Student Engagement with Technology Use in Mathematics Education: An Indonesian Secondary School Context

Completed Research Paper

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Abstract

This study investigates attitudinal factors attributed to the use of technology in mathematics in Indonesia, where access to technology is still seen as a symbol of modernity. Specifically, we focus on measures related to student engagement – mathematics motivation, attitudes to the use of technology in mathematics, technological confidence and mathematics confidence – in two different secondary school groups. In one school group, students engaged with technology-based learning devices individually on one-to-one basis, while the other school group had few learning devices, hence students shared devices and learned in small groups. Both quantitative and qualitative methods have been employed in this study. Statistical analysis on quantitative data has revealed attitudinal differences to be associated with how devices are being used in classrooms (i.e., on one-to-one basis or in small groups) and is also found to be gender related. Gender differences were more evident in schools where technology was available to small groups. Qualitative data obtained through open-ended questions has shed further light on how boys and girls construct their attitudes. The study findings indicate appropriate pedagogical approaches should be considered when using technology in mathematics and that providing better access to technology will help to alleviate some of the challenges related to student engagement in learning mathematics.

Keywords: attitude, technology, technological confidence, mathematics confidence, mathematics motivation, secondary school, gender

Introduction

Technology has become an integral part of life in the 21st century with its presence increasingly influencing almost every facet of our lives. Within mathematics education, technology is perceived as a valuable tool, the affordances of which allow mathematics learning to be reshaped and practised in distinctive ways. The Program for International Student Assessment (PISA) suggests that the teaching and learning of mathematics should not only measure the extent to which students can employ their mathematical content knowledge, it also needs to assess how students apply their knowledge to new situations (Thomson et al. 2013). Technology provides the tool for teachers to connect mathematical concepts with real-world problems so that their students are able to explore mathematical concepts, and analyse situations as they are problem solving (Sawaya and Putnam 2015). However, teachers are required to design innovative practices to gain the added benefits from technology-enhanced learning environments.

Infusion of technology substantially modifies the way in which mathematics is taught and learned. This may positively reflect on student engagement towards learning and doing mathematics with technology or as Eng et al. (2016) suggests it may cause them to develop a poor attitude to learning mathematics with technology. Therefore, a number of studies (e.g., Barkatsas et al. 2009; Eng et al. 2016; Pierce et al. 2007) caution the need to monitor students' attitudes towards mathematics and their learning with technology. Ursini and Sánchez (2008) suggest monitoring student attitudes towards mathematics when technology is first introduced in mathematics classrooms. We argue that investigating attitudinal factors attributed to the use of technology in mathematics in developing countries (i.e. Indonesia), where access to technology is still seen as a symbol of modernity, deserves particular attention. It becomes even more important to consider students' attitudes in developing countries as a key component that must be taken into account to ensure a smooth process of learning mathematics with technology.

In this paper, we focus on students' attitudinal factors in their use of technology-based learning devices in two different secondary school groups. In one school group, students were already using their own devices for specific subjects, hence we asked students to use these devices for mathematics lessons also. In the other group, only a few students were able to bring their own devices. This resulted in them needing to work collaboratively in small groups with shared devices. This study aims to explore overall student perceptions with use of technology for learning mathematics. Specifically, we focus on four factors – confidence with technology, mathematics confidence, mathematics motivation, and student attitudes towards technology – across secondary schools in the Semarang municipality of Indonesia. These factors have been further analysed along gender dimensions to share rich insights on how boys and girls perceive technology while of learning mathematics.

Gender, Technology and Attitudinal Factors in Mathematics

When considering the use of technology in mathematics, attention needs to be given to the attitudinal factors including those that appear to be gender-based. Some studies present inconsistent results in regard to student attitudes when gender is considered. Vale and Leder (2004), for instance, found that males and females have similar perceptions of their achievement in mathematics and computing, but males viewed computer-based mathematics lessons more positively than females. They also report that attitudes towards computer-based mathematics to be more closely correlated with positive attitudes towards computers than towards mathematics itself and that the correlation was higher for males than females. Pierce et al. (2007) drawing on five attitude scales comprised of mathematics confidence, confidence with technology, attitude to learning mathematics with technology, attitudinal engagement and behavioural engagement showed that male students' attitudes correlated positively only with confidence with technology. In contrast, for females the only relationship these researchers found was a negative correlation with mathematics confidence. Barkatsas et al. (2009) reported that male students expressed more positive views towards mathematics and more positive views towards the use of technology in mathematics, compared to females. They also found that students with high achievement in mathematics showed high levels of mathematics confidence, and very positive levels of affective engagement and behavioural engagement. They demonstrated that holding high level of confidence in using technology appeared to influence students in having a very positive attitude to learning mathematics with technology. Although Eng et al. (2016) found no significant difference in attitudes to learning mathematics with technology to be based on gender, they reported that there were significant differences in attitudes to learning mathematics with technology between students from rural and semi-urban schools. Students from semi-urban secondary schools had more confidence in using technology than those from rural schools.

