Caribbean Educational Research Journal
Vol. 3, No. 2, September 2015, 33-45

The University of the West Indies
Cave Hill Campus

Attitudes of Chemistry Undergraduate Students towards Mathematics at the UWI, Cave Hill Campus

Leah Garner-O'Neale* & Akieya Cumberbatch

Department of Biological & Chemical Sciences, Faculty of Science & Technology, The University of the West Indies, Cave Hill Campus, Barbados

Mathematics is core to all sciences, yet many science students can be heard echoing a general dislike for Mathematics and Mathematics-related topics. This study was conducted to determine the attitudes of Chemistry undergraduates toward Mathematics at the University of the West Indies, Cave Hill Campus. The questionnaire used in the study consisted of the Martha Tapia Attitude toward Mathematics scale which measured four domains: motivation, value, self-confidence and enjoyment. There were 124 students in the actual study. The data collected were tested and analyzed using SPSS V 18. Descriptive frequencies, independent t-test and one-way ANOVA analysis at a confidence level of 0.05 were carried out. The study highlighted that the overall Chemistry undergraduates' attitudes toward Mathematics were moderate however, there was no statistically significant differences based on their sex or level of study. Within the four domains most persons had a good level of value for Mathematics but the majority moderately enjoyed Mathematics, were motivated and had moderate self-confidence. There were no significant differences in these four domains based on sex or level of study. It is recommended that Chemistry lecturers can play a role in improving the attitudes of their students towards Mathematics.

Keywords: Mathematics, Chemistry, attitude, gender, level of study

Introduction

Understanding Mathematics is important in the daily practice of life (Tapia, 1996) from calculating grocery bills and evaluating hire purchase to preparing a budget. In Barbados, achievement in Mathematics has been emphasised from the primary level to the tertiary level. In fact, a passing grade in Mathematics is required for entry into the Faculty of Science and Technology (Undergraduate Admissions Entry Requirements, 2014) yet many of our Chemistry lecturers note that their students lack some basic mathematical skills.

Chemistry like other natural sciences is based on Mathematical theories (Ogilvie & Monagan, 2007) and requires the application of Mathematical logic (Bisenieks & Meija, 2004). Mathematics applications are used in areas such as statistical analysis, mole concept calculations, kinetics and group theory to name a few. It is therefore important that Chemistry students foster good attitudes towards Mathematics.

Attitude

Attitudes are symbolic in identifying behavioral patterns of individuals and in asserting definitive responses (Oluwatelure & Oloruntegbe, 2010). In addition, in an area such as Science it may postulate future participation (Busch, 1995). An attitude can be defined as a psychological

*Corresponding Author. Email: leah.garner-oneale@cavehill.uwi.edu

ISSN 1727-5512
©School of Education, The University of the West Indies Cave Hill Campus

tendency expressed by evaluating a particular entity with some degree of favor or disfavor (Ozgun-Koca, 2010). McLeod (1992) purports that attitudes towards Mathematics generally develop in two ways, either by having a series of repeated emotional reactions towards Mathematics or by the attachment of an existing emotion to the new scenario.

Literature suggests that students' attitudes toward Mathematics may affect their achievement (Cheug, 2009; Elliott, Oty, McArthur, & Clark, 2001; Tapia, 1996;). On the other hand, some argue that less positive attitudes are not always an indicator of low achievement scores (Rech, 1994) or that there is no statistical significant correlation between attitude and achievement (McKnight et al., 1987). McLeod (1992) sums up the relationship between attitude and achievement as complex and unpredictable. However, Cheung (2009) recognized that attitudes may be used to assess students' behaviours and Ozgun-Koca (2010) noted that students' attitudes can impact their career paths.

Additionally, gender disparities of student attitudes toward Mathematics have been extensively researched. Some researchers suggest that females have a less positive attitude than males towards Mathematics (Frost, Hyde & Fennema, 1994; Orhun, 2007; Osborne, Simon, & Collins, 2003; Townsend & Wilton, 2003). Grade level disparities have also been highlighted by McLeod (1994) who noted that there was a decline in Mathematics attitudes as students go higher in school and their learning. Other research concurred with the view of students' attitudes decreasing as they progressed through school (Ozgun-Koca, 2010; (Tapia, 1996).

