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STUDENTS' ATTITUDES TOWARDS LEARNING MATHEMATICS: IMPACT OF TEACHING IN A SPORTING CONTEXT

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Abstract

This study investigated the impact on Year 10 students' attitudes towards mathematics when learning mathematics in a sporting context. A closed ended, self-reported questionnaire with Likert type statements was used to collect data. Individual statements were analysed by comparing the percentage of students agreeing or disagreeing pre-teaching and post-teaching. In this study, students' attitude comprised of their confidence, awareness of mathematics and engagement. This study suggests that when students learn in a sporting context, their confidence, seeing the importance of mathematics and engagement increases. The paper also considers implications for teachers, teacher educators and for scholars who are interested in further research.

Key words

Attitudes; engagement; confidence; importance of mathematics; sports

Introduction

Learning mathematics does not only involve thinking and reasoning, it is dependent on the attitudes of the learners towards learning and mathematics (Anthony & Walshaw, 2007; Grootenboer, Lomas, & Ingram, 2008; Kele & Sharma, 2014). Han and Carpenter (2014) state that attitudes consist of cognitive, affective and behavioural reactions that individuals display towards an object or the surrounding based on their feelings or interest.

The cognitive component of attitude is what the individual thinks or believes about mathematics (Akinsola & Olowojaiye, 2008; Maio & Haddock, 2009; Mensah, Okyere, & Kuranchie, 2013). The affective component of attitude is the feeling or emotions of the individual associated with learning mathematics (Ingram, 2015). Thus, the affective component is the source of driving the engagement of students towards mathematics. Furthermore, the affective aspect is also influenced by the belief formed from the cognitive component of attitude, which creates a mindset that becomes constant over time and influences the feelings of the students towards learning mathematics (Ingram, 2015; Zan & Di Martino, 2007). As such, the cognitive and affective components of attitude are interrelated and deeply interact with each other (Di Martino & Zan, 2011).

The behavioural aspect of attitude is the tendency to respond in a certain way towards learning mathematics (Akinsola & Olowojaiye, 2008; Maio & Haddock, 2009; Mensah et al., 2013). Behavioural attitude is also influenced by affective attitude. Students feeling confident in doing mathematics is linked with being successful in mathematics, which is regarded as a positive behaviour. If students are not confident in doing mathematics, they may not experience success, and unsuccessful behaviour is regarded as negative feelings (Zan & Di Martino, 2007). Hence the behavioural component of attitude impacts on the cognitive component of attitude as well. When students see the importance of mathematics in real lives, they feel engaged, confident and connected to their learning (Attard, 2012). As such, the three components of attitude, confidence, importance of mathematics and engagement are interrelated (Mensah et al., 2013).

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An important question that arises here is how can an increased level of confidence, awareness of the importance of mathematics and engagement be achieved so that students' attitudes towards learning mathematics become more positive? Teaching mathematics in a meaningful context could be the solution.

Setting mathematical problems in a context can help students see the application of mathematics (Anthony & Walshaw, 2007; Ministry of Education, 2007; Reys, Reys, & Reys, 2013). In mathematics education, a range of meanings exist for the term context (Gilbert, 2006; Harvey & Averill, 2012) According to Gilbert (2006), a context is an event that takes place in a set environment The learning environment is the situation context and the characteristics of the task make up the task-context. In this paper, like Harvey and Averill (2012), we use the term context to refer to real-life situations.

The New Zealand Curriculum states that effective learning can take place in a social and cultural context that has a positive impact on students' learning (Ministry of Education, 2007). Gallian (2010) stated that games and sports are the best way to build students' engagement and confidence in mathematics. There are a number of advantages of using a sporting context to teach mathematics as most students can relate to sports and can understand the rules and meanings that are presented to them. Students enjoy sports and show a greater level of interest when sports is applied to mathematics (Gallian, 2010). Percy (2009) argues that mathematics is the science of space, number, quantity and arrangement and these four elements feature in every sport, making it the most relevant context in which mathematics can be taught.

Researchers have concluded that students' attitudes play a vital role in the learning of mathematics (Ingram, 2015; Kele & Sharma, 2014) However, only a few studies have investigated the effects of teaching mathematics in a sporting context on students' attitudes towards learning mathematics. Most of the research investigated the effects of sports on academic outcomes (Robinson, 2012).

The purpose of this study was to investigate if teaching in a sporting context would have an impact on students' attitudes towards learning mathematics. The data reported in this paper comes from a larger study (Sanchal, 2016).

