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Gender-related differences in the use of technology in mathematics classrooms

Student participation, learning strategies and attitudes

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Abstract

Purpose – The use of technology in education is still seen as a symbol of modernity in Indonesia. Without adequate technological infrastructural support from institutions, teachers develop ways to incorporate technology into their classrooms. The purpose of this paper is to investigate the affective domain in learning mathematics with technology across genders and across two student groups, where in one group the students shared learning devices, while the other group of students used individual devices.
Design/methodology/approach – The study adopts both quantitative and qualitative methods and is based on data collected from five secondary schools in Indonesia.
Findings – The findings reveal attitudinal differences are associated with technology usage in mathematics classrooms. Quantitative measurements across four attitudinal subscales—mathematics motivation, attitudes to the use of technology in mathematics, technological confidence and mathematics confidence—indicate that affordances in technologies influence boys and girls attitudes; while qualitative data share further insights on gender perspectives related to attitudinal differences.
Research limitations/implications – Appropriate pedagogical approaches with equitable access to technologies are important for engaging students in learning mathematics with technology.
Social implications – This empirical study reveals aspects related to student participation with technologies in classrooms, which has important implications for student development.
Originality/value – The study contributes to literature on mathematics education related to the use of learning technologies in secondary schools of a developing country.

Keywords Gender differences, Affective factors, Mathematics learning, Secondary school students, Student confidence, Technology attitude

Paper type Research paper

1. Introduction

Integrating technology into education practice is fast becoming an expected norm. Within mathematics education, infusion of technology substantially alters the way in which mathematics is taught and learned. Technology affordances allow the addition of novel resources to mathematics content, so that teaching methods can be practiced in unique ways. Technology provides the tool for teachers to connect mathematical theories with real-world problems so that their students are able to explore mathematical concepts, and analyze situations as they are problem solving (Sawaya and Putnam, 2015). Teachers work toward designing innovative practices to gain benefits from technology-enhanced learning

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environments. However, being able to do this depends upon teachers' skills, familiarity with technology and their assessment of the appropriateness of the subject content with student characteristics (Yu *et al.*, 2012). Students can easily tell about teachers' perspectives based on how they utilize technology in their instructional practice (Pate, 2016), which also impacts how students engage with technology. Furthermore, for teachers to implement innovative pedagogies they need to consider how prepared their institutions are in providing access to the required technological infrastructure. While teachers may have the best of intentions of combining pedagogies which incorporate mathematical knowledge and technology, students' attitudes toward this change also require consideration. Does this positively reflect on student engagement toward learning and doing mathematics with technology? Or, as Eng *et al.* (2016) caution, can it cause them to develop poor attitudes to learning mathematics with technology.

Understanding student experiences is central to structuring teaching and learning practices for transferring of knowledge, motivating students and ensuring their active participation (Smith and Hardaker, 2000). A key component to ensure a smooth process of learning mathematics with technology is having proper access to technology. A number of studies suggest the need to monitor students' attitudes toward mathematics and their learning with technology (e.g. Barkatsas *et al.*, 2009; Eng *et al.*, 2016; Pierce *et al.*, 2007). Ursini and Sánchez (2008) suggest monitoring student attitudes toward mathematics when technology is first introduced in mathematics classrooms. This includes consideration of individual and gendered attitudes of the learners, since students interest in taking up science and mathematics as a future career choice are highly influenced by school-related experiences (e.g. classroom exchanges, instructional materials and curriculum) (Morales *et al.*, 2016). In this paper, we investigate affective factors of students attributed to the use of technology in mathematics lessons in developing countries (i.e. Indonesia), where access to technology is still seen as a symbol of modernity.

Schools are often the first social platform where digital capabilities are developed; therefore, schools are important places for making investigations related to equitable development. We focus on affective factors of students in their use of technology-based learning devices in two different secondary school group settings. 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 the use of technology for learning mathematics. Specifically, we focus on four subscales—confidence with technology, mathematics confidence (MC), mathematics motivation (MM) and student attitudes toward technology—across secondary schools in the Semarang municipality of Indonesia. These subscales have been further analyzed along gender dimensions to share rich insights on how boys and girls perceive technology while learning mathematics.