Tapia and Marsh (2000a) suggest that attitude towards Mathematics can be analyzed under four factors. These are motivation, value, enjoyment and self-confidence.

Motivation

Motivation may be described as the drive behind an individual's actions towards a certain situation (Middleton & Spanias, 1999). There are two types of motivation: intrinsic and extrinsic. Intrinsically-motivated students are those who enjoy learning, for their personal benefit while extrinsically-motivated students partake in classroom activities for the appraisals (Middleton & Spanias, 1999). However, research states before intrinsic motivation can occur, students must be more than likely comfortable, challenged and expectant of success. Hence, a lack of teacher support and favourable learning environments will hinder intrinsic motives. If a student recalls bad experiences, it may explain the decrease in the number of students who actually value and enrol in further Mathematics due to weak motivational experiences. Given that motivation is strongly linked to students' beliefs, it is wise to pay special attention to what students believe about Mathematics so as to understand what drives their actual outcome (Pajares & Graham, 1999). Also, motivation is correlated to achievement therefore the more motivated individuals are; the more positive their attitude is toward Mathematics thus the higher their success (Singh, Granville, & Dika, 2002). To assist in the development of students' Mathematical abilities and motivation, teachers must possess a supportive character as teachers have a strong influence on building students' motivation (Kirk, 2013). In addition, teachers must also allow students to make connections between what they already know, the new material and how it may be used in future applications (Champion, Parker, Mendoza-Spencer, & Wheeler, 2011).

Value

When students value Mathematics, they consider it important, beneficial or useful. Rath, Harmin and Simon (1987) recognize that the process of valuing occurs in three stages: (1) free choice

from among alternatives after considering the consequences, (2) affirmation and (3) repeated action of choice, building a pattern. In fact, students value something more when they are able to make connections with it (Elliott, et al., 2001; Witten, 2005). Valuing Mathematics must be a factor in identifying Chemistry undergraduates' attitudes toward Mathematics simply because a person's values can influence his or her attitude and thus, his or her actions (Chen & Stevenson, 1995; Ozgun-Koca, 2010). When a student thinks that the knowledge gained from a particular subject will help them reach goals that are important to them (i.e. they value it) they are more likely to persevere with it and continue to strive to learn it amidst the pressure of achievement (Mac Iver & Reuman, 1998). Relating valuing Mathematics to achievement, Kloosterman and Stage (1992) purport that students who believe Mathematics is useful will be more motivated and hence have increased achievement. In terms of gender disparities, Wolters and Pintrich (1998) indicated that there were no gender variations in the usefulness of Mathematics, however, McLeod (1992) suggests that males generally value Mathematics more than females.

Enjoyment

Students who enjoy Mathematics find pleasure and satisfaction in it. Mac Iver and Reuman (1998) suggest that when a student believes that a subject (like Mathematics) is interesting or enjoyable, they are more likely to apply effort and be persistent with it until they master it (high achievement). These students tend therefore to be intrinsically motivated to do the subject (Middleton & Spanias, 1999) and to seek out the activity just because they enjoy learning (Middleton, 1993). Dickinson and Butt (1989) suggest that students tend to enjoy a task more when they have a level of success in it. In fact, when students are rewarded for their success in Mathematics, they tend to enjoy it more and have higher level of achievement than when incentives are not given (Middleton & Spanias, 1999). Frenzel, Pekrun, and Goetz (2007) reported a gender variation in enjoyment, noting that males tend to have higher levels of enjoyment than females. Additionally, it was noted that as students move up the ladder enjoyment declines (McLeod, 1992; Middleton & Spanias, 1999). The avoidance of calculations at the tertiary level as highlighted in Ogilvie and Monagan (2007) support the findings that enjoyment declines as students advance in school.