Literature review

Students' attitudes towards learning mathematics

Researchers (Attard, 2012; Grootenboer et al., 2008; Mata, Monteiro, & Peixoto, 2012) have identified important factors that contribute to students' attitudes towards learning mathematics. These include the students themselves, the school, the teachers' beliefs and attitudes (Beswick, 2006) and their teaching methods.

The teachers' teaching method have a major influence on students' attitudes (Akinsola & Olowojaiye, 2008; Mensah et al., 2013). Teachers can do many things to facilitate the classroom learning to alleviate students' engagement level and confidence in learning mathematics (Attard, 2012; Kele & Sharma, 2014). According to Sullivan and McDonough (2007), teachers can find ways to encourage student engagement and confidence in learning mathematics. This can be achieved by implementing meaningful activities embedded in real-life contexts (Kacerja, 2012).

Traditional teaching method and teaching in context

Many studies have identified that teaching mathematics in real life contexts enhance students' enjoyment of mathematics lessons (Anthony & Walshaw, 2007; Boaler, 2002; Dickinson & Hough, 2012; Kacerja, 2012). The relationship formed between the student and the task fosters students' engagement in the mathematical tasks. By creating, exploring and verifying mathematical ideas students tend to see the importance of mathematics (Reys et al., 2013).

In Boaler's (2002) study, students who were taught in a traditional manner viewed mathematics as a collection of procedures. In contrast, those students who were taught in a context viewed mathematics as an active and inquiry-based discipline. Dickinson and Hough (2012) worked on a project that

trialled teaching mathematics in a context. The project included the views of both teachers and students on the impact of teaching mathematics in a context.

Teaching mathematics in a sporting context

Students who are taught using a sporting context may feel that the task is more enjoyable since it is different from repetitive mathematics exercises (Reys et al., 2013). Reys et al. (2013) claim that connecting mathematics to the sports fields can provide a context for measurement, estimation and tessellation in mathematics problems. If students had played a game such as basketball, then that experience could provide a visual model to help them decide what mathematics is needed to solve the problem.

Since sports are often a part of students' everyday life (Gallian, 2010), they don't have to deal with an enormous amount of information and feel more engaged in the tasks. Students feel at ease in solving mathematical problems in context because problems can be solved at different levels and in different ways (Van Den Heuvel-Panhuizen, 2005; Widjaja, 2013). Students are often able to solve problems using their own informal strategies rather than the formal procedures they are unsure of. Students are able to represent the task using their own symbols and words before carrying out further solving and interpretation (Barnes & Venter, 2008).

Recently, Boyd and Hipkins (2015) confirmed in their report, which was based on Sport in Education Programme in eight New Zealand schools, that students feel more engaged and confident being taught in a sporting context. Students who were part of this project reported an increased sense of belonging and pride in their school.

Afari, Aldridge, Fraser, and Khine (2013) investigated the impact of using mathematical games on college students' attitudes towards learning mathematics. A pre-post design method was used to assess students' perception of the learning environment and their attitude towards learning mathematics. Eight classes out of 33 used a games context. The students from the classes that used games found their lessons more interactive, got involved and enjoyed learning mathematics.

Method

A Year 10 cohort consisting of 54 students participated in this study. These students were also active participants in the game of Ki-o-rahi[i] and had been actively involved in playing Ki-o-rahi for the school. The Ki-o-rahi field consists of three highly visible concentric circles (Figure 1). The radius of the outer most circle is 12 metres and there are seven posts (Pou) placed at equal intervals. The middle circle has a radius of six metres and the inner circle has a radius of four metres. Students use these measurements to draw the Ki-o-rahi field to scale on paper. The context of Ki-o-rahi features most of the aspects of the Measurement strand such as conversion between metric units, scale drawing, circumference and area (Ministry of Education, 2007). The placement of the posts on the outer most circle involves working with angles and the circumference of a circle. This activity can allow students to work at various curriculum levels.

[i] Ki-o-rahi is an ancient Māori ball game popularly played across New Zealand at marae, schools and during iwi festivals.

