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Subscales of Undergraduates' Attitudes toward Mathematics: A Quantitative Investigation

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The purpose of this study is to develop an instrument to measure undergraduate students' attitudes toward mathematics and to assess the data collected from the instrument for validity and reliability. The sample consists of 163 undergraduates enrolled in College Algebra course at a university in USA. The data is analyzed to answer the research question: if and how do undergraduate students' attitudes toward mathematics load using Principal Components Analysis (PCA)? Data analysis led to the emergence of three subscales: anxiety/self-confidence scale, enjoyment, and value scale. After deleting the last five items or the last two subscales from the initial MAT scale, the Cronbach's alpha was recalculated using the scores from 20 items and was found to be α = .95. It is important to note that the reliability of the initial MAT form was α = .93. This means that employing the revised MAT - Malik Attitudes Instrument (MAI) would yield consistent results in repeated uses. MAI is therefore more reliable as compared to the initial MAT form.

Keywords: attitudes toward mathematics, college algebra, principal components analysis, technology in math, Cronbach's alpha

Introduction

Attitude toward Mathematics

Attitude toward mathematics has been defined as the positive or negative emotional disposition toward mathematics (Haladyna, Shaughnessy, & Shaughnessy, 1983; McLeod, 1992; Zan & Martino, 2007). It has also been defined as the feelings and emotions that an individual associates with mathematics based on ones beliefs about mathematics (positive or negative), and by how one behaves in dealing with mathematical situations (Hart, 1989; Zan & Martino, 2007). Neale (1969), however, defined attitude towards mathematics as an aggregated measure of, "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (p. 632). Ma and Kishor (1997) extended Neale's definition of attitude toward mathematics to include students' affective responses to the easy/difficult as well as the importance/unimportance of mathematics. For the present study, attitude toward mathematics is based on Neale's definition and is included later.

Why Students' Attitudes toward Mathematics Need to be Addressed

Interestingly, not only within the United States, but in several countries and at different grade levels, studies have shown that students with positive attitudes toward mathematics tend to achieve higher grades in mathematics courses (Else-Quest, Hyde, & Linn, 2010; Hemmings & Kay, 2010; Ma & Xu, 2004; Shen & Tam, 2008; Singh, Granville, & Dika, 2002) than students who have a low attitude. These studies suggest that attitude toward mathematics is a significant predictor of mathematics achievement, meaning that students' attitudes toward mathematics is responsible at least in part for students' achievement scores in mathematics. However, other research literature indicate otherwise. For example, some have concluded that correlation between attitude toward mathematics and mathematics achievement is quite low, ranging between 0 and .25 in absolute value (Ma & Kishor, 1997), suggesting that the relationship between attitude toward mathematics and mathematics achievement is too weak to be of practical significance (Vachon, 1984; Wolf & Blixt, 1981).

Furthermore, research has repeatedly shown that attitude toward mathematics is a critical construct related to learning (Kupari & Nissinen, 2013), and this might be the reason why individuals with negative attitudes toward mathematics encounter obstacles in learning mathematics (Alkhateeb & Mji, 2005). Additionally, attitude toward mathematics is regarded by several researchers as an important factor to be considered when attempting to understand and explain differences and variability in students' performance in mathematics (Mohamed & Waheed, 2011; Singh et al., 2002). Furthermore, researchers have found that students' attitudes toward mathematics could be a predictor of mathematics anxiety (Betz, 1978; Wigfield & Meece, 1988). It is therefore important to measure and assess students' attitudes toward mathematics.

Students with positive attitudes toward mathematics have higher perceptions of the utility of mathematics and this may be why they appreciate the importance of mathematics in everyday and later life (Kupari & Nissinen, 2013). They have a better mathematical self-concept, meaning they have perceptions of their capability to master the subject matter and to do well in mathematics (Vandecandelaere, Speybroeck, Vanlaar, De Fraine, & Van Damme, 2012) and are more confident than low attitude peers about their abilities to learn mathematics (McLeod, 1992). Finally, attitude toward mathematics has been found to be an important variable because many occupations require some basic knowledge of mathematics (Broadbooks, Elmore, & Pedersen, 1981).

A positive attitude towards mathematics reflects a positive emotional disposition in relation to the subject, and in a similar way, a negative attitude towards mathematics relates to a negative emotional disposition (Hannula, 2002; Mata, Monteiro, & Peixoto, 2012). Emotional dispositions have an impact on an individual's behavior, as one is likely to earn better grades in a subject that one enjoys, has confidence in, and appreciates its usefulness (Eshun, 2004). It is therefore important to measure students' attitudes toward mathematics.

Studies (Köğce, Yıldız, Aydın, & Altındağ, 2009; Ma & Kishor, 1997; Nicolidau & Philippou, 2003) have so far indicated that many children begin schooling with positive attitudes toward mathematics. However, as children grow up their attitudes toward mathematics tend to become less positive, and frequently become negative in high school (Ma & Kishor, 1997). Köğce et al. (2009) found significant differences between younger and older students' attitudes towards mathematics with 8th graders having lower attitudes than 6th graders. These findings suggest that many undergraduates may have negative attitudes toward mathematics.

In my opinion, since mathematics is a language where symbols and Greek letters are extensively used, more so in high school and undergraduate mathematics courses, such as, Algebra, Trigonometry, Pre-Calculus, and Statistics; learning mathematics can be challenging. This is because many students are unable to decode terminologies and symbols involved in these advanced courses and eventually give up (Malik, 2015). That is why, negative attitudes toward mathematics may be more prevalent among students enrolled in high school and undergraduate mathematics courses and may be in need of an intervention.

Additionally, negative attitude towards mathematics affects various aspects of students' success and hinder academic achievement, such as: the refusal of many students to enroll in scientific undergraduate courses due to the presence of exams in mathematics; lack of motivation and low self-efficacy to problem solving; an explicit and generalized refusal to apply rationality characterizing scientific thinking; or, vice versa. That is why, the problem of 'negative attitudes toward mathematics' that many undergraduates might be facing need to be addressed.

Teachers should therefore strive to promote their students' positive attitudes. It is because changes in students' attitudes toward mathematics might be accompanied by changes in their mathematics achievement (Hannula, 2002). Furthermore, only by measuring students' current attitudes toward mathematics can teachers predict students' mathematics achievement (Hannula, 2002).

Several researchers (Aiken, 1974; Chapman, 2003; Fennema & Sherman, 1976; Tapia & Marsh, 2004) have developed instruments to measure their students' attitudes toward mathematics. However, the original instruments can no longer be found. Some of these researchers have included items in their published work but the final complete psychometrically sound instrument is non-existent. Most importantly, the meta-analysis of Ma and Kishor (1997) highlights the need to refine the measurement instruments.

Purpose and Research Question

The purpose of this study was first to develop an instrument to measure undergraduate students' attitudes toward mathematics and then to assess the scores from the survey items for psychometric properties. Specifically, the item scores were examined for validity and reliability. The research question that guided this study is if and how do undergraduate students' attitudes toward mathematics load using Principal Components Analysis (PCA)?

Even though researchers (Aiken, 1974; Chapman, 2003; Fennema & Sherman, 1976; Tapia, 1996; Tapia & Marsh, 2004) have developed instruments to measure attitudes toward mathematics for their studies; some of the existing instruments are questionable. For instance, the Fennema-Sherman Mathematics Attitudes Scales consists of 108 items, takes 45 minutes to complete (Tapia & Marsh, 2004), and might not be a valid scale for measuring attitudes toward mathematics (Mulhern & Rae, 1998). The instrument(s) developed for the current study are limited to 20-25 items, and the responders should find them easy to complete.

