

A COMPARATIVE STUDY OF MATHEMATICS SELF-EFFICACY AND ANXIETY LEVELS OF GRADES 10-12 STUDENTS AT THAI CHRISTIAN SCHOOL BEFORE AND AFTER SUPPLEMENTAL PRACTICE USE OF THE MATHEMATICS E-LEARNING APPLICATION WEBSITE KHAN ACADEMY

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Abstract: The purpose of this study was to determine if students' mathematics self-efficacy could be increased and their mathematics anxiety could be reduced by adding supplemental mathematics practice using the internet-based website Khan Academy to increase mastery experiences in solving mathematics problems. The study focused on 156 Grades 10-12 students at Thai Christian School in Bangkok. A research experiment was conducted during the course of the second semester of the 2016 school year based on Bandura (1977) sources of self-efficacy (mastery experience, vicarious experiences, verbal persuasion, psychological factors). During the experiment, the students received weekly supplemental mathematics practice by homework recommendations from the researcher sent using the Khan Academy website. A comparison was made between the students' mathematics self-efficacy and mathematics anxiety before and after the research experiment and after the research experiment. The research included four objectives. Objectives one and two were to determine students' mathematics self-efficacy levels and mathematics anxiety levels at the beginning and end of the research experiment. Objectives three and four were to determine if a significant increase in mathematics self-efficacy and a significant reduction in mathematics anxiety could be achieved through the addition of supplemental mathematics exercises using the mathematics e-learning website Khan Academy. The major findings in this research were that the average students' mathematics self-efficacy increased, and the average students' mathematics anxiety was reduced in all three-program emphasis (mathematics science, mathematics-English, English-Chinese). Overall Mathematics self-efficacy increased significantly for the entire sample and mathematics anxiety reduced significantly for the entire sample.

Keywords: Mathematics, Self-Efficacy, Anxiety, E-Learning, Khan Academy.

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Introduction

Self-efficacy is a multidimensional construct composed of mastery experiences, vicarious experiences, verbal praise and emotional arousal (Bandura, 1977). Self-efficacy levels determine the amount of effort a person will expend, and the resultant actions when confronted with obstacles – quit or persevere (Bandura, 1977). The higher the level of self-efficacy, the more perseverance and effort the person will expend when faced with obstacles, and less likely to give-up. In the face of failure and obstacles, people with high self-efficacy increase and maintain their efforts, while people with low self-efficacy will avoid the problem and give-up (Bandura, 1994).

Anxiety can result from either internal variable within a person from an unconscious arousal without thinking about the immediate situation (trait anxiety), or based on the situation (state anxiety). Mathematics anxiety is experienced across all ages and is correlated with poor performance in mathematics from elementary school through university. Due to mathematics anxiety's widespread occurrence and correlation to poor mathematics performance, it is important to understand it and to find methods to alleviate it (Beilock & Willingham, 2014). Clark (2004) researched concluded that mathematics anxiety level reducing techniques need to be central to any program seeking to improve mathematics performance.

Phillips (2014) reported that Thailand is rated among the top four countries (Tunisia, Argentina, Brazil, and Thailand) that have the highest mathematics anxiety among 15-year-old students. Phillips (2014) also noted that Thai students have both high mathematics anxiety and low mathematics performance.

Khan Academy has been studied in the United States with positive results. It has been used as the primary learning resource in a flipped classroom (Cotterell, 2013). It has shown positive results (e.g., increased test scores, and increased confidence to learn independently) when used as a supplemental tool for students to gain self-efficacy in the Mathematics classroom (Murphy, Gallagher, Krumm, Mislevy, & Hafter, 2014).

Research Objectives

Four research objectives were designated for this research.