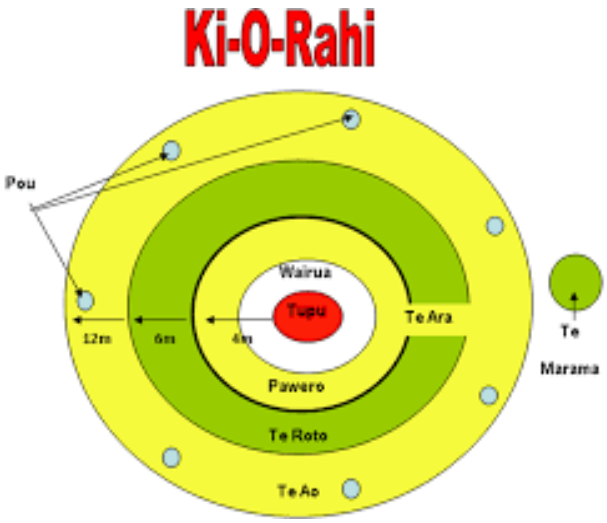

Figure 1: **The Ki-o-rahi field with measurements.**

Procedure

The attitude questionnaire used by Martha (1996) in investigating 'The Attitudes toward Mathematics Instrument' was reviewed and some statements specific to the topic of circle was added while designing the questionnaire for this study. To find out if teaching in context had an impact on students' attitudes towards learning mathematics, students completed the attitude questionnaire pre-teaching and post-teaching (Appendix A).

A five point Likert scale was used (Strongly Agree SA, Agree A, Undecided U, Disagree D, Strongly Disagree SD). On the questionnaire, students identified to what extent they agreed or disagreed with each statement. For every statement, the percentage of students strongly agreeing and agreeing was calculated and pre-teaching percentage was compared with post-teaching percentage.

Results and discussion

The 44 statements were classified into the three components of attitude: confidence, seeing the importance of mathematics and engagement.

Confidence

The first 20 statements, under the heading 'Confidence', were divided into three categories: mathematical thinking, fear, and feeling comfortable while learning mathematics. Pre and post percentage responses to the categories are presented in Table 1.

In the mathematical thinking category, Statement 2 showed an increase of 10 percent in the number of students feeling satisfied with solving a mathematics problem. Both Statements 1 (I want to develop my mathematical skills) and 3 (Mathematics helps develop the mind and teaches a person to think) showed a two percent increase.

In the category of fear, Statement 5 showed 18 percent more students were able to think clearly when doing mathematics in the Ki-o-rahi context. In addition, 8 percent more students wanted to take college mathematics and 7 percent more students started to feel confident when attempting mathematics.

Table 1: Pre and Post Teaching Percentage Responses to Confidence Categories

Category	Statements	Pre-teaching (SA + A) %	Post-teaching (SA + A) %
Mathematical Thinking	1	80	82
	2	48	58
	3	80	82
	13	59	58
Fear	4	53	47
	5	55	37
	6	28	32
	7	23	28
	8	22	32
	9	26	26
	14	39	32
	17	38	30
Comfortable	10	59	63
	11	35	44
	12	38	45
	15	37	37
	16	28	35
	18	31	37
	19	52	50
	20	37	36

In the category feeling comfortable while learning mathematics, the highest percentage of students agreed on Statements 11, 12 and 16. These statements related to students' self-confidence, their ability to solve mathematics problems without facing difficulty and being confident about learning advanced mathematics. Statements 10 and 18 also showed an increase in the percentage of students not feeling scared of mathematics and comfortable in expressing their own ideas.

In the confidence category, the percentage of students feeling positive about learning mathematics in a sporting context showed an overall increase. These findings resonate with the conclusions reached by a number of writers (Barnes & Venter, 2008; Gallian, 2010; Van Den Heuvel-Panhuizen, 2005; Widjaja, 2013) who pointed out that students tend to feel at ease and are comfortable in answering or solving mathematical problems when taught in a sporting context.

Importance of mathematics

The nine statements under this heading were further broken down into two categories: everyday mathematics and mathematics for advanced courses. Percentage responses are shown in Table 2.

Table 2: Pre and Post Teaching Percentage Responses to Importance of Mathematics Categories

Category	Statements	Pre-teaching (SA + A) %	Post-teaching (SA + A) %
Everyday mathematics	22	75	80
	23	77	79
	24	80	76
	29	66	67
Mathematics for advanced courses	25	74	65
	26	66	69
	27	59	48
	28	54	56
	30	76	76

The highest percentage of students felt that mathematics was a worthwhile and necessary subject (Statement 22). Students also felt that mathematics is important in everyday life.

There was a 3 percent increase in the percentage of students seeing the application of mathematics in other areas. Only 2 percent of the students felt that studying for advanced mathematics would be useful. In contrast, Statement 25 (High school mathematics courses would be very helpful no matter what I decide to study) and Statement 27 (I plan to take as much mathematics as I can during my education) showed a decline in the percentage of students strongly agreeing and agreeing.