Since the implementation of online homework and assessment in undergraduate mathematics courses is becoming more prevalent; the dimension of technology is a much needed one now than it was in the past (Scott, 2008). Due to these reasons, the dimension of technology is considered as one of the five dimensions of attitudes toward mathematics for this study. This study is therefore unique as it includes the final normed attitude toward mathematics instrument that may be of significance for undergraduate mathematics teachers and educators. It is anticipated that the results of this study will increase the understanding of factors that contribute to undergraduates' attitudes toward mathematics. In particular, new researchers may improve upon the subscales and corresponding items of the newly developed instrument from this study. The newly developed normed instrument will be called Malik Attitudes Instrument (MAI).

Since the primary purpose of this research was to develop and validate the instrument, a major part of this project is devoted to the development of the items of the instrument. Just to be clear, measuring student learning outcomes is not a part of this research.

Literature Review

Students' Attitudes toward Mathematics

It is well acknowledged that students' attitudes toward a subject can have significant implications for their academic success (Popham, 2005). Additionally, students' attitudes should be important to educators, because affective dispositions are powerful predictors of students' subsequent behavior (Popham, 2005; Tapia & Marsh, 2004) and achievement (Suydam & Weaver, 1975).

Teachers and educators generally believe that students learn more effectively when they are interested in what they learn. Therefore, continual attention should be directed towards creating, developing, maintaining, and reinforcing positive attitudes of students (Suydam & Weaver). For this reason, positive attitudes towards mathematics are desirable since they may influence one's willingness to learn (Eshun, 2004) and because the first rule to success in mathematics courses is to facilitate students' positive attitudes (Willis, 2010). Today many students attending mathematics classes have feelings toward the subject that make them unhappy doing mathematics (Willis, 2010). Generating positive attitudes toward mathematics among students is an important goal of mathematics education in many jurisdictions (The Third International Mathematics and Science Study [TIMSS], 1999).

Yusof and Tall (1999) examined the effects of a teaching strategy that encourages cooperative problem solving coupled with reflection on the thinking activities involved on students' attitudes toward mathematics. This study was an intervention to discourage rote memorization of mathematical concepts by incorporating problem solving in a 10-week mathematical problem-solving course. One of the main objectives of the problem-solving course was to provide students with opportunities to solve real-life problems in their mathematics classroom. Forty-four undergraduates, 24 males and 20 females, participated in this research. For this research project, participants spent the major part of the time (two-hours every class meeting) working on the problems in small groups of three or four. The students' performance and attitudes were monitored by classroom observation, a questionnaire at the beginning and end of the course, and semi-structured interviews. As a result of the intervention, students' comments on all three measures (classroom observation, questionnaire, and interviews) improved. A pre- and post-assessment revealed that attitudes changed significantly during the course. Most importantly, students who thought earlier that mathematics is a body of procedures to be learned later stated that mathematics is a process of thinking. The results reported in this study are of great value because the findings suggest that teachers can cultivate positive attitudes toward mathematics among undergraduates within a span of 10 weeks.

Stephens, Stones, & Beckmann (1983) examined 1,054 Pre-Calculus college students' attitudes toward mathematics using the revised form of the Mathematics Attitude Scale, first developed by Aiken and Dreger (1961). The revised scale consisted of 20 items that was administered to students of two- and four-year colleges enrolled in Pre-Calculus mathematics courses. Overall, the 1,054 students had a rather neutral attitude toward mathematics. This is not surprising since many of the students with a very positive attitude are likely to start in a calculus course rather than a pre-calculus course. Even though Stephens et al. dates to 1983, the findings conducted in a relatively newer study are no different as can be seen from the study by AlKhateeb and Mji (2005).

AlKhateeb and Mji (2005) assessed the attitudes toward mathematics of a sample of Pre-Calculus students. The sample consisted of 270 undergraduates (M= 90, F=180) who were enrolled in a university Pre-Calculus course. The participants completed a 20-item Mathematics Attitude Scale to report on their existing attitudes toward mathematics. The scale was designed so that a single score represented an individual's attitude toward mathematics. Cronbach's alpha score was $\alpha = .97$ and the mean score on the Mathematics Attitude Scale for the whole sample was 61.7 (SD = 17.5, Range = 78). Overall, the mean of 61.7 for 200 students was somewhat higher than the neutral score of 60 indicating that the sample of Pre-Calculus students had a slightly positive attitude toward mathematics.

The results reported by AlKhateeb and Mji (2005) are of great value because the current study also includes sample of undergraduates. Additionally, similar to AlKhateeb and Mji's study, the present study was also a one-time survey administration study. Most importantly, the authors AlKhateeb and Mji did not include the Mathematics Attitude Scale in their report and that is why it is difficult to compare the instrument developed for the current study with the one developed by AlKhateeb and Mji. Unlike AlKhateeb and Mji's study, the current study includes the final form of the developed instrument in the final report (MAI) hoping that future researchers may benefit from it.

Several conclusions can be made based on the above-mentioned literature. First, it can be seen from Yusof and Tall (1999) that instructors were able to change undergraduate students' attitudes toward mathematics in a 10-week course. However, it was only possible with an intervention that was significant and was rigorous enough to make students see the value of mathematics. In the case of one-time survey administration, it was revealed that undergraduates' attitudes toward mathematics is neutral (neither positive or negative). It can thus be concluded that studies (Stephens et al., 1983; AlKhateeb & Mji, 2005) have repeatedly shown that undergraduate students enrolled in mathematics courses, such as Pre-Calculus and Calculus that are at a higher level than College Algebra, have neutral attitude toward mathematics.

Hannula (2002) stated that students' attitudes in the early formation stage can change in a short period of time, and sometimes dramatically. He noted that once established an attitude is stable and only minor changes occur based on successes and failures. Therefore, due to all these reasons, teachers can reinforce the idea that mathematics is an interesting subject, which is used in many disciplines and extends college major and vocational choices (Anderson, 2007). Also, Ma and Xu (2004) found that when students, especially younger ones, are encouraged by teachers and find success in mathematics, their attitudes and beliefs can drastically improve. For these reasons, research focusing on students' attitudes toward mathematics should be of great value to teachers for their classroom practices.

Most importantly, none of these studies included the instrument that they employed for assessing their students' attitudes toward mathematics. The current study is therefore important and believes that instructors should have easy access to attitudes toward mathematics instruments, which they can use to assess their students' current level of attitudes in mathematics courses and thus provide early intervention to their students.

Attitude toward Mathematics and Its Subscales

Attitude toward mathematics may be multi-dimensional rather than uni-dimensional (Aiken, 1972). Uni-dimensional means, the items must all be indicators of one common underlying construct. According to DeVellis (1991), "a uni-dimensional scale or a single dimension of a multi-dimensional scale should consist of a set of items that correlate well with each other" (p. 25). Moreover, instruments to measure attitudes toward mathematics should consist of more than one dimensions or subscales.