1. To determine the levels of students' mathematics self-efficacy of Grades 10-12 students at Thai Christian School before and after using Khan Academy as a self-guided e-learning mathematics application website an average of 45 minutes a week during the second term of the 2016 school year.
2. To determine the levels of students' mathematics anxiety of Grades 10-12 students at Thai Christian School before after using Khan Academy as a self-guided e-learning mathematics application website an average of 45 minutes a week during the second term of the 2016 school year.
3. To determine if there is a significant increase in the level of mathematics self-efficacy of Grades 10-12 students at Thai Christian School after using Khan Academy as a self-guided e-learning mathematics application website an average of 45 minutes a week during the second term of the 2016 school year.
4. To determine if there is a significant reduction in the level of mathematics anxiety of Grades 10-12 students at Thai Christian School after using Khan

Academy as a self-guided e-learning mathematics application website an average of 45 minutes a week during the second term of the 2016 school year.

Research Hypotheses

The following two research hypotheses were examined.

1. There is a significant increase in the level of mathematics self-efficacy of Grades 10-12 students at Thai Christian School after using Khan Academy as a self-guided e-learning mathematics application website an average of 45 minutes a week during the second term of the 2016 school year at the .05 significance level.
2. There is a significant reduction in the level of mathematics anxiety of Grades 10-12 students at Thai Christian School after using Khan Academy as a self-guided e-learning mathematics application website an average of 45 minutes a week during the second term of the 2016 school year at the .05 significance level.

Conceptual Framework

After synthesizing the literature relevant to this research, the conceptual framework depicted in Figure 1 was developed. In such framework, the notions of self-efficacy and anxiety are explored in the mathematics classrooms of Grades 10-12 students at Thai Christian School (TCS) in Bangkok. During one semester, students were given supplemental mathematics instruction using Khan Academy website, through which students had opportunities to gain mastery experiences, receive verbal encouragement, and share vicarious experiences about completing recommended exercises on Khan Academy weekly during regular scheduled classroom learning time. Students were given the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (May, 2009), before and after the introduction of supplemental mathematics practice to determine their before and after levels of mathematics self-efficacy and mathematics anxiety. This information was used to determine if there was any significant change from the using Khan Academy website for supplemental mathematics instruction and practice exercises.

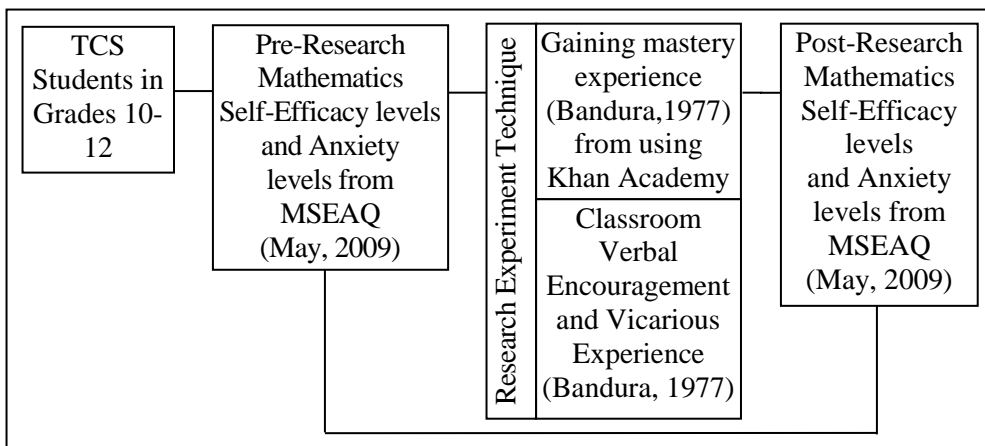


Figure 1: Conceptual Framework for the Present Study

Literature Review

Self-Efficacy Theory

Self-efficacy is a person's belief of ability to successfully accomplish certain tasks (Bandura, 1977). If a person has a belief that they can achieve a goal, they will tend to persist in working towards the task, despite having strong doubts about success (Bandura, 1977).

Self-efficacy beliefs are a major factor that determines the level of effort people will put into a task and the length of time they will continue to exert effort when difficulties arise. People with high-efficacy levels expect success from their efforts. They will exert greater effort and try more techniques and strategies when they expect their efforts to result in success (Pajares, 2002). In the face of failure, or after setbacks, they increase their effort and sustain their effort expecting success (Bandura, 1994). Students with lower self-efficacy levels tend to have lower motivation and lower effort and persistence in trying to understand concepts, and give up quickly when the answer is not obvious (Bandura, 1977).

