Students' Attitudes Toward Mathematics In Vocational Education: From Perspectives Of A Developing Country

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Abstract: There is a growing concern about students' attitudes toward mathematics in vocational education. However, not much is known regarding the factors that affect these attitudes. In this study, a new conceptual model is developed based on van Aalderen-Smeets and colleagues' theoretical framework of teachers' attitudes to explore the factors that affect students' attitude toward mathematics in vocational education. The new conceptual model consists of five constructs of attitudes: perceived difficulty, perceived relevance, anxiety, enjoyment and students' competence. This model would serve as a basis for future study in this field. The model is then tested on a sample of 215 vocational education students. These tests conclude that competence, enjoyment and perceived relevance significantly related to attitude and that competence was the most influential factor of attitude.

Index Terms: Research model, competence, attitude, mathematics, theoretical framework, vocational education, students

1 INTRODUCTION

Technical vocational education and training (TVET) refers to a range of learning experiences which happens in a range of learning environment and is designed to develop the competencies required for certain careers in the workplace [28]. UNESCO-UNEVOC [28] notes that TVET concentrates on training for specific occupations, training young people for the labour market and developing the skills of adults in the workplace. Currently, both developed and developing countries have shown interest in TVET due to its contribution to national skills development. As a way of closing the skill gaps, TVET has received national and international recognition in the past years [26]. As a result, nations have started to review their educational systems to meet socio-economic development needs [30]. Kararach, Hanson and Le´autier [11] note that continuous reviewing and revising of TVET curriculum make TVET more open to labour market wants and make a significant contribution to economic growth. Changes in TVET curriculum have added science, mathematics and reading courses that can boost the opportunities of TVET graduates in the labour market and boost their opportunities of gaining admission into higher institutions [18]. But, for many vocational students, mathematics are scary courses. Average and low performing learners tend to recoil from such subjects as they perceive mathematics to be difficult. To become competitive in the labour force, these obstacles must be overcome as the workforce with appropriate knowledge in mathematics are in great demand. Helping vocational students learn more about science and, mathematics to become more competent in solving and analyzing problems has become the objective of educators. However, students' performance and attitudes toward mathematics has over the years been a major problem and hence has attracted the attention of mathematicians, scientists, educators, and researchers [19].

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Several works have given partial meanings of the construct of attitude, gloss over the explanation of the variables of attitude that they tested, or do not differentiate between attitudes toward mathematics or other similar disciplines. Hence, it is uneasy to know precisely what is being tested or explored [4]. In addition, several investigators fail to defend their selections of testing certain elements, or objects of attitudes. These selections are based mostly on logical or simplistic arguments. Due to the misinterpretation of the construct of attitude toward mathematics, ambiguity still exists in scientific inquiry up till now. This ambiguity concerns the distinction between "attitudes toward mathematics" and "scientific attitudes". Many studies that assert to test usually concentrate mainly on testing "scientific attitudes". These attitudes are characterized by scientific thoughts such as inquisitiveness, being analytical about all assertions, a request for proof, or a respect for reasoning. Even though scientific attitudes are relevant to the progress of mathematics in school, they do not comprise what should be thought of as attitudes toward mathematics. Attitudes toward mathematics denotes a range of beliefs, relevance, affections, and behaviors regarding such matters as a person's belief about the level of complexity feature of mathematics, the relevance assigned to mathematics for society, feelings of interest concerning mathematics, and the desire or intention to learn more about mathematics. In this study, attitudes toward mathematics is the focus. Many studies have investigated students' attitudes toward mathematics mostly in elementary, middle, high and postsecondary education [23], but little is known about learners' attitudes toward mathematics in vocational education [2]. To address the above-mentioned issues, this study develops a new comprehensive research model to explore students' attitudes toward mathematics in vocational education. The components for this new research model were taken from van Aalderen-Smeets, Walma Van der Molen, and Asma's theoretical framework (2012). This is because the proponents of this theoretical framework pilot tested, validated, and evaluated their measurement instrument based on current psychometric standards [4]. Secondly, the theoretical framework tested attitude towards a subject or discipline (i.e. science) instead of attitudes toward teaching of a subject or discipline (i.e. science). Also, the framework has been mostly applied in developed countries but its application in developing nations such as sub-Saharan African countries is scarce. Finally, to the