Self-confidence

According to Cretchley (2008), self-confidence in Mathematics refers to the self-belief about the ability to do Mathematics or learn mathematical concepts. As we can well imagine, self-confidence and self-efficacy are critical factors that can affect a person's future (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). A person's belief may lead them towards a particular task (Bandura, et al., 2001) and if that person has little or no self-confidence in his or her ability they will most likely under perform. In fact, a person who is self-confident usually performs better than one who lacks self-confidence (Stiggins, 1999; Symonds, Lawson, & Robinson, 2010). In terms of gender, some literature support males as being more confident than females in Mathematics learning however, gender disparities in Mathematics achievement has diminished (McLeod, 1992; Orhun, 2007).

Purpose of the Study

The purpose of this study was to investigate the attitudes of Chemistry undergraduates towards Mathematics at the University of the West Indies, Cave Hill Campus. To determine a relevant position on the topic, the following research questions will be answered:

1. What is the general attitude of the Chemistry undergraduates towards Mathematics?
2. Is there a significant difference in the general attitude of the Chemistry undergraduates towards Mathematics based on their
    i. Sex?
    ii. Level of study?
3. What is the attitude of Chemistry undergraduates towards Mathematics in the following domains:
    i. Enjoyment
    ii. Motivation
    iii. Value
    iv. Self confidence
4. Is there a significant difference in these domains based on students'
    i. Sex?
    ii. Level of study?

Methodology

Design

This study is quantitative, with a descriptive survey research design. This allowed the researchers to collect data regarding the participants' views on a particular topic in a timely manner. (Creswell 2008; Leacock, Warrican & Rose, 2009).

The Sample

A total of one hundred and twenty-four (124) Chemistry undergraduates, representing over 77% of the population, from across all four levels of study participated in the study. Convenience sampling was employed. All Chemistry students who did not participate in the pilot and were attending classes the day of the study participated. This consisted of 90 females and 34 males. Thirty one of the participants were at the preliminary level, 64 at level 1, 13 at level 2 and 16 at level 3.

Instrumentation

A questionnaire comprising two sections was used to collect the data. The first section gathered demographic information and the second section was adapted from the Attitude towards Mathematics Index (ATMI) by Martha Tapia (Tapia, 1996; Tapia & Marsh, 2000b; Tapia & Marsh, 2004). The adapted ATMI consisted of forty questions and was answered based on a four-point Likert scale. According to Tapia (1996), the ATMI consisted of four domains: Motivation, Enjoyment, Value and Self-Confidence. There are five questions corresponding to the Motivation domain, ten questions measuring Enjoyment and Value each and fifteen questions for the Self-confidence domain.

Reliability and Validity

The instrument was subjected to expert suggestions and comments which were incorporated before administering. Thirty undergraduate chemistry students participated in the pilot. Cronbach's alpha, a measure of internal consistency was used to determine the reliability of the overall instrument as well as of each domain (Travakol & Dennick, 2011).

The Cronbach alpha of the entire scale was measured as 0.97 where as those of the domains were as follows: Value, $\alpha = 0.87$; Enjoyment, $\alpha = 0.89$; Self-confidence, $\alpha = 0.95$; and Motivation, $\alpha = 0.82$.

Scoring & Data Analysis

The participants' overall attitude was determined based on the total score of the ATMI. Possible scores range from a minimum of 40 to a maximum of 160 since a 4-point Likert scale was used. For analysis the ranges of scores were divided into 3 portions. Scores ranging from 40-80 indicated a poor attitude, 81-119 a moderate attitude and 120-160 a good attitude. Likewise the range of scores for the four domains can be found in Table 1.

Table 1

Range of scores for each domain of the ATMI

Domain	**Poor**	**Moderate**	**Good**
Motivation	5-10	11-14	15-20
Enjoyment	10-20	21-29	30-40
Value	10-20	21-29	30-40
Self-confidence	15-30	31-44	45-60

For research questions 1 and 3, means, percentages and standard deviation were used in the analysis and for research questions 2 and 4, independent samples T-test and One-way analysis of variance (ANOVA) were utilized. All analyses were run with an alpha level of .05.