Factors Affecting Self-Efficacy

According to Bandura (1977), self-efficacy is derived from four sources: mastery experiences, vicarious experiences, verbal persuasions, and emotional arousal.

Mastery experiences are the accumulation of a person's personal successful experiences in a subject area. The strongest contributing source to self-efficacy is mastery experiences, because they come from the individual's personal accomplishments and not from observations of others or encouragement from external sources (Bandura, 1977). Additional positive mastery experiences increase self-efficacy and reduces defensive behaviors and lowers anxiety allowing clearer thinking abilities (Bandura, 1977). Past successful experiences can have a lasting effect on self-efficacy (Usher & Pajares, 2009). Conversely, early failures or successive failures reduce self-efficacy levels. Repeated successive failures in attempting mastery experiences reduce self-efficacy levels and increase avoidance behavior (Bandura, 1977).

Vicarious experiences are internal beliefs generated from observing another student, perceived to be of similar abilities, performing the desired behavior successfully without out adverse consequences. It is a belief of a person that if other people, that are thought to be of similar abilities, can accomplish the goal, then they can also achieve the goal or at least make progress towards the same task (Bandura, 1977). But, since this factor depends on observations of others, and the perception of equal abilities, it is not as strong or reliable as mastery experiences (Bandura, 1977). The impact of vicarious experiences is greatly influenced by the perceived similarities between the student and the model (Bandura, 1994).

Verbal persuasions are words of encouragement from another person. It is an attempt, possible without any valid evidence, to make someone believe they can accomplish a task that has possibly overwhelmed them in the past. Verbal persuasion can be positive or negative. This aspect of self-efficacy, like vicarious experiences, is also weak since it is not generated from within one's own accomplishments (Bandura, 1977).

Emotional arousal refers to elevated feelings. They originate from a person's perception of the situation and from fear of failing. Fear of a pending situation can result in higher anxiety that results in the actual situation (Bandura, 1977). Emotional arousal is interpreted through cognitive processes. People with high self-efficacy levels often interpret heightened emotional arousal as stimulating and enhance performance. People with low self-efficacy levels usually interpret heighten emotional arousal as pending failure and the fear and anxiety are elevated and performance inhibited (Bandura, 1977).

Mathematics Self-Efficacy

Mathematics self-efficacy is concerned with the confidence levels to successfully perform tasks using mathematics and ability to perform well in a course requiring the use of mathematics (Hackett, 1985). Pajares and Miller (1995) stated the importance of the self-efficacy construct being measured be closely related to the performance. Mathematics self-efficacy related to solving a particular set of problems may predict performance about solving problems, but may not predict the ability to solve other types of problems.

Previous Research on Increasing Mathematics Self-Efficacy

Klinger (2006) performed a research study at Flinders University in Australia among students with negative experience in learning mathematics. A course was offered to present mathematics as a process, instead of a set of formulas and to provide a supportive environment to remove the stigma of mathematics. During the pre-test and post-test test analysis, all the self-efficacy indicators on the questionnaire moved in the positive direction.

Moradpour et al. (2016) investigated the effects of the effects of the *Know, want to know, Do, Learn* (KWDL) approach on high schoolers in Tehran. The results of the research showed an increase of mathematics self-efficacy levels in the test group implementing the KWDL approach, and a stable level of mathematics self-efficacy in the control group.

Anxiety Theory

Anxiety is a person's interpretation of heightened emotional arousal. Emotional arousal can be interpreted in a positive way increasing performance, or in a negative way increasing anxiety levels. Increases in anxiety levels are often due to a person's low self-efficacy belief that his lack of ability in an area will lead to failure (Bandura, 1977). High anxiety levels can be reduced by increased mastery experiences, thereby reducing performance inhibiting negative emotional arousal (Bandura, 1977). Avoidance behavior, resulting from elevated anxiety levels, is frequently the result low self-efficacy levels and beliefs about the lack of skills to handle the situation (Bandura, 1977).