best of the researcher's knowledge, no such study based on the new research model derived from [29]'s framework has been carried out in vocational education in Ghana. Moreover, the attention of this study is not on methodological concerns, but mainly on testing of the new research model. Therefore, the contribution of this study is to develop a new model from the [29]'s framework to investigate students' attitudes toward mathematics in vocational education in Ghana. The objectives of this study were to (1) investigate the factors that significantly affect students' attitude toward mathematics. (2) apply [29]'s framework to develop a new research model, to determine whether or not the new research model is acceptable and easy in predicting students' attitudes toward mathematics. The remaining of this paper discussed (i) TVET in Ghana, (ii) Theoretical framework, (iii) New research model, (iv) Hypotheses (v) Research methodology (vi) Results (vii) Discussions, (viii) Implications, and (ix) Limitations of the study, and (x) Conclusions.

2 Technical vocational education and training (TVET) System in Ghana

In Ghana, the educational system was reviewed in 1987 to include vocational education in the primary, secondary and tertiary levels. Vocational technical education is offered in both public and private institutions. The goal of TVET in Ghana is to promote the advancement of prolific labor force by connecting the education systems to the wants of the economy. TVET in Ghana can be grouped into formal and informal and non-formal systems. The formal TVET is taught in academic institutions within a stipulated time period and ends with formal certification. At the primary school level, students are prepared for higher education or occupational skills for gainful employment or self-employment. Graduates from primary level can also go into the informal sector for traineeship. At the secondary school level, an integration of two approaches is used to offer vocational technical education; the parallel system approach and core curriculum approach. For the parallel approach, the vocational technical school system is operated along with the senior high school system. Graduates from the primary level can enroll in the technical schools or the senior high schools. For the core curriculum approach, the conventional senior high school system is used. Graduates from the basic school level who gain admission into senior high schools study core academic subjects and a cluster of elective subjects including vocational technical subjects. After completion, TVET students may enroll in polytechnic institutions for further education to look for a job or engage in apprenticeship. At the tertiary level, vocational technical education is offered at the universities, polytechnics and other post-secondary institutions including Health training institutes, Nursing training colleges, Agricultural colleges, etc. The vocational technical courses offered at the tertiary level are between two and four years and end in obtaining a diploma or a degree certificate. Informal TVET prepares trainees for career and skills development with no formal certificate awarded [7]. The stipulated time period of completion of apprenticeship can range between 24 and 42 months. Non-formal training is offered by community organizations and Non-Governmental Organizations (NGOs). These organizations offer short programmes and seminars to young graduates who did not get admission to secondary education. These trainees can select from a variety of traineeships and courses to study with no certificate awarded. Recently, the Government of Ghana has established a Council for Technical and Vocational Education and Training to coordinate and oversee TVET developments in Ghana.

3 Theoretical Framework

Van Aalderen-Smeets, Walma Van der Molen and Asma [29] developed a theoretical framework to study teachers' attitudes toward science. The framework consists of three major components: cognitive beliefs, affective states, and perceived control (see Fig. 1). Cognitive beliefs refer to individual's ideas and judgment with regards to the attitude object. The cognitive construct consists of three variables including perceived relevance, perceived difficulty and gender roles. Perceived relevance of a discipline is about the relevance and important of a discipline to a person. Perceived difficulty is about individuals' beliefs of the complexity of a discipline. Gender role is about beliefs of different gender roles and proficiencies of males and females in a particular discipline.The affective component is the emotions an individual experiences with respect to the attitude object. The affective constructs are composed of enjoyment and anxiety variables. The enjoyment variable is the extent to which individuals enjoy studying a discipline or the pleasure of participating in various related activities of that discipline. Perceived control is that amount of control a person has over specific tasks. The perceived control constructs consist of self-efficacy and perceived dependency on context factors. Self-efficacy is individual's internal beliefs about his/her capability to execute a particular task. Perceived dependency on context factors is belief that individual has about the influence of external factors on a task. In the framework, behavior and behavioral components are considered outcomes of attitude and not constructs of attitude. Ajzen and Fishbein [1] argue that behavior and behavioral components differ from attitudes and these components should not belong to the construct of attitude itself. Rather, attitudes should be considered as antecedents of behavioral intention, which influences actual behavior.