Results & Discussion

Research question 1: What is the general attitude of Chemistry undergraduates towards Mathematics?

As seen in Table 2, the general attitude of the Chemistry undergraduates towards Mathematics was moderate (mean = 106.6). In particular, the majority of the population (60.5%) had moderate attitudes. This suggests that these students have a combination of both positive and negative attitudes towards mathematics. Table 3 further suggests that only 12.1% of the population had poor attitudes and 27.4% had good attitudes towards Mathematics.

Table 2

Mean and standard deviation of general attitude

	N	**Min**	**Max**	**Mean**	**Std. Dev.**
General Attitude	124	57	156	106.6	22.6

Table 3

Distribution of general attitude among participants

Score Range	Description	Frequency	%
40-80	Poor	15	12.1
81-119	Moderate	75	60.5
120-160	Good	34	27.4

When one considers the large range in score, 57-156, (Table 2) it is recognized that the general attitude widely varies. Moreover, the fact that only 27.4% of the population had an overall good attitude suggests that over 70% of the chemistry students do not have good attitudes towards Mathematics. This can be problematic since as suggested by McLeod (1992), these negative emotions regarding Mathematics can be attached to the calculations in Chemistry. Since attitude may affect achievement (Cheug, 2009; Elliott et al., 2001; Tapia, 1996) this may explain why to lecturers it appears as if Chemistry undergraduates lack some mathematical skills.

Research question 2: Is there significant difference in the attitude of Chemistry undergraduate students based on their sex or level of study?

Table 4

Difference in general attitude towards Mathematics based on sex

Sex	N	Mean	Std. Dev.	df	t	Sig
Male	34	108.2	23.4	122	-0.498	0.619
Female	90	105.9	20.3			

Table 4 shows the difference in means and standard deviation as well as results from the T-test when considering the difference between the attitudes of males and females towards Math. Aligned to that suggested by literature, (Frost et.al., 1994; Orhun, 2007; Osborne et. al., 2003; Townsend & Wilton, 2003), the males have better attitudes than females towards Mathematics, however, this difference was not significant ($t = -0.498$, $p = 0.619$). This is not surprising since as suggested by Ogunkola & Garner-O'Neale (2013) in the Caribbean there are no marked differenes between males and females in various sciences including Chemistry in the area of achievement which can be linked to attitude although the relationship is complicated (McLeod, 1992).

In terms of level of study (Table 5), there is a slight increase in the general attitude of the participants as the level of study increased although this change was not statistically significant ($F_{[3,120]} = 1.688$, $p = 0.173$).

Table 5

Difference in general attitude towards Mathematics based on level of study

Levels	N	Mean	Std. Dev.	Min	Max	df	F	Sig
Prelim	31	99.0	21.1	64	134	[3,120]	1.688	0.173
1	64	108.1	24.5	57	156			
2	13	110.2	14.4	82	134			
3	16	111.9	20.7	79	153			

This finding somehow contradicts findings by McLeod (1994) and Ozgun-Koca (2010) who suggest that as students progress in school their attitudes towards Mathematics decline. As students grow older and move forward, it is thought that their attitudes tend to worsen due to the increase in workload (Ali & Reid, 2012). This slight increase of positive attitude may be due to the fact that students have developed a better understanding of how mathematical concepts are used overtime as they progress. When students are introduced to new theories they do not immediately have a complete understanding of the concepts thus the lower frequency in the preliminary year. Thereby, as students advance to higher levels, the previous mathematical concepts and skills which were taught are reinforced thus helping to provide them with a better understanding; overall creating a better attitude towards Mathematics as they progress through the levels of the University.

Research question 3: What is the attitude of Chemistry undergraduates towards Mathematics in the various domains?

The ATMI can be divided into four domains: self-confidence, value, enjoyment and motivation (Tapia, 1996). Figure 1 shows the distribution of attitude towards Mathematics in each of the domains.