OECD (2013) in its report on structural policy of Indonesia noted that “disadvantaged schools may need additional resources as the challenging socio-economic profiles and varying needs of the students tend to push up teaching costs”. Schools in rural locations (or belonging to the lower-middle socio-economic regions) were disadvantaged since they did not have much access to technology. The perceived access to technology could be another factor that may contribute to differences in attitudes towards technology in mathematics. A study conducted by Forgasz et al. (2006) found that socio-economic status mediated differences in attitudes towards computers for learning mathematics. The socio-economic status may contribute to inequities in learning outcomes especially when technologies are integrated into instructions (Vale 2006). Schools with a majority of students from upper-middle socio-economic status are able to bring their own devices to support their learning process. This condition may be different for schools where the majority of students are from a lower-middle socio-economic status; hence, they may not have such ease of access to technology and not be in a position to afford personal devices.

Measuring Student Engagement in Mathematics

Student engagement in learning mathematics is influenced by many factors, including beliefs and conceptions, motivation, cognitive variables, emotions and attitudes (Ursini and Sánchez 2008). In their seminal studies Fennema and Sherman (1976) conducted survey questionnaires using mathematics attitude scale to gauge attitudinal factors and their relationship with gender differences in achievement and attitude. Over time questionnaires have become standard tools to assess student perceptions and attitudes towards learning. This is particularly so when attitudes are viewed as a factor which need monitoring to evaluate the success of a teaching innovation (Pierce et al. 2007).

Although there are a number of attitude scales, many are too complex, take too long to complete, or are designed for a specific age group of students. For instance, Fennema and Sherman’s (1976) scale had 108 items and required 45 minutes to complete. Galbraith and Haines (1998) also designed a scale to measure attitudes to technology in mathematics learning but this was for tertiary students. Although Pierce et al. (2007) designed a scale for measuring mathematics and technology attitudes which was easy to administer and could be completed in less than 10 minutes, the scale could not provide data to illustrate how students constructed their attitudes. Ardies et al. (2015), argue that knowing which factors influence students’ attitudes towards technology between the age of 12 and 14 is important to better understand how the attitudes are formed. Therefore, in this study, we designed an instrument comprising closed and open-ended questions. The closed questions constituted items of subscales, namely attitudes towards the use of technology in mathematics, technological confidence, mathematics confidence, and mathematics motivation which have been derived from earlier studies (i.e., Pierce et al. 2007; Torff and Tirotta 2010; Vale and Leder 2004). The open-ended questions aimed to gauge student viewpoints regarding their engagement with technology in the student’s own voices.

Attitudes towards the Use of Technology in Mathematics

Pierce et al. (2007) explain that “defining the composition of attitudes is not simple”. Vale and Leder (2004) used the term “attitude to computer-based mathematics”. This refers to “the degree to which students perceive that the use of computer in mathematics provide relevance for mathematics, aids their learning of mathematics and contributes to their achievement in mathematics” (p. 291). Galbraith and Haines (1998) use the term “computer and mathematics interaction” for a similar construct. They claim that students who intensely engage with computers and mathematics believe that computers contribute to an improvement in mathematical learning. Although some researchers (e.g., Di Martino and Zan 2001; Ruffell et al. 1998) state that attitude is an ambiguous construct there are at least two aspects which are in common. Ursini and Sánchez (2008) emphasise these two aspects: “that attitudes are created and modified by events and the way these are perceived and that the attitudes have affective, cognitive, and behavioural components”. In this study, we conceptualise the term attitude to encompass these three components as expressions of beliefs, feelings, and behavioural intention about using technology for learning mathematics.