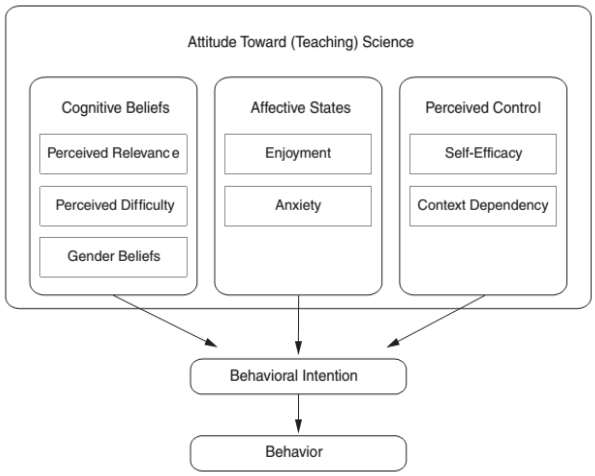

Fig.1. *Van Aalderen-Smeets et al's (2012) model for attitude.*

4 The Research Model of the Current Study

As discussed in the Introduction to this study, the main objective was to develop a new research model to investigate students' attitudes toward mathematics in vocational education. This framework is presented in Figure 1. Compared the original model in Figure 1 to the new model in Figure 2,

three modifications have been done. Initially, the gender belief was eliminated from the cognitive belief construct. Two reasons are assigned to this change: First, the gender beliefs describe the beliefs about differences in attitudes of particular individuals (males and females), while other variables describe the group of individuals altogether. Additionally, [29] found no predictive value of gender beliefs when testing the dimension attitude scale instrument. Hence, the gender beliefs were removed from the model. Furthermore, context dependency was omitted from the new model, because it can be complex to measure. Lastly, self-efficacy was omitted from the framework for the following reasons: (i) Prior studies have found that self-efficacy is viewed as closely related to competence [9] and (ii) prior studies have dealt with a variety of contextual factors with regards to the study of attitudes, however, personal factors such as anxiety and competence have received little attention [16]. Therefore, self-efficacy was taken from the model. Therefore, in this study, the new research model (see fig. 2) comprises of perceived relevance, perceived difficulty, anxiety, enjoyment and competence variables to explore students' attitudes toward mathematics in vocational education. In this study, the original model was modified by introducing competence as a new intrinsic motivational factor into the new model to investigate students' attitudes toward mathematics.

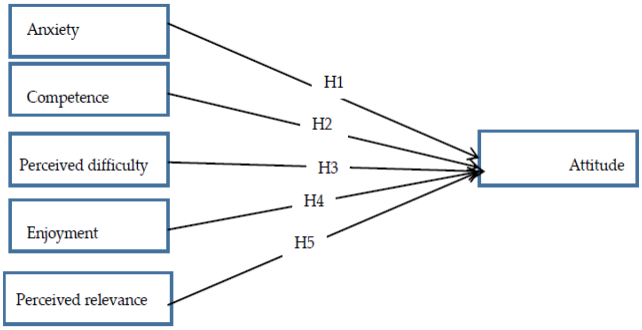

Fig. 2. *The new research model*

5 HYPOTHESES

5.1 Anxiety

Anxiety is an unfriendly expressive response that stems from the experience or judgment of a specific circumstance as scary [24]. Anxiety negatively affects students' learning exercises [31]. Students who have high levels of mathematics anxieties are unlikely to enroll in mathematics programs [8]. Similarly, [12] found that anxiety negatively affected students' attitudes toward the learning of mathematics. Though there have been various reports on users' characteristics and academic variables, there is scarce of research works on the association between anxiety and attitude towards mathematics among students in vocational schools. Therefore, the following hypothesis was developed

H1: Students' anxiety negatively affects their attitudes toward mathematics

5.2 Competence

Dubois [5] defines competency as knowledge, skills, attitudes, and belief patterns, that when applied whether individually or collectively, ends in successful performance. A review of the literature has found that a positive relationship exists between students' attitude towards mathematics and competence [10, 21]. Ramirez [21] indicated that students who had positive attitudes toward mathematics scored higher in mathematics than those who showed negative attitudes toward their studies. Based on the literature, the hypothesis below was formulated.