Sullivan and McDonough (2007) pointed out that when students become aware of the connections between the tasks and its relevance to their lives, they tend to see the importance of mathematics. The increase in the percentage of students believing that mathematics helps with problem solving in other areas and that mathematics is important in everyday life are linked with the highest percentage of the students' agreeing that mathematics is a worthwhile subject. The Year 10 students may have also started to see the importance of mathematics for everyday use when they were shown the application of mathematics in the Ki-o-rahi sport.

The data analysis of the five statements in the mathematics for advanced category showed mixed results in the students' attitudes. While there was an increase noted in the percentage of students who could see the application of mathematics outside of school, there was a decrease in the percentage of students thinking that a high school mathematics course is helpful.

Mensah et al. (2013) pointed out that students' high school experiences and their feelings towards learning mathematics are usually constant and takes a long time to change. Even though the Year 10 students involved in this study reported a 6 percent increase in the many ways mathematics can be useful outside of school, there was still a 3 percent decrease in the number of students not considering high school mathematics to be helpful. There could be many possible reasons for this discrepancy. From the measurement unit, the topic of circle was the only topic taught in context and this may not have given enough insight to the students about studying mathematics.

According to Ingram (2015), students form meaning in their minds about curricular subjects even before they learn anything or realise the importance of the subject. A certain percentage of students still wanted to avoid studying mathematics during their education. The Year 10 students might have formed a negative meaning in their minds about what they may have previously heard from other students or due to their unfavourable experiences in mathematics class. This could also be the reason for the decrease in the percentage of students not considering mathematics to be helpful.

Engagement

Eleven statements under this section were divided into three categories of dislike, like and enjoyment while learning mathematics.

Table 3: Pre and Post Teaching Percentage Responses to Engagement Categories

Category	Statements	Pre-teaching (SA + A) %	Post-teaching (SA + A) %
Dislike	32	54	55
	33	37	32
	35	48	45
Like	36	52	56
	38	33	42
	41	29	45
	42	40	42
Enjoyment	34	48	52
	37	43	46
	39	19	24
	40	43	50

Statement 33 showed that 5 percent more students felt clear and not confused in mathematics class. Furthermore, 3 percent more students felt mathematics learning was interesting after being taught in the Ki-o-rahi context.

After teaching in the Ki-o-rahi context, 16 percent of the students were willing to take more than the required amount of mathematics (Statement 41). Student's liking of mathematics increased by 9 percent (Statement 38).

On Statement 40, mathematics was viewed as a very interesting subject by 7 percent of the students and a further 5 percent of the students felt happier in a math class than in any other class. In addition to this, 4 percent of the students enjoyed studying mathematics after being taught in the Ki-o-rahi context.

The Year 10 students also reported a 7 percent increase in considering mathematics as an interesting subject. The interaction between mathematics and the game context enabled these students to interpret and make connections and at the same time enjoy mathematics lessons. The findings from Afari et al., (2013) also reported that students who were introduced to games in the teaching of mathematics enjoyed learning mathematics. Students involved in the study by Afari et al. (2013) found their mathematics lessons interesting because their lessons were more interactive.

As the percentage of students liking mathematics increased, students' enjoyment towards learning mathematics also increased. The students' feelings of dislike towards mathematics showed an 8 percent decrease. Zan and Di Martino (2007) stated that students who find pleasure in doing mathematics tend to enjoy mathematics and show positive feelings towards the subject. This means that as the Year 10 students started to develop a liking for mathematics and enjoyed the sporting context, their dislike towards mathematics lessened. The findings from this study revealed that a sporting context can have positive impacts on students' attitudes towards learning mathematics. To enhance students' confidence in mathematics, see the importance of mathematics and engagement in mathematics, teachers can use a sporting context such as Ki-o-rahi to teach mathematics.

Conclusions, limitations and implications of the study

The students' confidence towards learning mathematics in a sporting context was associated with developing mathematical thinking. The finding from this study show that the sporting context may have allowed students to express their mathematical ideas more comfortably giving them more confidence. With an increase of five percent in the percentage of students seeing the usefulness of mathematics outside of school, it can be stated that the sporting context made it possible for these

students to think of ways in which mathematics can be used outside of school. The findings also suggest that with an increased number of students feeling comfortable and enjoying mathematics lessons while studying mathematics, their engagement level also increased. Thus, with an increase in confidence, seeing the importance of mathematics and engagement in mathematics lessons, it can be stated that students' attitudes towards learning mathematics also improved.

