualitative data along with quantitative data. Thus, researchers could gain more in-depth insights about the different dimensions of the anxiety problem and collect data about the best guidelines for overcoming math anxiety.

Practical Implications and Recommendations

The findings of the current study emphasized the substantial role of *flow* theory in explaining and alleviating math anxiety among international undergraduate students as well as the role of math self-efficacy in controlling anxiety during mathematics classes. Lack of self-confidence, lack of motivation, fear of failure and stress were all root causes of anxiety when solving math problems. Research demonstrated that all types of stress, from parents, teachers, or time-restricted tests, were predictors and major factors affecting math anxiety (Finlayson, 2014; Estonanto & Dio 2019). With these factors in mind, the current study could help establish a more effective teaching policy that increases *flow*, escalates math self-efficacy, and directs educators to focus on the learning process, not just on completing all time bounded curriculum topics. By underlining the causes of math anxiety, especially fear of failure, the current study could be helpful when developing interventions for enhancing student success and retention in science, technology, engineering, and mathematics (STEM) majors. From a practical perspective, this study represented a helpful guide to assist teachers in developing teaching strategies to help students experience lower anxiety during math lessons. For example, giving feedback to students was identified as an important strategy because it provided an instant assessment of student performance (Jamieson et al., 2020). Moreover, keeping a balance between hard and soft skills and giving assignments to groups of students with different strengths were strategies that could increase mathematics self-efficacy. From an academic perspective, the current study created a foundation for subsequent studies to investigate and collect more in-depth data about math anxiety, math self-efficacy, and *flow* experience variables.

In the educational context this study encouraged teachers and responsible persons to apply various strategies to decrease stress and panic, increase math self-efficacy, and promote *flow* experience to control math anxiety among international undergraduate students. Accordingly, the recommendations are as follows.

In-Class Strategies

Flow experience could be increased by establishing clear goals and maintaining a balance between challenge and skills (Rameli et al., 2018). Accordingly, it is recommended that teachers:

1. Establish clear goals to allow students to concentrate deeply, give them a sense of control by freeing them from the burden of failure, and free students from feeling time-bound. Clear goals are achievable through the availability of the required information to gather the required resources and time management to execute certain tasks.
2. Maintain a balance between introduced challenges and student skills. *Flow* experience and anxiety change with the strength of how new challenges match the level of available skills; therefore, teachers are encouraged to keep a balance between the introduced challenges and student skill levels. Moreover, keeping a balance between hard and soft skills and giving assignments to groups of students with different strengths are effective strategies for increasing mathematics self-efficacy (Jamieson et al., 2020).

Math self-efficacy has an influence on math anxiety; therefore, teachers can adopt methods to help students escalate their math self-efficacy. Accordingly, it is recommended that instructors do the following:

3. Provide feedback to students. Feedback is an important strategy for increasing self-efficacy (Jamieson et al., 2020). Immediate feedback has the potential to increase *flow*. Feedback is an essential tool instructors can use to support self-efficacy among learners. One benefit of using feedback in mathematics is to improve attitudes towards mathematics among learners, by addressing areas of weaknesses and letting them gain proficiency in mathematics. Feedback should include learner success strategies and the process of solving the problem. Support and feedback increase student positive beliefs in their ability to address mathematical problems over time, allowing them to change their attitude and perceptions towards mathematics.
4. Students can be formed into groups including strong and weak students. The stronger students can tutor the more vulnerable students, giving the weaker students more knowledge in how to solve mathematical problems (Prabawanto, 2018).

Use of Polling Devices to Support *Flow*

5. Teachers can be encouraged to use polling devices (Lebuda & Csikszentmihalyi, 2017) to support the role of *flow* in alleviating anxiety and improving learning experiences. Clickers, one of the most common forms of polling devices, are tiny, portable devices that resemble a TV remote control and transfer and record student replies to classroom questions. Aside from the most basic application of clickers, which is to ask students to reply to questions separately, clickers may also be used to promote friendly rivalry among peer groups. Clickers incorporate a "game approach" into regular