Technological Confidence

Technological confidence is considered an important factor in learning mathematics with technology. Galbraith and Haines (1998) use the term "computer confidence" and they explain that students who "feel self-assured in operating computers, believe they can master computer procedures required of them, are more sure of their answers when supported by a computer, and in cases of mistakes in computer work are confident of resolving the problem themselves" (p. 278). Pierce et al. (2007) extend this definition to include not only the use of computers but also a broad range of technology available to students. Pierce et al. (2007) explain that technological confidence makes students more inclined to participate in lessons using technology and this in turn leads to them gaining increased confidence in doing mathematics.

Mathematics Confidence

Mathematics confidence is closely connected to a students' ability to learn and accomplish many mathematical tasks (Fennema and Sherman 1976). Pierce et al. (2007) explain that mathematics confidence refers to students' perceptions of their ability to achieve good results and their belief in their ability to deal with any difficulties in mathematics. Galbraith and Haines (1998) confirm that students with high mathematics confidence tend to believe they get value for effort. They are not anxious when required to learn challenging topics. They have high expectations of obtaining good results, and are always fascinated by mathematics as a subject.

Mathematics Motivation

Motivation is considered an important factor which contributes to effective outcomes for students while learning mathematics (Tella 2007). Motivation relates to students' beliefs about how hard they work in mathematics. Students with high mathematics motivation tend to have fun in doing mathematics, will persist in searching for different ideas to solve problems with and, prefer to do more challenging tasks, exhibit greater creativity and risk taking, and also intensely engage in mathematical activities (Galbraith and Haines 1998). Studies conducted by Torff and Tirotta (2010) proved that the use of technologies in mathematics classrooms led to improved motivation of students.

Research Participants and Procedures

This study is subsection of a larger study. For the larger study, we investigated teacher professional learning and their use of technology in their mathematics classroom teaching practice. This involved building an online professional learning community (via a closed Facebook group) which enabled teachers to share aspects of their classroom experiences. Teachers from five junior high schools in Semarang, Indonesia participated in this study. Teachers shared how they used innovative teaching practices to encourage students learning of mathematics with technology. Therefore, in a way, the students too have become subjects in this study. While the main study's focus was essentially on mathematics teachers, in this subsection, we report on the students' perceptions regarding their overall experiences with technology in mathematics classrooms.

Survey questionnaires were administered to students towards the end of their school semester. Students were assured that we would maintain their confidentiality and anonymity and only the researchers had access to their survey responses. We had obtained full ethics approval prior to administering the survey to students. Furthermore, the researchers were given access to only one class from each school. Hence, across all the five schools, we observed five mathematics classroom teaching sessions. We have segregated the five mathematics classrooms from the five schools into two school groups, based on their school's preferred teaching and learning strategy. In three schools (namely, school B, C and D), students studied in small groups with shared learning devices. This is because of lack of availability of devices with only some students having their own devices and with the school also providing a few devices. We refer to this school group as Group I in this study. The other two schools (namely, school A and E) preferred a one-to-one learning strategy with all students bringing their own devices to schools for their own learning, and is hereby referred as Group II. A total of 137 students (70 boys, 67 girls) across all five schools participated in this study. Of these, Group I comprised of 91 students (41 boys, 50 girls) while Group II had 46 students (29 boys, 17 girls).

Three experts validated the questionnaire. Then, the questionnaire was piloted with a group of 86 students who were not a part of observed classes in the current study although the pilot students had similar characteristics to those of the target groups. The purpose of the pilot was to test the face and content validity of the instrument and evaluate its reliability. In addition, it helped identify questions that did not make sense to participants, and which might lead to biased answers. After conducting the pilot test, some questions were amended to improve clarity. Overall, each student took no more than 20 minutes to complete the questionnaire.

Research Instrument

When we began the research, no suitable instrument was available which fitted our exact needs, so an instrument in the Indonesian language was designed with questions that the 13 to 15-year-old students would understand easily and complete within no more than 20 minutes. The original survey instrument titled Attitude towards Technology and Mathematics (ATM) scale covered students' demographic information and included sixteen Likert-scale questions of four factors, namely attitude towards technology use in mathematics (TM) (four items), technological confidence (TC) (four items), mathematics confidence (MC) (four items), and mathematics motivation (MM) (four items). The items of the first three constructs were measured on a 5-point Likert scale from strongly agree to strongly disagree (scored from 5 to 1). A different but similar response set was used for the mathematics motivation (MM) subscale. Students were asked to indicate the frequency (MM1), satisfaction level (MM2), and difficulty level (MM3, MM4).