Aiken (1974) thus developed two subscales of attitude toward mathematics namely enjoyment of mathematics, and value of mathematics. He developed the initial E (enjoyment) Scale, enjoyment of mathematics, by revising several of the 20 items on MAS-the Mathematics Attitude Scale (Aiken, 1972) and combining with new items. Thus, the initial E Scale had 12 items. As a measure of the "recognized importance" or value of mathematics, the initial V (value) scale included 11 items. The resulting 40-item instrument was completed by 185 (M = 87, F = 98) freshmen attending a college in the United States.

Eleven of the remaining 17 items on the 40-item instrument had statistically significant correlations with the E or V Scales suggesting that the two scales were functioning somewhat differently. To obtain further information on the validity of the E and V Scales; correlational analyses were conducted between E and V and the verbal and mathematical scores on the Scholastic Aptitude Test. The results of indicated that the E Scale is highly related to measures of mathematical ability and interest, whereas the V Scale is highly correlated with measures of verbal and general-scholastic ability. Both the E and the V Scales of Aiken's study are included in the present study. The next most important study discussing attitude toward mathematics is by Fennema and Sherman.

Fennema and Sherman (1976) developed the 108-item Fennema-Sherman Mathematics Attitudes Scales (FSMAS) to assess attitudes and beliefs of secondary and high school students. FSMAS consisted of nine subscales: (a) the Attitude Toward Success in Mathematics Scale, (b) the Mathematics as a Male Domain Scale, (c) the Mother, (d) the Father Scale, (e) the Teacher Scale, (f) the Confidence in Learning Mathematics Scale, (g) the Mathematics Anxiety Scale, (h) the Motivation Scale in Mathematics, and (i) the Mathematics Usefulness Scale. FSMAS has been the most popular instrument in research about attitudes toward mathematics (Tapia & Marsh, 2004).

Even though the FSMAS has been the most popular instrument, its items cannot be found in the literature. Most importantly, subsequent research has questioned the validity, reliability (Suinn & Edwards, 1982), and integrity of scores obtained from the nine subscales (O'Neal, Ernest, McLean, & Templeton, 1988). Due to these reasons, several authors (Mulhern & Rae, 1998; Tapia & Marsh, 2000; Tapia & Marsh, 2004) have proposed fewer factors than all the nine subscales of FSMAS. The next most cited work in the domain of mathematics attitudes is by Tapia.

Tapia (1996) conducted a study in response to: (a) the declining national test scores in mathematics and, (b) the increasing dislike for mathematics among high school students. The main goals of the study were to develop an instrument to measure students' attitudes toward mathematics (ATMI) and to find the underlying dimensions that comprise the ATMI. The sample consisted of 544 (M = 291, F = 253) students taking mathematics at a school in Mexico City. Students were asked to indicate their degree of agreement with each statement, from strongly disagree to strongly agree. The initial instrument consisted of the six scales: value, anxiety, motivation, confidence, enjoyment, and adults' perspectives. Factor analysis was conducted with three, four, five, six, and seven factors. Both the three and four factor structures resulted in good factor loadings matrices. After re-examining the items in the factor loading matrices, the four-factor structure provided the best simple structure fit. The final instrument thus had four factors only: students' sense of security, value of mathematics, motivation, and enjoyment of mathematics. Cronbach's alpha was found to be α = .97. Tapia concluded that ATMI had psychometrically sound properties. The present study used two of the four subscales of Tapia (1996): enjoyment of math, and the value of math.

Later, Tapia and Marsh (2000) conducted a study to identify the underlying dimensions of students' attitudes toward mathematics. They used the same ATMI as Tapia (1996) but with a different sample. The data were collected from 262 (M = 137; F = 125) middle school students at a bilingual college preparatory school in Mexico. Students were from 6^{th} to 8^{th} grade mathematics classes taught by three mathematics teachers.

For the purposes of reliability, Cronbach's alpha was calculated for the 49 items and was found to be α =.95. Nine items had correlations lower than r = .45. Items were deleted one at a time starting with the one with the lowest item-to-total correlation. After excluding the nine weakest items, the Cronbach's alpha was still α =.95. For validity purposes, the ATMI responses were subjected to an exploratory factor analysis using maximum likelihood method of extraction and a varimax, orthogonal, rotation. Results suggested that three factors be retained: self-confidence, enjoyment of mathematics, and value of mathematics. The Cronbach's alpha for the scores of the subscales were: α =.94, α =.92, and α =.84, respectively. The psychometric properties were therefore sound, and the Attitudes toward Mathematics Inventory was recommended for use in the investigation of students' attitudes toward mathematics. The current study included all the three factors: self-confidence; enjoyment of mathematics, and value of mathematics that Tapia and Marsh

(2000) had identified. However, the definitions are different for each of these constructs, specifically of the self-confidence scale. Another study about validation of attitudes toward mathematics instrument is by Chapman.

Chapman's (2003) study was conducted to develop a measure suitable for assessing primary grade students' mathematics attitudes. A 10-item instrument 'How I Feel About Math Scale' (HIFAMS) was written to minimize the demands made on students' literacy levels by simplifying the wording of statements. HIFAMS consists of items from MAS (Aiken, 1974) and FSMAS (Fennema & Sherman, 1976) but they were rewritten: (a) to fit the understanding of the primary school student, and (b) to simplify it for students with reading difficulties. HIFAMS was administered to 774 (M = 380, F = 394) 4^{th} through 7^{th} graders who rated their agreement with each HIFAMS item on a five-point scale. Schools that these students attended are located in Western Australia. Principal Components Analysis was conducted to explore the factor structure of the scale. The results indicated that the scale was comprised of three components: a reflection of students' overall enjoyment of mathematics; their perceptions of its value as a subject area; and perceptions of their ability to cope with their assigned mathematics work. The three components of the current scale were found to have acceptable reliability and validity across grades 4-6. Chapman included entire HIFAMS in their article and some of the items have been included in initial MAT scale. Most importantly, the present study also employed all the subscales of Chapman's (2003) study.

In 2004, Tapia and Marsh, conducted a new study by employing the same ATMI that they normed in the year 2000. To further examine the dimensions of ATMI, they administered ATMI to 545 (M = 302, F = 243) high school students in the United States. As noted earlier, the ATMI was based on the FSMAS, with some scales and the respective items eliminated in order to focus on only six scales: confidence, anxiety, value, enjoyment, motivation, and parent/teacher expectations. Content validity was established by relating the 49 items of the ATMI to the six scales: confidence, anxiety, value, enjoyment, and motivation, and the structure was explained by the four-factor model including students' self-confidence, value, enjoyment, and motivation as underlying dimensions of attitudes toward mathematics. The Cronbach's alpha was $\alpha = .96$ for the 49 items, showing a high degree of internal consistency. An item deletion process was performed in order to increase the value of alpha. As a result, nine items having correlations lower than .50 ($r < .50$) were deleted. After which alpha reached a value of .97. In factor analysis, the four-factor solution provided the best simple structure, so four factors were retained: self-confidence, value, enjoyment, and motivation. Tapia and Marsh (2004) published the three items of each factor in their publication' some of which are included in the current study.

For this study, only four of the above-mentioned dimensions or factors of attitude toward mathematics were employed: anxiety, self-confidence, enjoyment, and value. These factors are the recurring themes found across the research discussed above. Additionally, one more dimension, technology subscale, was added as a subconstruct of attitude toward mathematics. This was done in response to current trend of using online course tools, e.g., MyMathLab, in mathematics courses, specifically in College Algebra and also to address the questions and issues that students encounter while dealing with learning management systems, e.g., BlackBoard and Moodle. As a result, the final form of MAT, Malik Attitudes Instrument (MAI), developed for this study would be unique from previously existing instruments. This would possibly fill the gaps in the existing literature. The definition of each of these five subscales as well as the details about the items of the attitude toward mathematics instrument are included in the next section. First, it is important to provide the operational definition of attitude toward mathematics used in this study.