Mathematics Anxiety Theory

Kvedere (2014) defined mathematics anxiety levels as the amount an individual's interpretation of emotional arousal increases in response to needing to use mathematics, such as feelings of pressure to perform well, feelings of inadequacy to

perform mathematic functions in life, and fear about the ability to perform well on a mathematics test.

Previous Research on Reducing Mathematics Anxiety Levels

Clark (2004) studied the extent of mathematics anxiety in high schoolers in Los Angeles County. He concluded that mathematics anxiety level reducing techniques need to be central to any program seeking to improve mathematics performance. Beilock and Willingham (2014), researching on university students in America, stated that, in order to be able to reduce mathematics anxiety levels, it is important to understand the source of mathematics anxiety levels and the people most affected by it.

Relationship Between Self-Efficacy and Anxiety

Anxiety can weaken efficacy in students. By lessening anxiety, self-efficacy can be increased (Bandura, 2012). Schulz (2005), on examining the PISA 2003 data, found a negative correlation between mathematics self-efficacy levels and mathematics anxiety levels.

Mathematics e-Learning Application Website Khan Academy

Khan Academy is an e-learning application website with an extensive variety of learning videos on mathematics and many other topics. Its mathematics topics are setup as missions aligned with each grade level and mathematic topic taught in the United States (KhanAcademy, 2016).

Previous Research on Khan Academy for Learning Mathematics

Light and Pierson (2014) reported on a three-year pilot program sponsored by Intel for using Khan Academy in Chile. The study used Khan Academy website on over 5,000 students in 48 different schools. Students practiced skills, and the computer later returned to the same skills for the students to practice again providing mastery experiences. Students would learn at their own pace, allowing students to focus on their needs and progress faster.

Cotterell (2013) conducted research on the use of Khan Academy in 48 Idaho schools, involving 12,000 Idaho students in to use Khan Academy in a flipped classroom. Teachers had to make the transition from being the focal point (teacher centered) of the classroom to a facilitator of student self-learning. After the pilot program finished, schools recommended to the district to use the same approach in the rest of the district schools.

Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ)

MSEAQ questionnaire (May, 2009) was designed to measure changes in levels of mathematics self-efficacy and levels of mathematics anxiety. The motivation for the development of the MSEAQ questionnaire was to create a valid and reliable instrument to measures students' mathematics self-efficacy levels and mathematics anxiety levels.

Methodology/Procedure

The purpose of this research was to investigate the supplemental use of the mathematics e-learning application website Khan Academy at TCS mathematics classes' Grades 10-12 to increase mathematics self-efficacy levels and reduce mathematics anxiety levels.

The students were mixed male and female, mostly Thai nationals attending TCS, a private bilingual (Thai and English) school. There were 68 students in Grade 10, 45 students in Grade 11, and 43 students in Grade 12 in three different programs based on their interest: Mathematics-Science, Mathematics-English, and English-Chinese. For this study, a comparative experimental research pre-test and post-test design was developed and conducted to measure changes in mathematics self-efficacy and mathematics anxiety during an experiment period of one semester (about 16 weeks). The research experiment was designed to increase mathematics self-efficacy through adding supplemental mathematics practice as homework to gain mastery experiences using the website Khan Academy, as well as through the researcher giving verbal encouragement and students sharing vicarious experiences of progress using Khan Academy in the classroom.

The possible effectiveness of the supplemental exercises was assessed by measuring the mathematics self-efficacy and mathematics anxiety at the start and at the end of the second terms of the 2016 school year. The mathematics self-efficacy and mathematics anxiety levels were measured using the MSEAQ questionnaire (May, 2009).

The researcher allocated 20% of the term mathematics grade as an incentive for completion of the recommended supplemental exercises. Students' completion status of the Khan Academy exercises was monitored and posted weekly in the students' classroom. Students who showed inadequate progress were reminded of the required exercises.

At the end of the research, descriptive statistics and statistical hypothesis testing were used to determine if any significant increase occurred in the mathematics self-efficacy levels, as well as significant reductions in mathematics anxiety levels of the students.