2. Students outlook toward technology use

Educators seek to expand traditional definitions of literacy and teaching methods with new forms of interactive exchanges (Smith and Hardaker, 2000) as they work toward presenting the subject content in a manner which suits present-day student learning styles. The Program for International Student Assessment 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). To encourage students in developing an inquiry-based attitude, mathematics teachers identify suitable problems across different scenarios. Technology can help students discover new material and teachers must formulate problems which go beyond typing and substitution to cultivate a sense of dialogue and participation (Pate, 2016). Technologies offer a more immersive classroom experience to students with graphic stimulants involving coordination of hand-eye movements like using swipe screen, dragging and dropping objects or pinching for zoom-in and zoom-out events.

While the addition of technology into educational programs offers many avenues for teachers to engage students, we also need to pay attention to students' outlook toward technology use. Schools, in general, focus on "science, technology, engineering and mathematics" skills (Pate, 2016), and much research has been conducted on student attitudes toward applying technology for their learning. Some research suggests consideration should be based on gender; however, results in regard to gendered student attitudes are inconsistent. 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 reported attitudes toward computer-based mathematics to be more closely correlated with positive attitudes toward computers than toward mathematics itself and that the correlation was higher for males than females. Pierce *et al.* (2007) drawing on five attitude measures, namely, MC, confidence with technology, attitude to learning mathematics with technology, affective engagement and behavioral 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 MC. Barkatsas *et al.* (2009) reported that male students expressed more positive views toward mathematics and more positive views toward the use of technology in mathematics, compared to females. They also found that students with high achievement in mathematics showed high levels of MC, and very positive levels of affective engagement and behavioral engagement. They demonstrated that holding a high level of confidence in using technology appeared to translate toward a positive attitude in learning mathematics with technology. Although Eng *et al.* (2016) found no significant difference in attitudes to learning mathematics with technology based on gender, they reported that there were significant differences in attitudes while learning mathematics with technology between students from rural and semi-urban schools. Students from semi-urban secondary schools exhibited more confidence in using technology than those from rural schools.

A study conducted by Forgasz *et al.* (2006) found that socio-economic status mediated differences in attitudes toward computers for learning mathematics. The socio-economic status may contribute to inequities in learning outcomes especially when technologies are integrated into instructions (Vale, 2006). A report on structural policy of Indonesia by OECD (2013, p. 12) 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 (Pruet *et al.*, 2016). The perceived access to technology could be another aspect that may contribute to differences in attitudes toward technology in mathematics. 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.

3. The affective domain in learning mathematics with technology

Affective factors play a central role in mathematics learning (Barkatsas *et al.*, 2009; Vale and Leder, 2004). With regard to the affective factors, Galbraith and Haines (1998) used three terms, that is, beliefs, attitudes and emotions to refer to the term "affect." They state:

> […] *belief* reflects a judgment about a certain set of concepts; *attitude* represents an emotional reaction to an object, to beliefs about an object, or to behavior towards the object; *emotion* signifies a hot agitated arousal created by some stimulus (p. 276).

Attitudes, in particular, are deemed as a key aspect to be considered when studying about learning process (Ursini and Sánchez, 2008). In their seminal studies, Fennema and Sherman (1976) conducted survey questionnaires using mathematics attitude scale to gauge affective factors of students in their process of learning mathematics. Their scales were designed to measure overall learners' perceptions, such as their interest in mathematics, their outlook on achievement levels and largely their sense of responsibility toward their own learning. These scales were further analyzed to seek if any gender-related differences contributed to their attitudes. Over time, questionnaires have become standard tools to assess student perceptions and attitudes toward 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 scales to measure student attitudes, 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 ten minutes, the scale could not provide data to illustrate how students developed their attitudes. Ardies *et al.* (2015) argue that knowing what influences students' attitudes toward technology between the age of 12 and 14 is important to better understand how the attitudes are formed. Dündar and Akçayır (2014) add that the effects of the educational use of technology on students and their attitudes, teaching and the learning process need to be researched further.

Drawing upon prior research, the following subsections briefly elucidate the four affective subscales toward learning mathematics used in this study.

3.1 Attitudes toward the use of technology in mathematics

Pierce *et al.* (2007, p. 289) 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 subscale. They claim that students who intensely engage with computer 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 scale there are at least two aspects which are in common. Ursini and Sánchez (2008) emphasize 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 behavioral components." In this study, we conceptualize the term attitude to encompass these three components as expressions of beliefs, feelings and behavioral intention about using technology for learning mathematics.

3.2 Technological confidence (TC)

TC is considered an important scale in learning of mathematics using 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 TC makes students more inclined to participate in lessons using technology and this in turn leads to them gaining increased confidence in doing mathematics.