Operational Definition of Attitude toward Mathematics

The operational definition of *attitude toward mathematics* is the one that encompasses the five above-mentioned dimensions: enjoyment, anxiety, self-confidence, value, and technology. Therefore, for the present study, attitude toward mathematics is defined as an aggregate of *liking or disliking* of mathematics, a tendency to *panic or remain calm* while doing mathematics, a perception that one is *able or unable* to do well in mathematics, a perception that mathematics is *useful or useless*, and a perception that *technology can support or undermine* the learning of mathematics.

Methodology

Participants

Participants of this quantitative study consisted of undergraduate students, 18 years or older, enrolled in a College Algebra course during the summer 2017 semester. Students were taking College Algebra at the university located in the Mid-Western region of the US. Students were from diverse majors including, business, healthcare, applied technologies, graphic design. This school was selected because the researcher is a full-time instructor at this university.

Researchers have suggested that College Algebra students’ attitudes be examined because some believe that College Algebra is the one mathematics course that could be an important influence on students’ mathematical dispositions and an ideal time to examine how dispositions develop and change (Gordon, 2008; Herriott, 2006; Owens, 2003; Small, 2006). College algebra may be the last opportunity for helping students’ mathematical dispositions improve (Watson, 2015).

Sampling

In this survey study, convenience sampling was used to collect the data. Convenience sampling is a non-probability sampling technique where subjects are selected because of their convenient accessibility and proximity to the researcher (Gall, Gall, & Borg, 2007?). Since the participants were recruited based on acquaintance with mathematics instructors at the selected university, convenience sampling was appropriate.

Sample Size

Some studies have recommended that the general rule of thumb is to have five cases per item, that is if the instrument has 25 items then at least 125 responses are needed for every item. On the other hand, Gall et al. (2007) suggest that sample size must be in the range of 150 and 200 if the test has 20 items. Since the initial MAT instrument consisted of 25 items, a sample larger than 125 is included. However, since this was a quantitative study, a larger sample was preferential.

Instrumentation

Development of the initial MAT scale. The subscales of initial MAT scale are most commonly occurring and overlapping subscales of the previously discussed instruments. The items either are the same as included in the original instruments or are modified from the original ones. In the following paragraphs, a detailed account of the development of the items of the initial MAT scale is presented. Specifically, definitions of each of the five subscales are provided along with the details of how the items for each of the subscales were written.

The anxiety subscale. This dimension of attitude toward mathematics was taken from Fennema and Sherman (1976), who named it as the Mathematics Anxiety Scale (A). Scale A (Anxiety) was intended to measure feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics. This dimension ranges from feeling at ease to feeling anxious. According to Fennema and Sherman, the anxiety scale is not intended to measure confidence in, or enjoyment of, mathematics, as those constructs may align more closely with self-efficacy than attitude/anxiety.

It needs to be pointed out that only Fenemma and Sherman has included the anxiety subscale and no other previously mentioned studies have discussed this subscale in relation to attitude toward mathematics. The reason for including the anxiety subscale in this study is because attitude toward mathematics and mathematics anxiety have been found to be correlated (Dowker, Sarkar, & Looi, 2016; Kargar, Tarmizi, & Bayat, 2010; Sanci, 2014; Srivastava, Imam, & Singh, 2016). Also, by adding the anxiety scale as a separate factor, this study would be more unique and distinct from the previous studies mentioned above.

For this study, this subscale is defined as a tendency to *panic or remain calm* while doing mathematics. Since the anxiety subscale, by definition, tends to include items that measure feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics, it offers a challenge to avoid the use of negative wording. However, I tried my best to modify all the five items of anxiety scale to ensure positive wording. The following are some of the words that were used to write items for the anxiety subscale: confusing, ease, panic, and bother. All these terms indicate feelings that lead to bodily symptoms related to doing mathematics, which is why they were included as the items for the anxiety subscale.

As noted earlier, Fennema and Sherman included nine subscales in their study, but did not include any in their article, at least not in the ones available in the literature. For this study, modified versions of FSMAS available in the literature were therefore reviewed to write the items. As a result, four of the five items that I included are taken from Gundy, Liu, Morton, & Kline (2006), who used the modified version of FSMAS.

The enjoyment subscale. This subscale is the most frequently occurring dimension of attitude toward mathematics. It can be found in the works of Aiken, (1974), Chapman (2003), and Tapia and Marsh (2000; 2004). As mentioned earlier, for this study, enjoyment is the measure of like or dislike of mathematics. Additionally, the dimension of "enjoyment of mathematics," encompasses not only a liking for mathematics problems, but also a liking for mathematical terms, symbols, and routine computations (Aiken, 1974). The terms that I used to write the words for this dimension are: like, enjoy, and happier. I also tried my best to keep the items as they were found in literature.

The self-confidence subscale. Like the enjoyment subscale, the self-confidence or confidence subscale is included in many of the afore-mentioned literature (Chapman, 2003; Fennema & Sherman, 1976; Tapia, 1996; Tapia & Marsh, 2000; 2004). However, the definition that previous studies used to define self-confidence is different from how it is defined in this study. This difference is because the factors of confidence and anxiety were combined together to form a single factor self-confidence and thus include items that measure anxiety. For example, Tapia and Marsh (2004) included items three items in their final report and two of them are: "studying mathematics makes me feel nervous," and "I am always under a terrible strain in a math class." Since, the terms nervous and strain may be considered synonymous to worry and anxiety, for this study such items were disregarded from including them under the subscale of self-confidence.

First, for the definition of the dimension of self-confidence, I relied on Fennema and Sherman (1976) who termed it as The Confidence in Learning Mathematics Scale (C). C(onfidence) was intended to measure confidence in one's ability to learn and to perform well on mathematical tasks and ranges from distinct lack of confidence to definite confidence. Fennema and Sherman made it clear that C was not intended to measure anxiety or mental confusion, interest, enjoyment, or zest in problem solving. Also, Chapman (2003) included self-confidence as one of the dimensions of her study and defined it as perceptions of students' ability to cope with their assigned mathematics work. As discussed earlier, for this study; self-confidence was defined as perception that one *is able or unable* to do well in mathematics. To write the items for self-confidence subscale, I tried my best to borrow the same items as included in the above-mentioned research articles. Also, very minimal changes were made to the original items. The words that I used to write the items for self-confidence subscale are: can, confident, self-confidence, and able.

The value subscale. The value scale has been found in the works of numerous researchers including, but not limited to, Aiken (1974), Chapman (2003), and Tapia and Marsh (2000; 2004). It is defined as a perception of the value of subject (Chapman, 2003). Fennema and Sherman (1976) also included this scale but referred to it as Mathematics Usefulness Scale (U). U(sefulness) was designed to measure students' perceptions about the usefulness of mathematics currently, in relationship to their future education, vocation, or other activities (Fennema & Sherman, 1976). As mentioned earlier, the value subscale for this study was defined as a perception that mathematics is *useful or useless.* The words I used to write the items include: worthwhile, important, necessary, etc.