H2: Students' competence positively affects their attitudes toward mathematics

5.3 Perceived difficulty

Ramirez [21] found that the more students show interest in mathematics, the less difficult they found it, and the less difficult doing mathematics was perceived. Again, [21] asserted that students who perceived mathematics to be difficult scored lower than their colleagues who perceived the subject to be easy. When the perceived difficulty of mathematics is linked to the apprehension of these subjects, the consequence could lead to a high increase in students' anxieties which will then cause strong negative attitudes toward these courses among students. Thus, the following hypothesis was developed.

H3: Students' perceived difficult negatively affects their attitudes toward mathematics

5.4 Enjoyment

It is a fact that students who enjoy learning mathematics keenly contribute in class and engage more in the learning process. In addition, it is more likely that students who enjoy mathematics and science continually work hard without losing interest while solving scientific and mathematical problems [3, 20, 25]. Learners' enjoyment and perceived relevance of mathematics (cognition) can affect their attitudes. Students showing positive attitudes toward mathematics have a higher level of enjoyment and increased ability to work hard resulting in higher attainment [25].

H4: Students' enjoyment positively affects their attitudes toward mathematics

5.5 Perceived relevance

Students' perceived relevance for mathematics can affect their attitudes toward the course. If they know the value and use of mathematics in their lives, they are motivated to put it into practice (Pajares and Miller 1994). There are numerous learners who do not especially delight in mathematics and state that they hate the subject, but they still have respect for the usefulness of the subject in their future lives and careers [14]. Another study also revealed a strong correlation between participation/ achievement in mathematics and students' perception of the relevance of the course, both at present and in the future [15]. Students' attitudes influence their cognitive beliefs. By showing a positive attitude towards mathematics, the learners will believe that mathematics is relevant so that they will strive to study hard to achieve better in mathematics. Therefore, the following hypothesis was developed.

H5: Students' perceived relevance positively affects their attitudes toward mathematics

6 RESEARCH METHODOLOGY

6.1 Participants and data collection

A non-probability convenience sampling method was used to choose the vocational students for the study. The non-probability convenience sampling method helps the investigator to gather data from the respondents based on their accessibility. Also, it allows the investigator to choose the participants who are ready and available to partake in the study. Furthermore, it is less costly and less time-wasting compared with other methods. In total 350 students were selected from two vocational schools in Ghana. The two schools were located in the capital city of Ghana. The classes surveyed included welding technology, mechanical engineering, architectural engineering and electrical and electronics engineering. These occupations were selected because they needed different skills in mathematics. Paper-based questionnaires were administered to the students by the researcher to increase the response rate. Also, the students were notified that their participation in the study was voluntarily and that the information given would not be disclosed to a third party. Before administering the questionnaires, instructional technology experts were consulted to improve the validity of the survey instrument. Finally, the modified questionnaires were given out to the students to answer. Prior to the start of the questionnaires, the researcher explained the questionnaires to the participant. On average, each respondent spent at least 30 minutes answering the questionnaire. Of the 350 questionnaires distributed, 300 students responded to the survey questionnaires representing 85.7% response rate. Of these, 10 questionnaires were dropped due to data incompleteness remaining 290. After data screening, 75 data were deleted leaving 215 data for analysis. The reason for the deletion was that these data were detected as outliers [27] which could affect the result of this study if not deleted. Among the participants, 95.4% were males and 4.6% were females. The average age of all the participants was 19.5 (S.D = .486).

6.2 Survey instrument

Thirty-eight items, plus five demographic items were included in the paper-based survey instrument. Excluding the demographic items, the remaining items were adapted and modified from an instrument developed by [22]. This instrument has been applied to investigate participants' motivation in sports, schools, medical practice, and laboratory experiments [17]. The survey instrument comprised six constructs. The constructs were measured on a 5-point Likert scale with 1 designating strongly disagree and 5 designating strongly agree. Participants were told to complete the 18 statements on the five constructs. The constructs were perceived relevance (seven items), perceived difficulty (seven items), anxiety (five items), enjoyment (six items), perceived competence (seven items) and attitude (three items). Prior to the completion of the final questionnaire, the original questionnaire was pilot-tested to determine the content validity and reliability. The comments received from experts' and students' were added to the questionnaire. The Cronbach's alpha of the survey instrument was .82 signifying a high reliability. Additionally, the alpha values for the constructs ranged from .76 to .84 suggesting good reliability of the constructs [13].