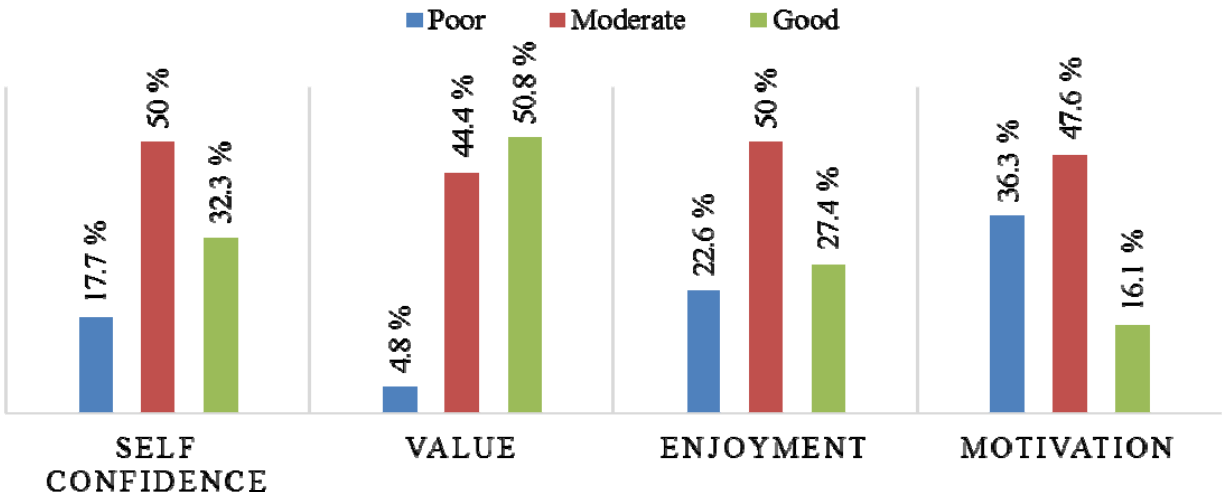

Figure 1. Distribution of attitude towards Mathematics in various domains

When the various domains are examined, it is noticed that about half of the participants (50.8 %) definitely valued Mathematics. Witten (2005) suggests that students value something more when they can relate it to their context. The participants understood the importance of Mathematics but they lacked the motivation, self-confidence and enjoyment in doing it.

In fact, in terms of enjoyment, only 27.4% of the participants greatly enjoyed Mathematics. This finding supports that of Ali and Reid (2012) who also noted that most students do not enjoy Mathematics. However, 50% of the participants reported moderate levels of enjoyment when doing Mathematics. Likewise, 50% of the participants also reported moderate levels of self-confidence to do Mathematics and 17.7% reported low levels. Tapia (1996) suggests that students who have low self-confidence may also receive or have received low scores in Mathematics, whereas students who have high levels of self-confidence may have received high grades in Mathematics (McLeod, 1992; Parsons, Croft & Harrison, 2009).

Far too many students lack the motivation to do Mathematics since only 16.1% of the participants were reportedly highly motivated. Almost 48% of the participants reported moderate levels of motivation to do Mathematics. This suggests that students lack the driving force or will to do Mathematics even within the context of Chemistry. This may have a negative impact on their achievement and progress in Chemistry (Singh et. al., 2002). It was suggested however, by Singh et. al., (2002) that teachers may increase students' motivation levels by creating relevant situations for students to make connections. Actually, Middleton and Spanias (1999) suggest that the culture of the classroom can have an impact on the students' motivation to do Mathematics. It must be condusive for learning and enjoying Mathematics.

Research question 4: Is there any significant difference in the four domains of attitude based on the participants' sex and level of study?

There is no difference between males and females in the four domains of attitude as seen in Table 6. This suggests that the females enjoy, value and are motivated to do Mathematics just as much as the males. The biggest difference between the two sexes was in the domain of self-confidence which may further support findings that males achieve more in Mathematics than females (Orhun, 2007) but this difference was not statistically significant ($t = -0.53$, $p = 0.600$).