The technology subscale. Implementation of online homework and assessment in undergraduate mathematics courses is becoming more prevalent (Scott, 2008) as the years pass. Many colleges and universities use the online course management systems, such as, MyMathLab, WebAssign, ALEKS, where students interact with computers rather than instructors and complete their mathematics courses 100% online. For example, WebAssign claims their online homework is used at 335 universities and colleges in the United States. In particular, these online course tools are frequently used in developmental math and College Algebra courses. Because of being enrolled for the course, students get access to online homework activities, lectures, tutorials, etc. Other technological tools include in mathematics courses are calculators in addition to PowerPoint lectures, online homework, and instructional videos on internet, such as YouTube. It has been noted that students' learning and performing mathematical tasks can be furthered using mathematical tools such as graphing calculator, and online course systems, such as, MyMathLab. Additionally, these technological tools can encourage students to utilize their general metacognitive abilities (Pierce, Stacey, & Barkatsas, 2007). In my opinion, it is also important to monitor and measure students' experiences, reactions, and attitudes toward using these technological tools in mathematics courses specifically at undergraduate level as technology becomes ubiquitous on college campuses. Due to these reasons, this dimension is included in this study.

To reiterate, the technology dimension is defined as a perception that *technology can support or undermine* the learning of mathematics. Additionally, the enjoyment and importance of using technology in mathematics classes are also included as items for the MAT. Also, for this study, the technological tools are restricted to include only the following forms: online homework, calculators, PowerPoints resources, and instructional videos.

Initial MAT form. MAT is based on a 4-Point Likert-type scale (see Appendix A for the initial MAT instrument). MAT consists of 25 items measuring Attitude toward Mathematics. Response choices for the items on MAT are: (a) strongly disagree, (b) disagree, (c) agree, and (d) strongly agree. The reason for not including the neutral as a choice was to force the participants for a response other than neutral or undecided. All items on MAT are positively coded and possible scores range from 25 to 100, and a higher score on MAT reflect positive attitude toward mathematics. It is important to note that a high score for attitude is desirable.

Research Design

The methodology of this study is quantitative research. Quantitative methods involve the processes of collecting, analyzing, interpreting, and writing the results of a study (Creswell, 2014). The type of quantitative methods suitable for this study is survey methodology. Since this study was aimed at developing attitudes toward mathematics instrument and then using it to assess undergraduates' attitudes toward mathematics, survey design is most appropriate.

Data Collection and Analysis Procedures

For this study, MAT was the only source of data. No other data was collected. The survey scores from the sample were assessed to examine the psychometric properties of MAT. Only those students who filled out all the 25 survey items were the participants.

Institutional Review Board (IRB) approval was obtained before data collection. Once approval was obtained, College Algebra instructors were contacted for data collection. Upon receiving all data, analysis began. The survey data was coded using IBM SPSS 24.0. The total attitude toward mathematics score for each participant was obtained by taking the mean of his/her responses on the survey items.

Validity analysis. To assess the validity or accuracy of the initial MAT instrument, the scores from MAT were subjected to Principal Components Analysis (PCA) to see how factors load or which factors or items "go together." Those that did not load were eliminated, based on the extent to which they did not load.

Reliability analysis. Internal consistency reliability is the degree to which every test item measures the same construct or idea. For this study, internal consistency reliability was most appropriate to assess the survey items for consistency. In particular, Cronbach's alpha was conducted to test the consistency of the initial MAT instruments' items.

Results

Procedure and Results

Reliability analysis of the initial MAT. The reliability of the 25 (combined) items of MAT using Cronbach's alpha was extremely high with α = .93. The reliability coefficient alpha has value higher than the commonly accepted criterion value of >.80 as recommended by Gall, Gall, & Borg (2007) indicating that the instrument is highly reliable. Practically speaking, this means that users of the instrument can expect consistent results (data) in repeated uses.

Principal components analysis of the initial MAT. Coded data were subjected to Principal Components Analysis (PCA) to explore the factor structure of the initial MAT scale. Item responses from 163 undergraduate students constituted the data. PCA is a data reduction technique used to extract factors. It may be used as the first step to reduce the data (Tabachnick & Fidell, 2007) or to reduce the number of variables while retaining as much of the original variance as possible (Conway & Huffcutt, 2003). For this study PCA was employed mainly because it is the default extraction method in SPSS and it is easy to interpret.

Assumptions for PCA. Before extraction, the following assumptions were checked: sampling adequacy, and correlations.

1. **Sampling adequacy.** There should be sampling adequacy, which simply means that for PCA to produce a reliable result, large enough sample sizes are required. Ideally, there should be over 150 and there should be a ratio of at least five cases for each variable (Pallant, 2001). In this study, the sample size was n =163, which is why this assumption was regarded as met. Another method to detect sampling adequacy, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy for the overall data set, was also employed. For this study, the KMO Measure of Sampling Adequacy was significant with a value of .912 greater than .05; suggesting the sample size was appropriate. Refer to Table 1 below.
2. **Correlations.** There should be correlation among the factors ($r > .30$) to be considered for PCA. That is, data should be suitable for data reduction. In other words, adequate correlations between the variables are needed in order for variables to be reduced to a smaller number of components. The method used by SPSS to detect this is Bartlett's test of sphericity. In this study, Bartlett's test of sphericity was significant; $p = .000 < .05$. This indicated that there are at least two (perhaps more) items or variables that were highly correlated. Refer to Table 1 below.

Table 1
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.912
Bartlett's Test of Sphericity	Approx. Chi-Square	2595.772
	df	300
	p value	<000.1

Extraction. The next step, after checking for assumptions, is the extraction in which it is decided how many factors need to be retained. The eigenvalues and scree plot (scree test) are used to determine how many factors to retain (Yong & Pearce, 2013). Also, Gorsuch's (1983) recommendation is to employ the Keiser-Guttman (Kaiser, 1970) criterion for retaining factors with eigenvalues greater than 1 and Cattell's (1966) scree test to determine the number of factors to extract. After careful consideration, both of these criteria for deciding on the number of factors to retain were adopted. The total variance explained by 25 items of MAT and the scree plot helped in preliminary assessment of the number of underlying dimensions of the attitude toward mathematics construct. Refer to the total variance explained (see Appendix 3) and the scree plot (Figure 1) below. Results from both these methods were similar, meaning they both suggested that five new significant factors be extracted. Hence, five factors were accepted.

The above total variance table shows the actual factors that were extracted. By looking at the section labeled "Extraction Sums of Squared Loadings," and in particular by looking at the cumulative %, one can see the overall variance explained by the five factors retained (nearly 70%). This means that the remaining 20 factors account for almost 30% of the variance and further explains why they were not retained (because each of the remaining factor explains such a minute amount of variance). Moreover, the five factors retained are those that met cut-off value of eigenvalue greater than 1. In other words, SPSS always extracts as many factors initially as there are variables in the dataset, but the rest of these, 6 through 25, did not have an eigenvalue greater than 1. The "percent of variance" column tells how much of the total variability (in all of the variables together) can be accounted for by each of these factors. For instance, factor 1 accounts for 42.033% of the variability in all 25 variables, and so on. The second evidence of retaining five factors came from the scree plot included below.