Item		Factor			
		MM	TM	TC	MC
MM1	How much have you liked learning mathematics using technology?	0.83			
MM2	How much fun has learning mathematics been using technology?	0.65			
MM3	How easy has it been to learn mathematics using technology?	0.69			
MM4	How hard have you worked in learning mathematics using technology?	0.62			
TM1	Mathematics is more interesting when using technology (laptop/smartphone/tablet).		0.65		
TM2	Technology helps me learn mathematics better.		0.84		
TM3	I like using a laptop/smartphone/tablet to run applications for doing mathematics in class.		0.43		
TM4	Using a laptop/smartphone/tablet in mathematics is worth the extra effort.		0.53		
TC1	I am good at using technology.			0.68	
TC2	I can handle technical problems when using technology.			0.68	
TC3	I can master procedures in using applications that run on laptop/smartphone/tablet quickly.			0.62	
TC4	I am good at using technology like a laptop, smartphone, tablet, and some applications needed for school.			0.53	
MC1	I can get good results in mathematics.				0.54
MC2	I know I can handle difficulties in mathematics.				0.92
MC3	I have a mathematical mind.				0.58
MC4	I am confident with mathematics.				0.65
Eigenvalues		5.04	2.16	1.97	1.08
% of variance		31.49	13.49	12.33	6.75
α		0.81	0.78	0.76	0.82

Table 1. EFA results for the ATM scale

The questionnaire items were initially analysed with an exploratory factor analysis (EFA) using IBM SPSS. The analysis was performed in order to check for construct validity that is the degree to which the measured variables used in the study represented the hypothesized factors (Heppner et al. 1992). Principal axis factoring with oblique rotation was used for the factor analysis on the instrument. The principal axis factoring was chosen as an extraction method because the assumption of multivariate normality is not fulfilled. Fabrigar et al. (1999) recommended using one of the principal factor methods for dealing with non-normally distributed data. The results of EFA can be seen in Table 1. The analysis yielded the four-factor structure accounts for a total of 64.06% of variance, with 31.49% attributed to the first factor (mathematics motivations).

The reliability of the ATM scale (Cronbach's alpha = 0.85) can be considered as acceptable (Kerlinger and Lee 2000). Meanwhile, Cronbach's alpha for each subscale (MM = 0.81; TM = 0.78; TC = 0.76; MC = 0.82) exceeded 0.7, thus indicating a good or acceptable degree of internal consistency in each subscale.

Further, to measuring of sampling adequacy the Kaiser–Meyer–Olkin (KMO) and Bartlett's Test of Sphericity (BTS) were calculated. According to Field (2013), sampling adequacy is satisfied if a value of KMO greater than 0.5 and BTS is significant. For this part of study, the KMO = 0.77 and BTS < 0.01, so sampling adequacy was satisfied.

The questionnaire also consisted of four open-ended questions to explore possible factors that might emerge in the arguments of students as they explained and justified their attitudes towards technology for learning mathematics. The open-ended questions consisted of the following:

- How was your experience of learning mathematics with technology?
- What interesting ideas emerged using from the technology-assisted learning?
- Did you face any problems with this type of learning?
- Can you suggest ways in which teachers could make better use of technology while conducting mathematics lessons?

Data Analysis

Responses given to the sixteen Likert-scale questions were analysed using descriptive statistics and inferential statistical procedures using IBM SPSS. Data were organised by subscale and differentiated according to gender and perceived ease of access to technology. The responses of items of each subscale were added together to generate a subscale score ranging from 4 to 20. The composite score was dichotomised using mean (which was 12) as a cut-off value. Thus, for MM subscale, scores above the cut-off value indicated a high mathematics motivation and scores below the cut-off value showed low mathematics motivation. Similarly, on the TC and MC subscales, scores above the cut-off value were considered to have positive technology and mathematics confidence, while scores below the cut-off value were considered to reflect negative technology and mathematics confidence, respectively. Further, on the TM subscale, scores above the cut-off value were considered to have a positive attitude to the use of technology in mathematics, otherwise the scores indicated a negative attitude. To evaluate the significance differences of each subscale by perceived ease of access to technology and gender, the non-parametric Mann–Whitney U tests were employed (Field 2013).