Table 6

Differences in the four domains of Attitude based on Sex

Category	**Sex**	**N**	**Mean**	**Std. Dev.**	**df**	**t**	**Sig**
Self Confidence	Female	90	40.3	10.4	122	-0.53	0.600
	Male	34	41.4	9.2			
Value	Female	90	29.1	5.6	122	-0.50	0.617
	Male	34	29.6	4.9			
Enjoyment	Female	90	25.3	6.6	122	-0.10	0.920
	Male	34	25.4	5.7			
Motivation	Female	90	11.2	3.4	122	-0.78	0.436
	Male	34	11.7	3.1			

In terms of level of study (Table 7), although not statistically significant, there is a slight increase in the students' level of self-confidence ($F_{[3,120]} = 1.213$, $p = 0.308$) and value ($F_{[3,120]} = 2.250$, $p = 0.086$) as the level of study increases. Increased self-confidence suggests that final year Chemistry students are more confident when solving mathematical problems (McLeod, 1992) than the other lower levels of study. This may be because they would have had much more practice with these types of questions. Witten (2005) suggests that high value could indicate that Chemistry undergraduates have an understanding of the importance of Mathematics and its interconnection with Chemistry. Ozgun-Koca (2010) also suggests that students use their prior experiences in Mathematics to determine its usefulness. Therefore as students increase in level of study they would have increasingly more experiences as hence would a greater tendency to value Mathematics. In terms of enjoyment, the students at level 2 have the highest mean (26.6) whereas the preliminary level students were least motivated (mean of 10.5). However, there was no statistically significant difference in enjoyment ($F_{[3,120]} = 1.500$, $p = 0.218$) or motivation ($F_{[3,120]} = 1.053$, $p = 0.372$) as the level of study increased.

Table 7

Differences in the four Domains of Attitude based on Level of Study

Domain	**Levels**	**N**	**Mean**	**Std. Dev.**	**df**	**F**	**Sig**
Self Confidence	Prelim	31	38.1	9.8	[3,120]	1.213	0.308
	1	64	40.8	10.9			
	2	13	42.8	7.4			
	3	16	43.1	8.7			
Value	Prelim	31	27.2	5.9		2.250	0.086
	1	64	29.8	5.3			
	2	13	29.3	4.6			
	3	16	30.9	4.8			
Enjoyment	Prelim	31	23.2	5.5		1.500	0.218
	1	64	25.9	7.1			
	2	13	26.6	4.2			
	3	16	26.2	5.8			
Motivation	Prelim	31	10.5	3.3		1.053	0.372
	1	64	11.7	3.6			
	2	13	11.4	2.1			
	3	16	11.7	2.9			

Implications & Recommendations

Less than 30% of Chemistry students in the study have a good attitude towards Mathematics and this is likely to impact how they approach those topics in Chemistry that rely heavily on Mathematics as well as their demeanor in the classroom. Although students value Mathematics, they lack self-confidence, motivation and enjoyment which can be transferred to Chemistry.

Some efforts must therefore be placed on encouraging good attitudes towards Mathematics among the Chemistry students.

It is recommended that Chemistry lecturers can play a significant role in this by bridging the gap between Mathematics and Chemistry whether it is done explicitly through lectures or demonstrated by helping to build the students' awareness of the influence of Mathematics on Chemistry (Ruffell, Mason & Allen, 1998). This is all part of building a positive culture in the classroom as suggested by Middleton and Spanias (1999) which is conducive for learning and enjoying Mathematics. One way in which this can be done by the University lecturers is by scaffolding the Mathematics experience within the Chemistry classrooms so that students can have small successes as they progress, according to Dickinson and Butt (1989) this can lead to increased enjoyment. This may help build self-confidence as students who value and enjoy Mathematics tend to have higher achievement and greater self-confidence (Pokay & Blumfeld, 1990). Chemistry lecturers can also extrinsically motivate students by rewarding them for their successes in solving mathematical applications or problems in Chemistry which may also lead to higher levels of enjoyment (Middleton & Spanias, 1999). In any event, topics of Mathematics in the Chemistry classroom must be addressed rather than ignored.