lecture sessions by introducing game features such as goals, rules, contests, timing, reward systems (for example, points), or feedback. Clickers can engage learners and boost student motivation and happiness while encouraging participation in class by utilizing the motivating pull of games (Buil et al., 2019). Wireless polling device systems are based on Wireless/WiFi, radio frequency, or infrared modalities. The most flexible technology uses the Wireless/WiFi systems, but they entail access to a wireless device. Wireless polling device systems are useful as tools for question types, confidentiality, question entry, and record keeping. They include test generation software such as TestGen and question banks. All types of questions from multiple choice, true/false, single numerical answer, single text answer, to open-ended are supported. For confidentiality options, they include student names, student ID numbers, or no identifier at all. Wireless polling devices include stand-alone software as well as applications compatible with a course management system such as Blackboard or WebCT; they can import/export grade book information through data base files or spreadsheets (Hall & Swart, 2007).

Positive Psychology Programs

6. High schools can host positive psychology programs to introduce positive education to students. Undergraduates can improve their preparation for collegiate work by building positive attitudes toward mathematics and all STEM content. Seligman and Csikszentmihalyi (2014) argued that “positive psychology at the subjective level is about valued subjective experiences:

well-being, contentment, and satisfaction (in the past); hope and optimism (for the future); and *flow* and happiness (in the present)" (p. 5).

Students with Exceptionalities

7. Lastly, students with exceptionalities need special attention. For example, students who have conditions related to anxiety, such as misophonia, show steady negative emotional responses to specific sounds and sometimes to visual triggers. Such students can develop anxiety, disgust, and/or anger, or other emotional responses. Thus, misophonia triggers anxiety. The emotional responses are in reaction to sounds such as chewing, breathing, mouth noises, nail picking, or speaking. Adolescence or childhood can be when development of misophonia occurs; misophonia exists in about 15% of people (Cecilione et al., 2022). Experiences of misophonia are worse when students are in a negative mood, which can be when solving a difficult math problem. Accordingly, positive psychology education programs may increase *flow* and treat misophonia. Educators should be alerted about misophonia. Existing treatments revolve around coping with the symptoms and rely upon transdiagnostic cognitive-behavioral approaches (Guetta et al., 2022). Accordingly, the researcher recommends raising awareness among educators about such issues and their consequences and setting up policies or strategies to ensure that educational classes, in particular primary and high schools, are free of such sounds that could trigger misophonia anxiety. Thus, we can provide a better educational environment for students with misophonia, attempting to avoid combining math anxiety and misophonia anxiety. Students

with other exceptionalities also require adaptations of the classroom to improve their learning environment. Apart from misophonia there are other disabilities that can contribute to math anxiety as well. Language disability is one such common condition where students struggle with vocabulary used in math which stops them from fully understand the problem and hence, they fail in solving the problem correctly. This in return causes the fear of failure and anxiety in them. Dyscalculia is another learning disability in which the students are unable to understand numbers and calculations presented in math problems. Orly (2010) conducted research to explore the relationship between math anxiety and dyscalculia. The results found that the fear or anxiety during math was strongly related to dyscalculia (Rubinsten, 2010).

Future Research

For future work, the current study could be extended by employing mixed-design research and collecting primary in-depth data both quantitively and qualitatively about the underlying variables. Research could evaluate empirically various strategies of increasing math self-efficacy and *flow* experience. Reliability would be increased in random sampling is used for future research. However, this research is affiliated with an educational setting and it is almost impossible to randomize the samples. The alternative future approach would be to create a control group. Having a control group is not only possible but a better approach to measure the results by comparing them with the experimental group.

Mathematics anxiety impacts the academic performance and working memory of students. International students who already have a lot to cope with while settling into a new culture and environment, are at even more risk of math anxiety affecting their math performance. The current study gave in-depth knowledge of mathematics anxiety among international undergraduate students to education policy makers. Stakeholders can develop policies and implement accommodations for international students to allow them to experience *flow* and reduce their level of mathematics anxiety. Other countries who send their students to the United States to pursue studies, can use the current findings to understand the pressure and anxiety felt by their students. In turn, these countries can start teaching their students in ways to manage their mathematics anxiety, which will help them when they move to the United States for higher education. Such strategies could facilitate a comparative study where researchers would explore the relationships between mathematics anxiety, *flow*, and other variables. This study could also help students experiencing math anxiety, if they choose to read it and get insight into their anxiety; they could then seek help from their teachers or other professionals. This could help control their anxiety and will improve the likelihood of academic success. In conclusion, this study was beneficial for policy makers, teachers, students, and educators from other countries who are preparing their youth for higher education in the United States.