The responses of open-ended questions were organized and differentiated by gender and then examined using content analysis, an approach "for the subjective interpretation of the content of text data through the systematics classification process of coding and identifying themes and patterns" (Hsieh and Shannon 2005, p. 1278). All the responses were organized into NVivo where emerging themes were noted and the data coded. The process of coding was continuously revised and rechecked until sufficient coding consistency was achieved.

Results

In this section, the results of inferential statistical analyses with regard to students' attitudes towards technology in mathematics are presented. Student responses (from both closed and open-ended questions) have been subjected to further analysis based on gender differences.

Gender Differences in Attitudes towards Technology in Mathematics

In a previous study, Forgasz et al. (2006) indicated that students' socio-economic status in terms of their ability to bring their own devices appeared to influence attitudes towards technology in mathematics for boys and girls in different aspects. Our findings found some gender differences also. This section reports the results of the four subscales further based upon factors of perceived ease of access to technology and by gender.

Distribution of the ATM scores by gender for students who worked in small groups (i.e., Group I) do not reveal significant differences between boys and girls for each subscale (see Figure 1). Statistical analysis revealed scores pertaining to MM ($U = 846$, $z = -1.442$, $p = 0.149$, $r = -0.123$), TM ($U = 923$, $z = -0.826$, $p = 0.409$, $r = -0.071$), TC ($U = 988$, $z = -0.298$, $p = 0.766$, $r = -0.025$), and MC ($U = 899.5$, $z = -1.013$, $p = 0.311$, $r = -0.087$). In the distributions of TM scores, both boys and girls have the same interquartile ranges and the same level of median. These show that both boys and girls have similar views about the use of technology in mathematics. Further, the distributions of scores of MM, TC and MC have some overlap in both the interquartile ranges and medians. These indicate no differences in boys or girls attitudes with respect to mathematics motivation, technological confidence and mathematics confidence.

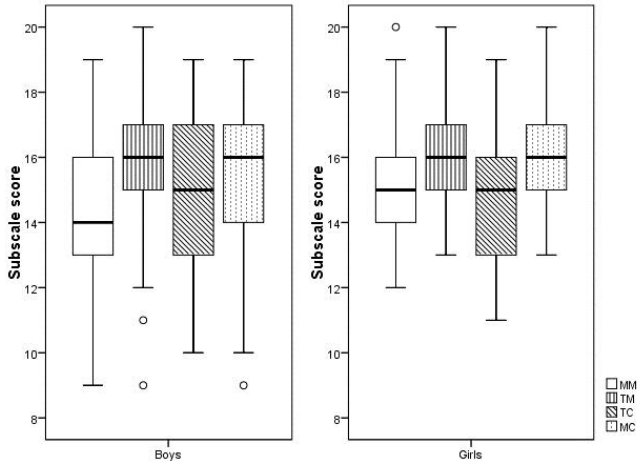

Figure 1. The ATM scores of subscales by gender for Group I students who were studying in small-groups

Figure 2 depicts the distribution of the ATM scores by gender for Group II students who used one-to-one devices. Statistical analysis yielded that both boys and girls have no significant differences for each subscale except TM (U = 161, z = –1.966, p = 0.049, r = –0.168). TM scores are significantly higher for boys, with approximately 50% of boys scoring 14+ and only 25% of the girls. This result indicates that boys hold a more positive attitude towards use of technology in mathematics, compared to girls. Barkatsas et al. (2009) too report similar results.

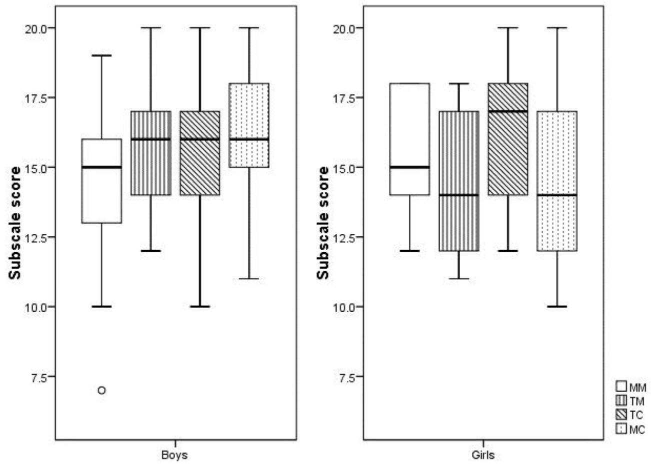

Figure 2. The ATM scores of subscales by gender for Group II students who were using one-to-one devices