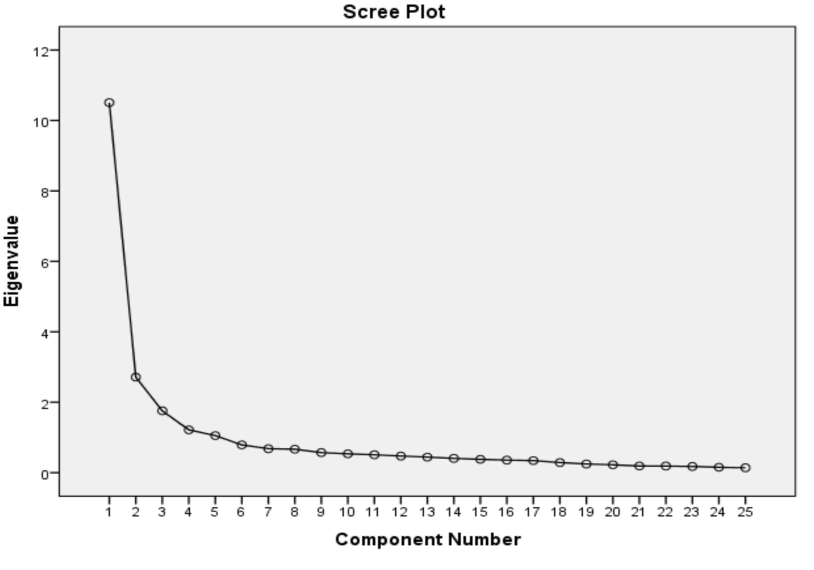

Figure 1. *Scree plot.*

Looking at Figure 1, it appears that there are five factors with eigenvalues greater than 1; all the other factors, 6 through 25, have an eigenvalue lower than one. Eigenvalues measure the amount of variation in the total sample accounted for by each factor. A factor's eigenvalue is the sum of its squared factor loadings for all the variables. If a factor has a low eigenvalue, then it is contributing little to the explanation of variances in the variables and is ignored as redundant with factors that are more important.

Rotation. After extraction of five new factors, the next step was to do the rotation. Researchers need to perform rotation regardless of the extraction technique so that factors are rotated for better interpretation since un-rotated factors are ambiguous (Tabachnick & Fidell, 2007). Rotation is conducted to attain an optimal simple structure in which each variable load on as few factors as possible, while maximizing the number of high loadings on each variable (Rummel, 1970).

For this study, it was not predetermined if the factors have some correlation or not. However, previous studies focusing on affect in mathematics have consistently used the assumption that factors correlate to some extent (e.g., Chamberlin, Moore, & Parks, 2017). Hence, the Direct Oblimin methods of Oblique rotation was adopted because while checking for assumptions, Bartlett's test of sphericity was found to be significant suggesting that at least two items of MAT will have some type of correlation. In addition, Direct Oblimin is the default option in SPSS for oblique rotation and all the other options are meant to give orthogonal solutions. Most importantly, SPSS does not produce the new factor correlation table that was needed in order to check whether correlation between the new factors exists. Due to these reasons, the Direct Oblimin technique that produced component correlation matrix as an output was employed.

Table 2
The Component Correlation Matrix

Component	I	II	III	IV	V
I	-				
II	.346	-			
III	.087	.184	-		
IV	.047	.151	.215	-	
V	.528	.371	.113	-.026	-

Note: Extraction Method is Principal Components Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

The component correlation matrix (Table 2) was found to have no correlations among most of the factors, but moderate correlations among factors 1 and 5 (Anxiety-Self Confidence and Online Learning in Math) with $r = .528$ and a weak correlation among factors 1 and 2 (Anxiety-Self Confidence and Value) with $r = .346$. Since most factors indicted extremely low correlations among each other, it was concluded that oblique rotation was not appropriate for this data set.

Given the afore-mentioned situation, the data was re-analyzed but this time an orthogonal rotation was used. In particular, a varimax rotation technique was used because it is a commonly accepted method. As a result, the rotated component matrix was produced showing the correlations among the new extracted factors or components and the items, also called factor loadings.

The Rotated Component Matrix (Table 3) shows the factor loadings for each variable. The factor loadings give an idea about how much the variable has contributed to the factor; the larger the factor loading the more the variable has contributed to that factor (Harman, 1976). Factor loadings are very similar to weights in multiple regression analysis, and they represent the strength of the correlation between the variable and the factor (Kline, 1994). Once a correlation matrix is computed, the factor loadings are then analyzed to see which variables load onto which factors (Yong & Pearce, 2013).

Table 3

The Rotated Component Matrix

Component	I	II	III	IV	V
1	.721				
2	.738				
3	.846				
4	.788				
5	.510				
6	.572		.605		
7	.481		.611		
8			.709		
9	.541		.580		
10	.519		.711		
11	.810				
12	.664				
13	.785				
14	.706				
15	.711				
16		.812			
17		.752			
18		.774			
19		.767			
20	.412	.639			
21	.449			.513	
22				.841	
23				.785	
24					.766
25					.885

The correlation *r* must be .30 or greater since anything lower would suggest a very weak relationship between the variables (Tabachnick & Fidell, 2007). There should be few item cross-loadings or split loadings meaning an item loads at .32 or higher on two or more factors (Costello & Osborne, 2005). In this study, some of the items loaded on two components, so each row was analyzed, and the factor that each variable loaded most strongly on was adopted over the lower value.

As shown in rotated component matrix above (Table 3), component I was defined by 10 items. The first five of them were originally categorized as the items of the anxiety subscale, whereas the other five items were a part of self-confidence subscale. That is why, the component I was labelled as "Anxiety-Self Confidence Scale (ASC)" formed by combining the anxiety items and the self-confidence items of the initial MAT scale. In case of components II and III, they were both termed as "Value" and "Enjoyment" respectively because they consisted of the same items that initial MAT had as items for value and enjoyment subscales. Component IV was defined by the three items: (a) I am comfortable using technology in math class, (b) mathematics is easier to understand with technology than without it, and (c) calculators are an important (piece of) technology in my math classes. All three items comprised the technology subscale of the initial MAT scale. This component was therefore labelled as "Technology in Math." In the case of component V, there were only two items: (a) I like using online resources, such as educational videos and PowerPoint lectures, when learning mathematics, and (b) online homework facilitates my learning of mathematical concepts; both regarding online resources and online homework, and thus this component was labelled as "Online Learning in Math."

Having retained five factors or subscales, Cronbach's alpha was calculated to estimate internal consistency and reliability of the scores on each of the five extracted factors. This is often the next most logical step in a process such as PCA because if the internal consistency is poor, then the factors, or subscales, should not be retained. Subscale I, the "Anxiety-Self Confidence" (ASC) scale, contains 10 items with a composite mean $M = 25.40$ and composite standard deviation $SD = 6.42$ (item $M = 2.54$ and item $SD = .64$). As noted above, this subscale is labelled as "Anxiety-Self Confidence" (ASC) scale. Items in this subscale came from among those generated for anxiety and self-confidence subscales of the initial MAT scale. The 10 items are: (a) mathematics is not confusing, (b) I have usually been at ease during math courses, (c) I don't panic when I think about trying hard math problems, (d) I have usually been at ease during math tests, (e) It wouldn't bother me to take more math courses, (f) I have a lot of self-confidence when it comes to mathematics, (g) I can keep up with the work we do in math courses, (h) I am able to solve mathematics problems without too much difficulty, (i) I am confident that I could learn advanced mathematics, (j) I expect to do fairly well in any math class I take. The scores derived from these items had a Cronbach's alpha of .93.