3.3 Mathematics confidence

MC is closely connected to a students' ability to learn and accomplish many mathematical tasks (Fennema and Sherman, 1976). Pierce *et al.* (2007) explain that MC 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 MC 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. In terms of the use of technology in mathematics, the students with high MC tend to have a better control on the type of technology-related activities and tend to do well mathematics test performance (Xu and Jang, 2017).

3.4 Mathematics motivation

Motivation is considered an important scale 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 MM 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.

4. Framing the research intent

This study is an offshoot of a larger study. The larger study investigated teacher professional learning where teachers developed innovative pedagogical practices through the use of technology in mathematics classroom teaching practice. Here five mathematics teachers shared aspects of their classroom experiences with each other over an online professional learning community (via a closed Facebook group). All five teachers teach mathematics in five junior high schools in Semarang, Indonesia. The online community provided a forum for teachers to share teaching practices with their peers. They demonstrated innovative teaching practices showcasing how they used technology to support and encourage student learning of mathematics. Their forum posts comprised photos, videos and blogs showcasing problem cases where technology had been applied to classroom teaching. This then raised further question on how students perceive the technology-mediated classroom sessions. While searching appropriate pedagogies for classroom practices, teachers were themselves keen to know how their students viewed the overall classroom experience with technologies in the area of mathematics.

This brought clarity to the research intent of this study. Our intent is to understand what students thought about these innovative teaching practices. We wanted to know whether the new practices motivated students and made them feel confident in using technology for learning of mathematics. To capture end-user's voices, we decided to use both closed and open-ended questions to capture aspects of student attitudes, participation and learning strategies with the newly adopted technology interventions in classroom practice. With the research intent now clearly laid out, our next step was to design a research instrument to gather responses from students belonging to the five mathematics classrooms. To get these insights from students, our responsibility was to ensure that students feel safe in expressing positive and negative views regarding their overall classroom experiences. So, our strategy then was to administer a survey questionnaire to students, where access to student responses would be with the researcher team alone, while the five mathematics teachers would be given summarized information without disclosing the identity of the students or the school.

5. 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. We planned a research instrument with both closed- and open-ended questions. For the closed questions, we identified items corresponding to four subscales from literature. These subscales relate to attitudes toward the use of technology in mathematics, TC, MC and MM (i.e. Pierce *et al.*, 2007; Torff and Tirotta, 2010; Vale and Leder, 2004). Our survey instrument titled "attitude toward technology and mathematics" (ATM) covered students' demographic information and included 16 Likert-scale questions, of which four questions took account of four subscales, namely attitude toward technology use in mathematics (TM) (four items), TC (four items), MC (four items) and MM(four items). The items of the first three subscales (TM, TC and MC) were measured on a five-point Likert scale from strongly agree to strongly disagree (scored from 5 to 1). A different but similar response set was used for the MM subscale. Students were asked to indicate the frequency (MM1), satisfaction level (MM2) and difficulty level (MM3, MM4).

Three experts (not belonging to the teaching team) 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 the questions that did not make sense to participants, and which might lead to biased answers. Accordingly, some questions were amended to improve clarity.

The questionnaire items were initially analyzed with an exploratory factor analysis (EFA) using IBM SPSS. The analysis helped 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 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 I. The analysis yielded the four-factor structure accounts for a total of 64.06 percent of variance, with 31.49 percent attributed to the first factor (MMs).

The reliability of the ATM scale (Cronbach's $\alpha = 0.85$) can be considered as acceptable (Kerlinger and Lee, 2000). Meanwhile, Cronbach's α 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 which were designed to gauge student views regarding their experiences with technology in their own voices. These questions were deliberately designed to make students explain their reasons for having a particular attitude toward using technologies for learning of mathematics. The open-ended questions are:

- 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?

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

Note: $n = 86$

Table I. EFA results for the ATM scale

6. Participants and data collection

A total of 137 students (70 boys, 67 girls) across all five schools participated in this study. 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 the 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, Schools 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. Group I comprised of 91 students (41 boys, 50 girls) while Group II had 46 students (29 boys, 17 girls).

The validated instruments were administered to students toward 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. Each student took no more than 20 minutes to complete the instrument. Full ethics approval was taken prior to administering the research instrument to the students.