In general, each box plot is uneven in size. This indicates that both boys and girls have similar perceptions at certain parts of the scale, but in other parts of the scale, they have different perceptions. Hence, a more in-depth study is needed to gain understanding of these subtle differences in students' views. This will help gain deeper insights on gender biases and explain how both genders relate to technology, mathematics and teaching, which in turn can help in evaluating the effectiveness of technology use for learning mathematics. The students' views are analyzed in the following section.

Students' Views about the Use of Technology in Mathematics

Qualitative data gathered from the questionnaire were analyzed to identify factors from which students' attitudes to technology in mathematics could be inferred. Comparison between the codes and categories from the four sources of qualitative data helped to identify the main categories that emerged from students' views. Three main themes emerged from students' responses in the use of technology in mathematics: attitudinal factors which influenced students' attitudes towards technology use in mathematics classrooms, challenges faced by students when using technology in schools and teachers' pedagogical skills (see Table 2).

Theme	Meaning/indicators	No. of references
Attitudinal factors which influence students' attitudes towards technology use in mathematics classrooms	▪ The use of technology in mathematics provides relevance for mathematics. ▪ Feelings of self-assurance in operating technology. ▪ Feeling more confident of their problem solving abilities. ▪ Belief in their ability to deal with any difficulties in mathematics. ▪ No longer thinking of mathematics as a difficult subject.	283
Challenges faced by students when using technology in schools	▪ Internet connection problems. ▪ Technical issues in using devices and apps. ▪ Lack of instructions on how to use the apps.	148
Teachers' pedagogical skills	▪ Methods used to deliver mathematics materials using technology ▪ Maintaining a well-behaved classroom when using technology.	68

Table 2. Coding of the three main themes and its meaning of responses to the four open-ended questions

Views from Students Studying in Small Groups

In this section, we will outline the perceptions of Group I students who were studying in small groups towards learning mathematics. Teachers from these schools used collaborative learning strategy to manage the lack of availability of technological devices. The teachers arranged the students into small groups of two to four students, depending on the availability of devices. Few students in this group who brought their own devices were encouraged to share their devices with those who did not have devices. Vale (2006) has acknowledged that teachers have a responsibility to give equal access to the students with technologies as a way to "close the gap" for their students.

Our findings indicate significant gender differences among students in regard to their attitude to technology in mathematics. Boys showed more positive attitudes towards the use of technology in mathematics, in comparison to girls. Boys were more likely to express opinions in which they considered the use of technology made mathematics lessons easier to understand. For example, the boys stated"

> [Using technology for learning mathematics] *is exciting because the materials become easier to understand.*
>
> *It is very interesting and exciting, I am not so bored and I can understand all the materials clearly.*

Boys also thought that technology was useful for doing mathematical measurement:

> *Using technology* [GPS Fields Area Measure – a mobile app], *I can easily measure perimeter* [of the school field] *and distance* [between two objects using GPS tracking].
>
> *I can measure* [angles and slopes] *of an object by activating camera mode feature* [of Smart Protractor app].

These views show that technology positively reinforced overall the learning process of mathematics for boys and increased their engagement in which boys attracted to the learning process.

High engagement with technology in the mathematics classrooms was also evident in the girls' responses. Typical responses included:

> *I am happy following the learning process using this very advanced technology.*
>
> [Technology usage in mathematics] *is very interesting because it can improve our knowledge and lift our motivation and confidence* [in mathematics].
>
> *It is so fun because it improves my knowledge and lifts my learning spirit.*
>
> *Using GeoGebra, I can solve mathematics problems easily, especially about linear equations.*

These responses indicate that the use of technologies have contributed to the girls' learning, increased their engagement, assisted them with mathematical reasoning and made mathematics easier.