Research Instrument

In order to accomplish the objectives of this research, the research instrument known as Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) was chosen. This is a 28-item questionnaire, developed by May (2009), where students are asked to respond to statements relating to their mathematics self-efficacy and mathematics anxiety levels. There are 13 items relating to mathematics self-efficacy and 15 items relating to mathematics anxiety. The items are measured on a 5-point Likert-type scale from 1 (*never*) to 5 (*usually*) for students to indicate the frequency the statement applies to them.

Findings

The finding from Objective 1 revealed an increase in the average mathematics self-efficacy of all the students and in each of the three programs. The mean mathematics self-efficacy of students in the Mathematics-Science program was higher at the start

of research and at the end of research than the students in the Mathematics-English program and English-Chinese program. No students in the English-Chinese program had high mathematics self-efficacy. The percentage of students with very low mathematics self-efficacy was highest in the English-Chinese program followed by the Math-English program. This result suggests that students with lower mathematics self-efficacy tended to avoid the Mathematics-Science program.

The finding from Objective 2 revealed there was a reduction in the average mathematics anxiety over the entire sample of 156 students in each of the three-program emphasis. At the end of the research, there were no students considered to have very high mathematics anxiety. The mean mathematics anxiety of students in the Mathematics-Science program was lower at the start of research and at the end of research than the students in the Mathematics-English program and English-Chinese program. This finding suggests that students with higher mathematics anxiety tended to avoid the Mathematics-Science program.

The finding from Objective 3 revealed a significant increase in mathematics self-efficacy in all the students in Grades 10 to 12 and for each individual program emphasis. This finding suggests that mathematics self-efficacy can be increased in high school students with different interest and different starting levels mathematics self-efficacy through increased mastery experiences from supplemental internet-based mathematics websites like Khan Academy.

The finding from Objective 4 revealed a significant reduction in mathematics anxiety in all the students in Grades 10 to 12. The conclusion about reducing mathematics anxiety in each individual program emphasis was initially inconclusive. Taking outliers into account, all three programs individually revealed a significant reduction. This finding suggests that mathematics anxiety can be reduced in high school students through increased mastery experiences from supplemental internet-based mathematics websites like Khan Academy.

Discussion

As it is discussed below, this study not only provides new evidence on the implications of using Khan Academy for supplemental practice in the mathematics classroom, but also is consistent with previous studies on mathematics self-efficacy and mathematics anxiety.

Mathematics Self-Efficacy Levels

Students in the mathematics-science program had the highest mathematics self-efficacy, followed by students in the Mathematics-English program and finally the English-Chinese program. Pajares and Miller (1995) stated people make choices in their life based on their beliefs that they are capable of successfully performing. Hackett (1985) research found students' mathematics self-efficacy was correlated to their mathematics achievements and to their choice or majors involving mathematics. The research results agree with previous research that students with higher mathematics self-efficacy tend to have greater self-confidence and belief in success to choose the Mathematics-Science program. Students with lower mathematics self-efficacy seem to have the tendency to choose the English-Chinese program, which requires a lower level of mathematical ability.

Based on eight years teaching mathematics to junior high and high school students in Bangkok in a Thai-English bilingual program, the researcher has observed the students in the Mathematics-Science program tend to have the highest motivation and greatest perseverance for learning mathematics. The students in the English-Chinese program tend to have the lowest motivation for learning mathematics and give-up quickly before even trying to understand. The findings from Objective 1 of this study revealed that students in the Mathematics-Science program had the highest average mathematics self-efficacy levels, while students in the English-Chinese Program had the lowest ones.

Mathematics Anxiety Levels

Students in the Mathematics-Science program had the lowest mathematics anxiety, followed by students in the Mathematics-English program and finally the English-Chinese program. The researcher has observed in eight years of teaching that students in the English-Chinese program have had many bad experiences in mathematics classes. Fear of failure raises anxiety levels (Bandura, 1977). Students choosing the English-Chinese program often expect to fail mathematics exams and have high mathematics anxiety. The results of this research confirmed previous ones, stating that students with a history of negative experiences in the math classroom tend to have high mathematics anxiety (Clark, 2004).

The results imply that students with high mathematics anxiety tended to avoid school programs that required greater mathematics skills and frequently choose the English-Chinese program. This result confirms previous research about students' choices based on their beliefs about success or failure (Pajares, 2002).