7 RESULTS

7.1 Students' Demographic Data

From Table 1, 95.4% of the students were males while 4.6% were females. Most of the students were in the age bracket of 16-20 (78.5%) while few (21.5%) were in the age range of 21and above 30. Also, the majority of the students (45%) were in year 2 while only small number (3.1%) was in year 4. In addition, over half of the students (58.1%) spent between 0 and 2 hours per a day to study mathematics while the rest (47.4%) spent between 3 and above 8 hours per a day to learn mathematics. Nearly half of the students (49.6%) study electrical and electronics engineering while few of the students (7%) study welding technology.

Table 1
Demographic Data

Variable	Category	Frequency	Percentage
Gender	Male	248	95.4
	Female	12	4.6
Age	16-20	204	78.5
	21-25	51	19.6
	26-30	4	1.5
	>30	1	.4
School year	Year 1	83	31.9
	Year 2	117	45.0
	Year 3	51	19.6
	Year 4	8	3.1
Hours per a day spent on learning mathematics and science	0-2	151	58.1
	3-5	61	23.5
	6-8	7	2.7
	>8	29	11.2
Programme	Welding technology	7	2.7
	Mechanical engineering	46	17.7
	Architectural engineering	78	30.0
	Electrical and electronics engineering	129	49.6

7.2 Multiple Regression Analysis

Prior to the analysis of multiple regression, initial testing of assumption was conducted to establish sample size, outliers, multicollinearity, linearity, normality, and homoscedasticity. First, univariate and multivariate outliers were checked. For the univariate outliers, the normal Q-Q probability plots revealed that the data points were very close to the diagonal line starting from the base to the top indicating that there were no serious outliers present. Additionally, skewness and kurtosis were calculated to check for univariate normality. The values of skewness ranged from -.02 to -.51 and the values of kurtosis ranged from -.45 to .19. Both skewness and kurtosis values indicated approximately normal distribution [13]. For the multivariate outliers, the maximum Mahalanobis distance value for the six continuous variables (14.265) was less than the critical chi-square value for six variables (22.458) indicating multivariate outliers were absent. In all, 75 outliers were removed, leaving 215 cases for data analysis. Second, the sample size was determined. According to [6], 10 or 15 cases per factor are good for data analysis. In this study, with a sample size of 215 and 5 factors, 43 cases per predictor was obtained. Hence the condition was not violated. Third, both the variance inflation factor (VIF) and tolerance values were checked for multicollinearity. Field [6] recommended that the VIF values must be less than 10 and tolerance values must be above .1. The VIF values for the independent variables ranged from 1.08 to 2.00 and the tolerance values ranged from .50 to .93 indicating no breach of multicollinearity assumptions. Fourth, the residual scatter plot showed an approximate

rectangular distribution with points condensed in the centre indicating no linearity and homoscedasticity occurred. Finally, the histogram was approximately similar to the normal distribution curve (mean = 5.39E-15, standard deviation = 0.99) and the normal probability plot was nearly a straight line with a diagonal line extending from the base to the top. These results indicated that no violation of normality occurred. The new research model as shown in figure 2 was tested using the multiple regression analysis. Five independent variables were tested in this research model. These were anxiety, competence, difficulty, enjoyment, and relevance. As shown in Table 2, these five independent variables accounted for 60% of the variance in attitude towards mathematics.

Table 2
Students' Analysis of Variance

Sources	Sum of Squares	Df	Mean Square`	F	R	R^2	Adjusted R^2	*p*
Model	71.688	5	14.388	62.612	.774	.600	.590	.000**
Error	47.859	209	.229					
Total	119.547	214						

Note: ** = *P* < .001

The results of the hypotheses testing of the new research model were shown in Table 3. From Table 3, competence, enjoyment and relevance variables significantly related to attitude. Both anxiety and difficulty did not significantly relate to attitude. Competence was the most influential factor of attitude with β = .345. This was followed by enjoyment with β = .324 and relevance with β = .241.