Subscale II contains five items with *M* = 14.49 and *SD* = 2.86 (item *M* = 2.90; item *SD* = .57), and this component is named as the Value or Value of Mathematics scale. Items in this subscale came from among those originated for value subscale of the initial MAT scale. The items are: (a) mathematics is important in everyday life, (b) mathematics is a very worthwhile and necessary subject, (c) a strong math background could help me in my professional life, (d) mathematics helps develop a person's mind and teaches him to think, (e) I think studying advanced mathematics is useful. The items when scored and summed produced a Cronbach's alpha of .86.

Subscale III also contains five items with *M* = 11.43 and *SD* = 3.48 (item *M* = 2.29; item *SD* = .70), and it is termed as Enjoyment in mathematics. Items in this subscale came from among those originated for enjoyment subscale of the initial MAT scale. The five items of this subscale are: (a) I really like mathematics, (b) I enjoy working algebra problems, (c) I enjoy my math lessons, (d) I am happier in a math class than in any other class, and (e) I have usually enjoyed studying mathematics in school, and the scores on these five items produced a Cronbach's alpha of .90.

Subscale IV, on the other hand, contains three items with *M* = 9.40 and *SD* = 1.54 (item *M* = 3.13; item *SD* = .51). These three items in this subscale were the first three items of technology subscale of the initial MAT scale. That is why, this component was labelled as Technology in Math. The scores derived from these items had a Cronbach's alpha of .69. These items were therefore deleted to make the scale more reliable because the current alpha is lower than the criterion value of >.80 recommended by Gall et al. (2007).

Finally, subscale V that contains only two of the five items from the technology subscale of the initial MAT scale, has *M* = 4.91 and *SD* = 1.35 (item *M* = 2.45; item *SD* = .67). This component was labelled as "online learning in mathematics," because the two items included questions regarding online resources etc. Unfortunately, the scores derived from these items had a Cronbach's alpha of .67. These items were therefore deleted to make the scale more reliable because the current alpha is lower than the criterion value of >.80 recommended by Gall et al. (2007).

Thus, the last five items or the last two subscales were deleted from the initial MAT scale and the Cronbach's alpha from the scores of 20 items was .95. The new MAT scale therefore consists of three subscales and has 20 items. From this point onwards, the new MAT scale will be called Malik Attitudes Instrument (MAI).

Discussion

The purpose of this study was first to develop an instrument to measure undergraduate students' attitudes toward mathematics and then to validate the scores from its items. The instrument consisted of five subscales: anxiety, enjoyment, self-confidence, value, and technology. The first four subscales anxiety, enjoyment, self-confidence, and value were the overarching themes that were found across the research articles. The technology dimension was added as the fifth subscale of attitude toward mathematics. Each of the five subscales were comprised of five items. The items for four subscales were found in literature whereas the items for the fifth subscale were written on my own. The initial MAT was administered to undergraduates enrolled in College Algebra course. The data collected was analyzed to answer the research question: if and how do undergraduate students' attitudes toward mathematics load using Principal Components Analysis (PCA)?

The analysis led to the extraction of five subscales that were named as follows: anxiety-self-confidence (collapsed due to data analysis), value, enjoyment, technology in mathematics, and online learning in mathematics. Subscale I consists of 10 items, whereas subscale II, and subscale III, each have five items. Refer to Appendix B for the items of each of these subscales.

Subscale IV, technology in mathematics scale, had only three items (a) I am comfortable using technology in math class, (b) mathematics is easier to understand with technology than without it, and (c) calculators are an important (piece of) technology in my math classes. Subscale V, on the other hand, consisted of only two items: (a) I like using online resources, such as educational videos and PowerPoint lectures, when learning mathematics, and (b) online homework facilitates my learning of mathematical concepts.

Cronbach's alphas were calculated to estimate internal consistency and reliability of the scores on each of the five subscales. The Cronbach's alpha coefficients from subscales I (.93), II (.86), and III (.90) were higher than .80, the value recommended by Gall et al. (2007), whereas those from subscales IV and V were lower than .80. The low alpha coefficients for the final two scales may be a result of the few number of items that comprised the scales. Subscales 1V and V, along with their items, were therefore deleted from the survey and require additional attention if they are to be used in future iterations of the instrument. Further details about the decision to delete the two subscales is included in the following paragraphs. Thus, the final form of MAT scale called Malik Attitudes Instrument (MAI) consists of 20 items and the following three subscales: anxiety-self confidence in mathematics, value of mathematics, and enjoyment of mathematics (Refer to Appendix B for Malik Attitudes Instrument (MAI)).

Subscale I, anxiety-self/confidence scale, is a mix of both the anxiety and self-confidence subscales of the initial MAT. Most of the loadings are strong with r = .846 being the largest and r = .510 being the lowest. Also, there are no split-loadings among the variables or items and subscales. All the 10 items seem to load really well on this subscale and are therefore part of the MAI.

Interestingly, the ATMI that Tapia and Marsh (2004) employed also had two of the original six variables, anxiety and confidence, combined to form a single factor, self-confidence. The original six scales of the ATMI were confidence, anxiety, value, enjoyment, and motivation, and the structure was explained by the four-factor model including students' self-confidence, value, enjoyment, and motivation as underlying dimensions of attitudes toward mathematics. The findings of the present study are in agreement with the results of the previous study by (Tapia and Marsh, 2004)

The correlations of the five items on subscale II, the value scale, range between .639 and .812, indicating that all of these items load fairly well on this subscale with one item having a split-loading of $r = .412$ with subscale I. This might be because this item is worded as an individual's perception about studying advanced mathematics, all the other four have very general wording. Rewording it similar to others may fix this problem. The value subscale found in the present study has also been identified as an important factor of attitude toward mathematics in the works of numerous researchers including, but not limited to, Aiken (1974), Chapman (2003), Tapia (1996) and Tapia and Marsh (2000; 2004).

Subscale III, the enjoyment scale, also consists of five items, however, four of these have split-loadings with subscale I. This might be because students' anxiety may have factored into their responses while completing the survey. Since most of the questions are worded as students' own perceptions and abilities about mathematics, this could be a possibility. To rectify this issue, rewording the items and making them more general than they currently are may be helpful in fixing these split-loadings. The factor loadings among this subscale and its items range between .580 and .711. This indicates that all the five items had fairly decent factor loadings ($r > .30$) with the enjoyment subscale (Tabachnick & Fidell, 2007). Similar to the value scale, subscale III, the enjoyment scale, identified in the present study has also been the most frequently occurring dimension of attitude toward mathematics mentioned by Aiken, (1974), Chapman (2003), Tapia (1996) and Tapia and Marsh (2000; 2004).

Subscales IV and V were of some concern in instrument design due to their extremely low number of items. In accordance with many instrument design experts, Anderson and Bourke (2000) recommend that at least four or more items constitute a subscale. The basic reason for having at least four items pertains to the stability of the subscale. Using only two to three items increases the pressure that all items are correctly interpreted. The reason for deleting subscales IV and V was mainly that they did not have the minimum desired number of four items. Additionally, the Cronbach's alphas make these subscales quite suspect, which is likely due to having less than four number of items, because alpha stabilizes with items. Even though the fifth subscale "online learning in mathematics" looks most promising with the load numbers, .766 and .885; due to not having enough items (only two) and due to Cronbach's alpha being moderate (α = .67), it could not be retained. Due to similar reasons, fourth subscale "technology in mathematics" was also deleted. As a reminder, these items were deleted to make the scale more reliable because the current alpha is lower than the criterion value of >.80 recommended by Gall et al. (2007).