Increasing Mathematics Self-Efficacy

A positive finding of this research revealed a significant increase in mathematics self-efficacy for all Grade 10-12 students. Different researchers have investigated ways to increase mathematics self-efficacy. For example, Schunk (1991) found mathematics self-efficacy can be increased by goal setting and rewards and by teaching problem solving strategies, which is a fundamental aspect of the Khan Academy website. (Bandura, 1977) stated mastery experiences is the strongest source of self-efficacy, which is another fundamental aspect of the Khan Academy website.

The philosophy of the Khan Academy website is to establish mastery experience before an exercise task is considered completed. It uses a criterion of 5-in-a-row correct to achieve "practiced" status and retention of knowledge over a period of time to achieve "mastery" status (KhanAcademy, 2016). When students successfully complete five problems in a row correctly, they felt success and gained confidence (Khan, 2012).

This research set achievable goal for achieving mastery experiences on supplemental mathematics exercises provided by the Khan Academy website. Videos demonstrating problems solving techniques as well as step-by-step hints were available and used by the students to assist students to obtain mastery experiences. This finding supports previous research that mathematics self-efficacy can be increased by providing mastery experience and setting achievable goals (Schunk, 1991).

This researcher used Khan Academy as a learning resource to provide mastery experience, along with classroom verbal encouragement and vicarious experience. The significant increase in mathematics self-efficacy finding supports previous research on the effects of providing mastery experiences, verbal persuasion and vicarious experiences on increasing self-efficacy (e.g., Cotterell, 2013).

Reducing Mathematics Anxiety

Based on getting a significant increase in mathematics self-efficacy in all the students in the research, the research expected to see a reduction in mathematics anxiety. Schulz (2005), on examining the PISA 2003 data found that in the area of mathematics there was a negative correlation between mathematics self-efficacy levels and mathematics anxiety levels. The findings of this study support Schulz's (2005) research results, of an inverse relationship between mathematics self-efficacy and mathematics anxiety.

Recommendations

The recommendations of the study are intended for students, teachers and school administrators at Thai Christian School, as well as to future researchers interested in conducting similar studies.

Recommendations for Students:

This research revealed that students that gain mastery experience on mathematics topics increase their mathematics self-efficacy. Students should strive to change their attitudes towards homework from simply completing mathematics homework, without concern for correctness, to gaining mastery experience by checking correctness of work and striving to accurately complete mathematics homework.

Recommendations for Teachers:

This research demonstrated that mathematics self-efficacy can be significantly increased in high school students by providing resources for students to obtain mastery experiences. Since self-efficacy is significantly positively correlated with performance (Bandura, 1977), teachers should strive to adapt teaching methods and resources to increase self-efficacy. Teachers should discourage students from turning-in mathematics practice exercises with many errors. Since mastery experience has been shown as the strongest source to increase self-efficacy (Bandura, 1977), teacher should provide students resources to learn and exercises to obtain mastery experience and the expectation. It is important to provide students with resources that will enable them practice problems until mastery experience is achieved and provide a learning environment to assist students learning to be able to successfully obtain mastery experience.

Recommendations for Administrators:

This research suggests the important of mathematics mastery experience for improved mathematics self-efficacy. Administrators could encourage teachers to provide learning opportunities to obtain mastery experience by check lesson plans

include objectives that focus on mastery experience and not just completion of a task. Books could be selected that provide opportunities for mastery experience.

Recommendations for Future Researchers:

This research had limitations due to using limited grade levels, short time frame, mostly Thai students, only middle-class students, and no control group. Future researchers could use the results of this study to expand research to include

- other grade levels,
- stricter consequences for lack of performing supplemental exercises,
- longer period of time (1-2 years),
- international schools,
- students in different socio-economic schools and
- the addition of a control group.

This research used mastery experiences as the primary method to increase mathematics self-efficacy combined with verbal encouragement and vicarious experiences (Bandura, 1977). Future research may try other resources to provide students with mastery experience resulting in increased mathematics self-efficacy and reduced mathematics anxiety.

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