Conclusion

Among the Chemistry undergraduate students at the University of the West Indies Cave Hill Campus the overall attitude towards Mathematics depicted was moderate. In addition the Chemistry undergraduates scored moderately in all four affective domains of the ATMI used. However it was noted that there is a higher valuing and self-confidence towards Mathematics than enjoyment and motivation. Furthermore, the study highlighted there was no statistical significant differences between sex or across grade levels as it relates to the overall attitude of the Chemistry undergraduates or subdivided into the four domains.

References

Ali, A. A., & Reid, N. (2012). Understanding Mathematics: Some key factors. *European Journal of Educational Research, 1*(3), 283-299.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187-206.

Bisenieks, J., & Meija, J. (2004). Mathematical charm in chemistry problems. *Journal of Chemical Education, 81*(7), 995-996

Busch, T. (1995). Gender differences in self-efficacy and attitudes toward computers. *Journal of Educational Computing Research, 12*(2), 147-158.

Champion, J., Parker, F., Mendoza-Spencer, B., & Wheeler, A. (2011). College Algebra Students' Attitudes Toward Mathematics in their Careers. *International Journal of Science and Mathematics Education, 9*(5), 1093-1110.

Chen, C., & Stevenson, H. W. (1995). Motivation and mathematics achievement: A comparative study of Asian-American, Caucasian-American, and East Asian high school students. *Child Development, 66*(4), 1215-1234.

Cheung, D. (2009). Students' attitudes toward chemistry lessons: The interaction effect between grade level and gender. *Research in Science Education, 39*(1), 75-91.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative,* 3rd ed. Pearson Merrill Prentice Hall.

Cretchley, P. (2008). Advancing research into affective factors in mathematics learning: Clarifying key factors, terminology and measurement. In *Navigating currents and charting directions: Proceedings of the 31 st Annual conference of Mathematics Education Research of Australasia* (pp. 147-154).

Dickinson, D. J., & Butt, J. A. (1989). The effects of success and failure on the on-task behavior of high achieving students. *Education and Treatment of Children*, 243-252.

Elliott, B., Oty, K., McArthur, J., & Clark, B. (2001). The effect of an interdisciplinary algebra/science course on students' problem solving skills, critical thinking skills and attitudes towards mathematics. *International Journal of Mathematical Education in Science and Technology*, *32*(6), 811-816.

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics—A "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education*, *22*(4), 497-514.

Frost, L. A., Hyde, J. S., & Fennema, E. (1994). Gender, mathematics performance, and mathematics-related attitudes and affect: A meta-analytic synthesis. *International Journal of Educational Research*, *21*(4), 373-385.

Kirk, K. (2013) Motivating Students. Retrieved from http://serc.carleton.edu/NAGTWorkshops/affective/motivation.html

Kloosterman, P., & Stage, F. K. (1992). Measuring beliefs about mathematical problem solving. *School Science and Mathematics*, *92*(3), 109-115.

Leacock, C., Warrican, S., & Rose, G. (2009). Research methods for inexperienced researchers. *Kingston Jamaica: Ian Randle Publishers*.

Mac Iver, D., & Reuman, D. A. (1988, April). D*ecision-Making in the Classroom and Early Adolescents' Valuing of Mathematics.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. *Handbook of research on mathematics teaching and learning*, 575-596.

McLeod, D.B. (1994). Research on affect and mathematics learning in the JRME: 1970 to the present, *Journal for Research in Mathematics Education 24*, 637–647.

McKnight, C. C., Crosswhite, F. J., Dossey, J. A., Kifer, E., Swafford, J. O., Travers, K. J., & Cooney, T. J. (1987). The Underachieving Curriculum: Assessing US School Mathematics from an International Perspective (Champaign, IL, Stipes).