This study had a number of limitations. The Year10 cohort consisted of 54 students from one school, and one-year level. Future research could focus on students from different schools and at different year levels.

The use of closed questions in the questionnaire did not allow the participants to add any remarks or explanations. Moreover, the questionnaire did not include any statements about how the students felt about using mathematics to construct the Ki-o-rahi field. In addition, the questionnaire consisted of forty-four statements and this could have created participant fatigue. In future research, the number of statements could be reduced and the questionnaire could be complemented with interviews in order to explore these issues in more depth.

The relationship between the students and the researcher was that of the student-teacher relationship. However, due to the power balance relationship between the teacher and the students, students could have felt obliged to take part in the questionnaire and may not have stated their true feelings. This could have affected the reliability and manageability of the data collected.

Students in this study had a good understanding of the rules of Ki-o-rahi. Therefore teachers need to learn and know their students, their culture and background before a context is picked for teaching. Careful planning is needed to achieve a balance between focusing on the mathematics and the context.

This study was carried out in a school where the participants were 67 percent Māori and the sporting context was the Māori game of Ki-o-rahi. Other factors, such as the school decile and the location of the school, can also have an impact on the students' attitudes towards learning mathematics in a sporting context. Further research can look at teaching mathematics in a sporting context that is appropriate to all cultures.

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Appendix A: Questionnaire

Students' attitudes towards learning mathematics: Impact of teaching in a sporting context

Pre-teaching / Post-teaching

Name:_____

Teacher _____

Directions: This inventory consists of statements on the following three categories: Confidence in mathematics, Importance of mathematics as a subject and Emotional attachment to mathematics. These three categories can reflect on your attitudes towards learning mathematics. There are no correct or incorrect responses. Read each statement carefully. Please think about how you feel about each statement . Enter the letter that most closely corresponds to how each statement best describes your feelings. Please answer every question.

PLEASE USE THESE RESPONSE CODES:

SD – Strongly Disagree

D – Disagree

U – Undecided

A – Agree

SA – Strongly Agree

Confidence in Mathematics	
1. I want to develop my mathematical skills.	
2. I get a great deal of satisfaction out of solving a mathematics problem.	
3. Mathematics helps develop the mind and teaches a person to think.	
4. Mathematics is one of my most dreaded subjects.	
5. My mind goes blank and I am unable to think clearly when working with mathematics.	
6. Studying mathematics makes me feel nervous.	
7. Mathematics makes me feel uncomfortable.	
8. I am always under a terrible strain in a math class.	
9. It makes me nervous to even think about having to do a mathematics problem.	
10. Mathematics does not scare me at all.	
11. I have a lot of self-confidence when it comes to mathematics.	
12. I am able to solve mathematics problems without too much difficulty.	
13. I expect to do fairly well in any math class I take.	
14. I feel a sense of insecurity when attempting mathematics.	
15. I learn mathematics easily.	
16. I am confident that I could learn advanced mathematics.	
17. I would like to avoid using mathematics in college.	
18. I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.	

19. I am comfortable answering questions in math class.	
20. I believe I am good at solving math problems.	
21. I am good at using formulas to work out Circumference and Area of a circle.	
Importance of Mathematics	
22. Mathematics is a very worthwhile and necessary subject.	
23. Mathematics is important in everyday life.	
24. Mathematics is one of the most important subjects for people to study.	
25. High school math courses would be very helpful no matter what I decide to study.	
26. I can think of many ways that I use math outside of school.	
27. I plan to take as much mathematics as I can during my education.	
28. I think studying advanced mathematics is useful.	
29. I believe studying math helps me with problem solving in other areas.	
30. A strong math background could help me in my professional life.	
31. I know the application of Circumference of a circle in real life.	
Engagement in Mathematics	
32. When I hear the word mathematics, I have a feeling of dislike.	
33. I am always confused in my mathematics class.	
34. I have usually enjoyed studying mathematics in school.	
35. Mathematics is dull and boring.	
36. I like to solve new problems in mathematics.	
37. I would prefer to do an assignment in math than to write an essay.	
38. I really like mathematics.	
39. I am happier in a math class than in any other class.	
40. Mathematics is a very interesting subject.	
41. I am willing to take more than the required amount of mathematics.	
42. The challenge of math appeals to me.	
43. I like the topic of Measurement.	
44. I like working on the topic of Circles.	