The girls also indicated that the use of technology in mathematics enabled them to learn technological skills; however, these views depended on the app. For example, they made statements like:

> *Socrative is easy but GeoGebra is not.*

> *Using FX Draw and Screencast-O-Matic is fun but also quite difficult. I cannot completely understand about them.*

One girl suggested*:*

> *All students should be guided first how to use laptop* [especially programs used in the learning activities] *appropriately.*

In contrast to the boys who held more positive views towards the use of technology in mathematics, a number of girls expressed dissatisfaction with the way technology were employed in mathematics. For example:

> *I prefer the conventional method to this* [technology-mediated learning].

> *Do not focus too much using technology* [in delivering mathematics materials] *because* [the teacher just asked students to focus on PowerPoint slide or video used so that we do not have notes, hence] *I cannot understand* [the materials] *better. Sometimes we need to use conventional methods such as* [the teacher] *explains* [the materials] *on the board* [so students can make copy of notes on the board to their book].

> *Learning* [mathematics] *using technology is fun, but I prefer using conventional methods so that I can understand the materials well.*

These findings are similar to those of Vale and Leder (2004). They also indicated the critical attitudes held by some students to the use of technology in mathematics. As we found, Vale and Leder also described how a few girls preferred to use pen and paper instead of using technology.

A number of girls provided responses that indicated factors that showed their dissatisfaction towards technology for learning mathematics and how it caused them to disengage from learning. For instance:

> *The teaching delivered by T2* [code for teacher name] *is a little bit boring.*

> *Please do not go so fast in explaining* [the materials] *because not everyone can easily catch them.*

> *Some of my friends are not serious* [in paying attention to the teacher], *and they talk too much.*

> *We are always late for breaks when we have this type of mathematics learning*

> *If we do not have any gadgets then we certainly cannot practise the apps.*

These views suggest reasons why some girls preferred to learn in the traditional way. Nevertheless, some girl's views indicated the importance of teachers having the pedagogical skills to manage the use of technology as a teaching aid. These skills enabled the teachers to create a learning environment in which all students were engaged and supported to learn. At the same time, they inferred that good pedagogical skills enabled the teachers to select management strategies which reduced behavioral problems and allowed them to manage time effectively. One girl highlighted the availability of devices as sometimes problematic. In this regard, Vale (2006) suggested teachers need to find ways to bridge the gap for their students.

Views from Students using One-to-One Devices

In this section, we will outline the perceptions of students in Group II who used one-to-one learning devices in mathematics classrooms. In these schools, all students brought their own devices. These included such items as laptops, mobile phones and tablets. Interestingly, within these schools both girls and boys predominantly expressed positive attitudes to the use of technology in mathematics. There was no statistically significant difference in their attitudes. These students used such terms as "*interesting*", "*exciting*", "*happy*", "*fun*" and "*easy*" to describe how they felt. However, the boys were more explicit and emphasized those aspects that made learning mathematics easier when technology was used:

> *It is quite exciting because the students learn easier than using manual methods* [writing on the board] *and other boring practices, using technology we only need to move our fingers, unlike manual writing which is so tiring for us.*

> *At first, I felt so confused but later I realized that it is simpler and easier to learn with a mobile phone, and the materials are well presented using an LCD projector.*

> *The* [Adobe Flash-based] *interactive learning media is very interesting,* [when the teacher delivers his materials] *using this media, mathematics is easier to understand…I am very happy with this kind of media.*

In turn, the girls stressed aspects that made mathematics more pleasant and useful. For example, different girls stated:

> *It is just like learning by playing so that it is not boring at all.*
>
> *It is fun and catches my attention. It does not make me feel so bored and sleepy.*
>
> *I am able to practise in solving realistic mathematics problems* [posted in Socrative – a web-based student response system].

Although most students have positive feelings about the use of technology in mathematics, two girls and a boy remained less convinced. The girls' responses were:

> *In my opinion, using technology means we have to work twice.*
>
> *I think nothing is interesting* [about technology-mediated learning].

In addition, the boy stated:

> [There is] *nothing special* [with technology-mediated learning].

These views of students about the use of technology in mathematics have been found in a number of studies (Forgasz et al. 2006; Ursini and Sánchez 2008; Vale and Leder 2004). They confirmed that students have different feelings in using technology in mathematics. Some students felt that technology usage is interesting, exciting and useful but some others may feel it is challenging. Pierce et al. (2007) used the terms "affective engagement" and "behavioral engagement" to refer to how students feel about the use of technology in mathematics and how they behave in using technology in mathematics, respectively. Barkatsas et al. (2009) recommend that positive levels of affective and behavioral engagement need to be considered for students to develop a positive attitude in using technology in mathematics.