APPENDICES

Appendix A

DEMOGRAPHIC QUESTIONNAIRE

Please respond to each of the following demographic items listed below.

Age: ________

Gender:

- Female
- Male
- Other (please specify: ___________)
- Prefer not to say

Race/Ethnicity:

- Hispanic or Latino
- American Indian or Alaska Native
- Asian
- Black or African American
- Native Hawaiian or Other Pacific Islander
- Caucasian or White
- Multiracial
- Other (please specify_)
- Prefer not to say

What best describes your current profession?

- Middle School
- High School
- Undergraduates
- Masters
- Doctorate

What is your current employment status?

○ Employed full-time
○ Employed part-time
○ Self-employed full-time
○ Self-employed part-time
○ Active military
○ Inactive military/Veteran
○ Temporarily unemployed
○ Full-time homemaker
○ Retired
○ Student
○ Disabled
○ Prefer not to answer

Are you taking a developmental math course?

○ Yes
○ No

Appendix B

MATHEMATICS SELF-EFFICACY AND ANXIETY QUESTIONNAIRE

GENERAL MATHEMATICS SELF-EFFICACY FACTOR

In order to better understand what you think and feel about your developmental math course, please respond to each of the following statements. Remember there are no right or wrong answers, just answer as accurately as possible. Use the scale below to answer the questions.

	No response	Never	Seldom	Sometimes	Often	Usually
1. I feel confident enough to ask questions in my mathematics class.						
2. I get tense when I prepare for a mathematics test.						
3. I get nervous when I have to use mathematics outside of school.						
4. I believe I can do well on a mathematics test.						
5. I worry that I will not be able to use mathematics in my future career when needed.						
6. I worry that I will not be able to get a good grade in my mathematics course.						
7. I believe I can complete all of the assignments in a mathematics course.						
8. I worry that I will not be able to do well on mathematics tests.						
9. I believe I am the kind of person who is good at mathematics.						
10. I believe I were able to use mathematics in my future career when needed.						
11. I feel stressed when listening to mathematics instructors in class.						
12. I believe I can understand the content in a mathematics course.						
13. I believe I can get an “A” when I am in a mathematics course.						
14. I get nervous when asking questions in class.						

	No response	Never	Seldom	Sometimes	Often	Usually
15. Working on mathematics homework is stressful for me.						
16. I believe I can learn well in a mathematics course.						
17. I worry that I do not know enough mathematics to do well in future mathematics courses.						
18. I worry that I will not be able to complete every assignment in a mathematics course.						
19. I feel confident when taking a mathematics test.						
20. I believe I am the type of person who can do mathematics.						
21. I feel that I were able to do well in future mathematics courses.						
22. I worry I will not be able to understand the mathematics.						
23. I believe I can do the mathematics in a mathematics course.						
24. I worry that I will not be able to get an “A” in my mathematics course.						
25. I worry that I will not be able to learn well in my mathematics course.						
26. I get nervous when taking a mathematics test.						
27. I am afraid to give an incorrect answer during my mathematics class.						
28. I believe I can think like a mathematician.						
29. I feel confident when using mathematics outside of school.						

Appendix C

THE CORE *FLOW* SCALE

The following questions will measure *flow* during the math class. Please choose between the choices below.

During Math class:	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1- I am 'totally involved'					
2- It feels like 'everything clicks'					
3- I am 'tuned in' to what I am doing					
4- I am 'in the zone'					
5- I feel 'in control'					
6- I am 'switched on'					
7- It feels like I am 'in the *flow*' of things					
8- It feels like 'nothing else matters'					
9- I am 'in the groove'					
10- I am 'totally focused' on what I am doing					

Appendix D

IRB APPROVAL

Andrews University
Office of Research & Creative Scholarship

March 31, 2022

Samah Abduljabbar
Tel. 330-319-0725
Email: samah@andrews.edu

RE: APPLICATION FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS
IRB Protocol #:22-031 **Application Type:** Original **Dept.:** Graduate Psychology & Counseling
Review Category: Exempt **Action Taken**: Approved **Advisor:** Nadia Nosworthy
Title: Investigating the relationship between flow, mathematics self-efficacy and mathematics anxiety among international undergraduate students in the USA.