After deleting the last five items or the last two subscales from the initial MAT scale, the Cronbach's alpha was recalculated using the scores from 20 items and was found to be α = .95. This is a very impressive alpha coefficient for reliability. As a reminder, the Cronbach's alpha from the 25 items of the initial MAT form was α = .93. This means that employing the Malik Attitudes Instrument (MAI) would yield more consistent results in repeated uses than the initial MAT form. The Malik Attitudes Instrument (MAI) is therefore slightly more reliable as compared to the initial MAT form, though with an initial reliability of .93, it is difficult to be much more reliable than the first iteration of the instrument. The decision to get rid of the last five items was therefore made to improve reliability.

Although the subscales of attitude toward mathematics found in this study are in agreement with those of previous studies; the methods and findings of this study are far more consistent with those of Chapman's (2003) study. Similar to the present study, the results from Principal Components Analysis and Exploratory Factor Analysis in Chapman's study also indicated that the 10-item instrument 'How I Feel About Math Scale' (HIFAMS) consisted of three subscales, though the current MAT expanded the ability of the instrument to collect much-needed data. The three subscales in Chapman's work were: (a) a reflection of students' overall enjoyment of mathematics, (b) students' perceptions of value of mathematics, and (c) students' perceptions of their ability to deal with assignments in mathematics. These three components correspond to the enjoyment, value, and self-confidence subscales of the Malik Attitudes Instrument (MAI) of this study. Additionally, the three components of HIFAM scale were generally found to have acceptable reliability and validity. Even though the sample of Chapman's study consisted of students from grades four through six, there are interesting parallels with this study. Thus, the results of the current study provide further support for the existence of these three subscales in the instruments assessing students' attitudes toward mathematics. In addition, this study has shown that an instrument initially created for upper grade elementary students could be appropriately adapted for use with undergraduate college students.

Conclusion

This sample of this study was overwhelmingly business major undergraduates (76%), so the results will be generalizable to schools with similar population. Also, the study was conducted with College Algebra students only; mostly freshmen, and the results might be different if students from higher level undergraduate mathematics courses, such as Calculus and Linear Algebra were included. Also, the school where this study took place consisted of mostly white students (66.7%); the results are therefore generalizable to schools with similar demographics. The fact that all of the participants were from the same academic institution limits the ability of these findings to be generalized to a larger, more diverse population. Additionally, in this survey study, due to the participants' awareness about being studied, some students may have responded to the survey questions inaccurately or reactively, which may have influenced the results to some extent. Finally, since in this non-experimental survey study there was no random assignment of participants to a control or treatment group, therefore it is not possible to generalize the sample results to general population.

Now that Malik Attitudes Instrument (MAI) has been developed and is reduced to 20 items that are clearly stated, the MAI holds promise for providing researchers and educators with a brief instrument to assess their students' attitudes toward mathematics that is valid and suitable for use with students in algebra courses. Future researchers can adapt MAI for use in different math classes and not just algebra courses. Also, some researchers may translate MAI from English to different languages and assess the scores obtained from their samples for validity and reliability.

Even though the last two subscales were deleted due to having less than four items; in future research, more items can be added to these subscales. The existing items on these subscales have fairly decent factor loadings and thus they need no modification. As a reminder, a subscale needs to have more than four items to be retained (Anderson & Bourke, 2000).

It is suggested that further researchers include undergraduates from different majors, such as psychology, mathematics, liberal arts, engineering and conduct research examining their attitudes toward mathematics using MAI. Future researchers may also do a comparison of undergraduates' attitudes toward mathematics based on their ethnicities using MAI.

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Appendix A—Initial MAT Form

Anxiety Subscale

1. Mathematics is not confusing.
2. I have usually been at ease during math courses.
3. I don't panic when I think about trying hard math problems.
4. I have usually been at ease during math tests.
5. It wouldn't bother me to take more math courses.

Enjoyment Subscale

6. I really like mathematics.
7. I enjoy working algebra problems.
8. I enjoy my math lessons.
9. I am happier in a math class than in any other class.
10. I have usually enjoyed studying mathematics in school.

Self-Confidence Subscale

11. I have a lot of self-confidence when it comes to mathematics.
12. I can keep up with the work we do in math courses.
13. I am able to solve mathematics problems without too much difficulty.

14. I am confident that I could learn advanced mathematics.
15. I expect to do fairly well in any math class I take.

Value Subscale

16. Mathematics is important in everyday life.
17. Mathematics is a very worthwhile and necessary subject.
18. A strong math background could help me in my professional life.
19. Mathematics helps develop a person's mind and teaches him to think.
20. I think studying advanced mathematics is useful.

Technology Subscale

21. I am comfortable using technology in math class.

22. Mathematics is easier to understand with technology than without it.
23. Calculators are an important (piece of) technology in my math classes.
24. I like using online resources, such as educational videos and PowerPoint lectures, when learning mathematics.
25. Online homework facilitates my learning of mathematical concepts.

Appendix B—Malik Attitudes Instrument (MAI)

Anxiety-Self Confidence Subscale

1. Mathematics is not confusing.
2. I have usually been at ease during math courses.
3. I don’t panic when I think about trying hard math problems.
4. I have usually been at ease during math tests.
5. It wouldn’t bother me to take more math courses.
6. I have a lot of self-confidence when it comes to mathematics.
7. I can keep up with the work we do in math courses.
8. I am able to solve mathematics problems without too much difficulty.
9. I am confident that I could learn advanced mathematics.
10. I expect to do fairly well in any math class I take.

Value Subscale

11. Mathematics is important in everyday life.
12. Mathematics is a very worthwhile and necessary subject.
13. A strong math background could help me in my professional life.
14. Mathematics helps develop a person’s mind and teaches him to think.
15. I think studying advanced mathematics is useful.

Enjoyment Subscale

16. I really like mathematics.
17. I enjoy working algebra problems.
18. I enjoy my math lessons.
19. I am happier in a math class than in any other class.
20. I have usually enjoyed studying mathematics in school.

Appendix C—Total Variance Explained

Initial Eigenvalues				Extraction Sums of Squared Loadings		
Component	*Total*	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	10.508	42.033	42.033	10.508	42.033	42.033
2	2.712	10.849	52.882	2.712	10.849	52.882
3	1.756	7.026	59.907	1.756	7.026	59.907
4	1.216	4.865	64.772	1.216	4.865	64.772
5	1.053	4.211	68.983	1.053	4.211	68.983
6	.789	3.155	72.138			
7	.681	2.724	74.862			
8	.666	2.664	77.527			
9	.571	2.283	79.809			
10	.535	2.139	81.948			
11	.509	2.037	83.985			
12	.472	1.889	85.874			
13	.442	1.769	87.643			
14	.405	1.621	89.264			
15	.379	1.514	90.776			
16	.357	1.429	92.207			
17	.343	1.373	93.580			
18	.287	1.148	94.727			
19	.247	.987	95.714			
20	.224	.897	96.610			
21	.190	.760	97.370			
22	.189	.755	96.125			
23	.176	.706	98.830			
24	.153	.612	99.442			
25	.140	.558	100.000			
Note: Extraction Method: Principal Components Analysis						

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