Challenges in the Use of Technology in Mathematics

At all classes, challenges were identified in the use of technology. The challenges perceived by students included Internet connection problems, technical issues in using devices and apps, and lack of instructions on how to use the apps. For example, students' responses outlined the problems caused by these factors:

> *Good wireless connectivity should be provided to support technology-mediated learning.*
>
> *Please check the Internet connection first. If the connection is bad, then the learning process will not be optimum and the students will use their mobile phones only for playing music and games, and it is so disturbing for me.*
>
> *If we want to use technology-mediated learning methods then strong Internet connection must be provided.*

Others suggested the need to

> *Provide good wireless connection to help those who do not have Internet data plans.*

Clearly, they believed that having a good wireless connectivity would lead to effective learning. Other challenges related to technical issues in the use of devices and apps. Different students explained:

> *…the mobile phone gets hung up, the battery is also running out.*

Others said:

> *The* [Socrative] *app is often stuck.*
>
> [When using Socrative] *I have to wait for the teacher initiating the application before doing the mathematics exercise.*
>
> [Socrative suddenly] *being logged out* [because the Internet connection is lost] *and I have to complete the mathematics exercise* [from the beginning again].

Some studies (Forgasz et al. 2006; Ursini and Sánchez 2008; Vale and Leder 2004) confirmed that some students thought that the use of technology is somewhat challenging. However, these studies did not mention specifically what kinds of challenges faced by the students. Our study adds rich insights into challenges (i.e., the availability of wireless connectivity and understanding of the technical issues of devices and apps) schools encounter. By considering these challenges, teachers will be able to find appropriate strategies to draw on to expose students to technology. This in turn will increase student engagement in mathematics with technology.

Conclusion and Limitations for Future Research

Students in the current study showed positive feelings about the use of technology in mathematics. From the results we can infer that they had increased motivation, and were technologically confident; factors which are important for student engagement in mathematics. This aligns with what Galbraith and Haines (1998) argue, that active engagement on the part of students contributes to effective outcomes. They view that if students can engage in computer-assisted environments for mathematics, they will have a belief that technology has contributed in improving their learning.

Significant gender differences regarding attitudes towards technology use in mathematics were evident in schools where availability of devices was limited. Boys expressed more positive attitudes towards the use of technology in mathematics, in comparison to girls. Most boys believed that the affordances of technology in mathematics positively affected the learning process of mathematics. On the contrary, a number of girls expressed dissatisfaction with the way technology was employed in their mathematics classes. These findings are consistent with a study conducted by Vale and Leder (2004) in which girls persisted with conventional methods instead of using technology. Students who were studying using one-to-one technology-based learning devices predominantly expressed positive attitudes towards the use of technology in mathematics. However, boys and girls showed no significant difference in their overall attitudes to technology. Both revealed positive feelings about technology use in mathematics. However, there remained a few students less convinced. Previous studies also found similar results regarding the different feelings among students in the use of technology in mathematics (Forgasz et al. 2006; Ursini and Sánchez 2008; Vale and Leder 2004). Students' comments have shed light on the need to consider appropriate pedagogical approaches when using technology in mathematics, and the necessity of giving equal access to technology to ensure their continued engagement in learning mathematics. This will help alleviate some of the challenges related to student engagement.

This study is not without limitations. As a result of school policy, it was not possible to have data in regard to those students who did not use technology for learning mathematics. Therefore, no comparisons with their attitudes could be made. The generalizability of the study is limited to students who use technology in mathematics; attention is not given to those students who did not use technology in their mathematics classrooms. As a result, our conclusions must be considered in the context of the current study. Despite these limitations, the findings are consistent with those of previous studies (Barkatsas et al. 2009; Forgasz et al. 2006; Ursini and Sánchez 2008; Vale and Leder 2004). Further research is needed to investigate teachers' practices in their use of technology in mathematics classrooms in order to understand the way teachers from different groups of classes (i.e., BYOD classes and non-BYOD classes) integrate technologies within mathematics activity. We also need to investigate ways in which technology-mediated learning environments can contribute to students' learning of mathematics in rich and meaningful ways.

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