Table 3
Results of hypotheses testing

Hypotheses		Path	t-value	*p*-value	β-value	Remarks
H1	Anxiety	→ Attitude	1.881	.061	.086	Not supported
H2	Competence	→ Attitude	5.579	.000**	.345	Supported
H3	Difficulty	→ Attitude	-.248	.805	-.013	Not supported
H4	Enjoyment	→ Attitude	5.326	.000**	.324	Supported
H5	Relevance	→ Attitude	4.489	.000**	.241	Supported

Note: ** = *p* < .001

8 Discussions

The analysis of the multiple regression found that the five factors explained 60% of the variance in attitude. Competence was found to be the most influential variable of attitude. This implies that students who feel competent show positive attitude towards the studying of mathematics. This finding is consistent with researchers [10, 21] who found positive relationship between attitude and mathematics. The second influential factor of attitude was enjoyment. This finding corroborated [25]'s study which asserted that students' positive attitudes toward mathematics and science linked with the higher level of enjoyment, increased ability to work and higher attainment. The third influential factor from the result of multiple regression analysis was perceived relevance. This finding implies that students who believe that mathematics are relevant for their future career will not hesitate to learn them. By knowing the relevance of mathematics and science, students will demonstrate a positive attitude towards learning of mathematics and science, hence resulting in higher performance in those subjects. The results of this study showed that competence, enjoyment and perceived relevance significantly predicted students' attitudes toward the study of mathematics. But, perceived difficulty and anxiety did not significantly predict students' attitudes toward the study of mathematics and science. This study developed a new framework from [29] model to investigate students' attitudes toward the learning of mathematics in vocational education. A substantial contribution of this study is to show the significance of competence as a predictor of attitude in the setting of mathematical studies. This variable has earlier been tested and proven to be significant but had not been incorporated into [29] model nor had it been examined with regards to students' attitudes toward the study of mathematics. The results of this study validated and confirmed that competence was a significant factor of attitude.

9 Implications

From a theoretical standpoint, the main end result of this study is to develop a new research model that helps to study the factors that influence students' attitudes toward the learning of mathematics in vocational education in developing countries. This study contributes to the limited studies that consider a set of discrete variables (competence, enjoyment, perceived relevance, perceived difficulty, and anxiety) and stress the significant role these factors play in determining students' attitudes toward learning of mathematics. This research deduces that competence, enjoyment and perceived relevance were key determinants of students' attitudes toward the study of mathematics and science. This finding is consistent with earlier studies [10, 15, 21, 25]. This study found that perceived difficulty and anxiety were not significant determinants of attitude. This finding is contrary to the previous finding [21]. From the practical perspective, few female students were found to enroll in mathematics programs. Therefore, it is prudent to give incentives in the form of scholarships to encourage female students to enroll in mathematics programs and also to reduce the cutoff point for entry to these programs. Also, more educational programs on mathematics should be organized for prospective female students to highlight the importance of these subjects in their chosen profession. Furthermore, the study found that students spent less time studying mathematics. It is thus suggested that frequent tutorial classes are organized for students in school to help to study these subjects. Finally, the results showed that competence, perceived relevance, and enjoyment significantly contributed to students' attitudes toward the learning of mathematics. It is therefore believed that students who find the relevance of mathematics and are competent, enjoy doing these subjects. Therefore, it is important to organize training and seminars for students on these subjects to improve their skills and also to understand the relevance of these subjects for their future careers.

10 Limitations and Future Study

Firstly, convenience sampling technique was used to select the participants from two public vocational institutions. Their opinions may be different from those participants enroll in other vocational schools. Therefore, caution should be taken when generalizing the results of this study. Furthermore, the study used students in vocational schools context. Future studies should consider using students in high and middle schools. Also, future studies may expand this study to include other potential factors to examine students' attitude. Additionally, this work adopted a cross-sectional approach to

collect data. Therefore, longitudinal studies could be investigated to determine key determinants that influence attitudes toward the learning of mathematics and science over time.

11 CONCLUSION

The objectives of this study were to (1) investigate the factors that significantly affect students' attitude toward mathematics. (2) apply [29]'s framework to develop a new research model, to determine whether or not the new research model is acceptable and easy in predicting students' attitudes toward mathematics. The results of this study demonstrated that the new research model was useful in determining students' attitudes toward mathematics. Though the researcher found support for [29] model constructs of perceived relevance and enjoyment in determining attitudes toward mathematics, the researcher found that competence was the stronger determinant compared to these in this educational setting. Even though [29] model has been empirically tested, studies keep on adding social factors to enhance the explanatory power of the model. This research work tow in that path. By adding competence to a set of individual variables, students' attitudes toward mathematics can be better explained. It is the researcher's hope that future works can foster on the results of this study and give a better understanding of the social and individual factors.

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