Your IRB **modification** application for approval of research involving human subjects entitled: "*Investigating the relationship between flow, mathematics self-efficacy and mathematics anxiety among international undergraduate students in the USA"* IRB protocol # 22-032 has been evaluated and determined Exempt from IRB review under regulation CFR 46.104 (2)(i): Research that includes survey procedures in which information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subject. You may now proceed with your research.

Please note that any future changes made to the study design and/or informed consent form require prior approval from the IRB before such changes can be implemented. Incase you need to make changes please use the attached report form.

While there appears to be no more than minimum risks with your study, should an incidence occur that results in a research-related adverse reaction and/or physical injury, this must be reported immediately in writing to the IRB. Any research-related physical injury must also be reported immediately to the University Physician, Dr. Katherine, by calling (269) 473-2222.

We ask that you reference the protocol number in any future correspondence regarding this study for easy retrieval of information.

Best wishes in your research.

Sincerely,

Mordekai Ongo, PhD.
Research Integrity and Compliance Officer

Institutional Review Board – 8488 E Campus Circle Dr Room 234 - Berrien Springs, MI 49104-0355
Tel: (269) 471-6361 E-mail: irb@andrews.edu

Appendix E

INFORMED CONSENT

You are being invited to participate in a research study titled "The relationship between *flow* and mathematics self-efficacy on mathematics anxiety among international undergraduate college students." The study is being conducted by Samah Abduljabbar from Andrews University. You were selected to be a part of this study because you are enrolled in developmental math course, and you are an undergraduate international student. The main purpose of this study is to investigate the relationship between *flow* experience, mathematics anxiety and mathematics self-efficacy in international undergraduate students and to compare if there is any difference in *flow* experiences between males and females.

If you give your consent to participate in this study, you were directed to complete a survey through SurveyMonkey. The survey will ask you questions about math self-efficacy, *flow*, math anxiety and academic performance. It will take a maximum of 30 minutes to complete the survey. We understand that there might not be a direct benefit of this study for the participants but in the long term, it will allow the educational researchers to understand the psychological state of international students, especially during mathematics classes and will enable them to create strategies to reduce the anxiety of students and increase their academic performance. To our knowledge, there are no known risks associated with this research study; however, as with any online related activity the risk of a breach of confidentiality is always possible. The risk was minimized by having the survey filled anonymously. You will not be asked to provide personal information except for gender and age. All data collected were securely saved in a password protected folder on the researcher's personal computer.

You are free to end the questionnaire at any time. If you have any questions about this research study or the survey, you may contact the researcher's advisor Dr. Nadia Nosworthy at (269) 471-6175 or nosworthy@andrews.edu or the researcher Samah Abduljabbar at or samah@andrews.edu. If you have any questions concerning your rights as a research participant, you may contact the Andrews University IRB Office at (269) 471-6361 or irb@andrews.edu.

By clicking "I agree" below you are indicating that you are at least 18 years old, have read and understood this consent form and agree to participate in this research study. Please print a copy of this page for your records.

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Education

2017-2023	Ph.D. candidate in Educational Psychology Andrews University	Berrien Springs, MI
2015-2017	Master of Arts, Psychology Concordia University of Chicago	Chicago, IL
2000-2005	Bachelor, Geography College of Social Science	Mecca, Saudi Arabia

Professional Experience

2016	Guest Speaker Chicago Public Schools, IL
2015	Mentor University of Concordia River Forest, IL
2009-2010	Teacher, Social Science AL Khattab Secondary School, Mecca, Saudi Arabia
2007-2008	Teaching 9th Literacy School Mecca, Saudi Arabia

Publications

2023	Keller, Helen: Analysis of the concept of education. *Educational Thinkers*. Palgrave Handbook.
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Conference Presentations

2015	International Neuroscience Conference (Stress and Behavior) Miami, FL
2015	American Education Research Association Chicago, IL
2016	Association for Psychological Science Chicago, IL
2016	American Society of Business Behavioral Sciences for Las Vegas, NV Navigating Major life Changes by Older Women
2018	APA Annual Convention San Francisco, CA
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Professional Affiliations

2020 – present	The International Honor Society of Psychology
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