Middleton, J. A. (1993). An analysis of the congruence of teachers' and students' personal constructs regarding intrinsic motivation in the mathematics classroom (Doctoral dissertation, University of Wisconsin-Madison, 1992). Dissertation Abstracts International, 53, 3150A.

Middleton, J. A., & Spanias, P. A. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the research. *Journal for Research in Mathematics Education*, 65-88.

Ogilvie, J., & Monagan, M. (2007). Teaching mathematics to chemistry students with symbolic computation. *Journal of Chemical Education*, *84*(5), 889-896

Ogunkola., B. J & Garner-O'Neale, L. (2013). Gender Differences in Participation and Achievement in Science: Implications and intervention strategies for scientific and technological development in the Caribbean. *Mediterranean Journal of Social Sciences*, *4*, 543-551.

Oluwatelure, T., & Oloruntegbe, K. (2010). Effects of parental involvement on students' attitude and performance in science. *African Journal of Microbiology Research, 4*(1), 001-009.

Orhun, N. (2007). An investigation into the mathematics achievement and attitude towards mathematics with respect to learning style according to gender. *International Journal of Mathematical Education in Science and Technology, 38*(3), 321-333.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079.

Ozgun-Koca, S. A. (2010). If mathematics were a color... *Ohio Journal of School Mathematics, 62*(Fall), 5-10.

Pajares, F., & Graham, L. (1999). Self-efficacy, motivation constructs, and mathematics performance of entering middle school students. *Contemporary Educational Psychology, 24*(2), 124-139.

Parsons, S., Croft, T., & Harrison, M. (2009). Does students' confidence in their ability in mathematics matter? *Teaching Mathematics and its Applications, 28*(2), 53-68.

Raths, L. E., Harmin, M., & Simon, S. B. (1987). Selections from 'values and teaching'. In J. P.F. Carbone (Ed.), Value theory and education (pp. 198-214). Malabar, FL: Robert E. Krieger.

Rech, J. F. (1994). A comparison of the mathematics attitudes of Black students according to grade level, gender, and academic achievement. *The Journal of Negro Education, 63*(2), 212-220.

Ruffell, M., Mason, J., & Allen, B. (1998). Studying attitude to mathematics. *Educational Studies in Mathematics, 35*(1), 1-18.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. *The Journal of Educational Research, 95*(6), 323-332.

Stiggins, R. J. (1999). Assessment, student confidence, and school success. *The Phi Delta Kappan, 81*(3), 191-198.

Symonds, R., Lawson, D., & Robinson, C. (2010). An investigation of Physics undergraduates' attitudes towards mathematics. *Teaching Mathematics and its Applications, 29*(3), 140-154.

Tapia, M. (1996). The Attitudes toward Mathematics Instrument. Paper presented at the Annual Meeting of the Mid-South Educational Research Association (Tuscaloosa, AL, November 6-8, 1996)

Tapia, M., & Marsh, G. E. (2000a). *Effect of gender, achievement in Mathematics, and ethnicity on attitudes toward Mathematics*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association (Bowling Green, KY, November 15-17, 2000)

Tapia, M.,& Marsh, G. (2000b). *Attitudes Toward Mathematics Instrument: An Investigation with Middle School Students.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association (Bowling Green, KY, November 15-17, 2000)

Tapia, M. & Marsh, G. E. (2004) An Instrument to Measure Mathematics Attitudes. *Academic Exchange Quarterly, 8*(2), 16-21.

Townsend, M., & Wilton, K. (2003). Evaluating change in attitude towards mathematics using the 'then-now'procedure in a cooperative learning programme. *British Journal of Educational Psychology, 73*(4), 473-487.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53-55.

Undergraduate Admissions Entry Requirements. (2014). Retrieved from http://www.cavehill.uwi.edu/admissions/entry-requirements.aspx

Witten, G. Q. (2005). Designing a mathematics course for chemistry and geology students. *Educational Studies in Mathematics, 58*(1), 1-19.

Wolters, C. A., & Pintrich, P. R. (1998). Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms. *Instructional Science, 26*(1-2), 27-47.