7. Quantitative analysis of the survey data

The ATM questionnaire comprising 16 Likert-scale questions items have been analyzed using descriptive statistics and inferential statistical procedures using IBM SPSS. The data have first been organized by the subscale, and next has been differentiated based on gender attribute and how devices are being used in classrooms. The responses of items for each subscale were added together to generate a subscale score ranging from 4 to 20. The composite score was dichotomized using mean (which was 12) as a cut-off value.

This means, that for MM subscale, scores above cut-off value indicate a high MM and scores below the cut-off value show low MM. Similarly, for the TC and MC subscales, scores above cut-off value are considered to have positive TC and MC, respectively, but meanwhile scores below cut-off value reflect negative TC and MC. Likewise, for TM, scores above cut-off value indicate positive attitude to the use of technology in mathematics, else the scores indicate a negative attitude. Moreover, to evaluate the significance of differences for each subscale by school's preferred teaching and learning strategy and by gender, the non-parametric Mann–Whitney U tests have been employed (Field, 2013).

Further, to study whether any correlations exist between subscales of the ATM scale, the non-parametric correlation tests, Kendall's τ_b were employed (Field, 2013). The following two subsections presents the results of inferential statistical analyses to examine the significance of differences of students' attitudes toward technology in mathematics based on school's preferred teaching and learning strategy and then further on gender. The third subsection applies further inferential statistical procedures to investigate the correlation between the subscale scores for all students and also for boys and girls separately across the two school groups.

7.1 Differences in students' attitudes toward school's preferred teaching and learning strategy

This section extrapolates on the distribution of the ATM scores for subscales differentiated by the school's preferred teaching and learning strategy. As shown in the box plots in Figure 1, there are statistically significant differences in TC ($U = 1{,}501$, $z = -2.717$, $p = 0.007$, $r = -0.232$). A likely reason for higher confidence levels (median = 16) for students who used one-to-one devices (i.e. Group II) could be due to their familiarity with technological devices in classrooms; while Group I students were newly introduced to these devices (median = 15). Further, statistically significant differences are also noted for TM ($U = 1{,}624.5$, $z = -2.16$, $p = 0.031$, $r = -0.185$). Our data further indicate that students from Group I are likely to have more positive attitudes in using technology in mathematics

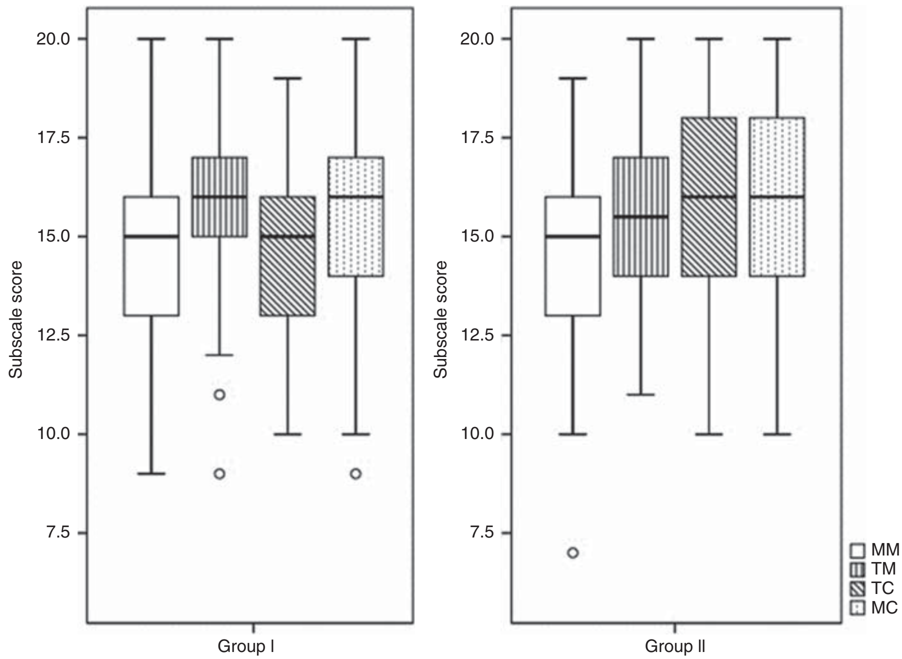

Figure 1. ATM scores for subscales by school groups

(median = 16) than those from Group II (median = 15.5). We also observed that Group I students showed more eagerness than Group II in their use of technology. These results are consistent with a study conducted by Forgasz *et al.* (2006) which showed that socio-economic status (in this case, issues of the availability of devices) appeared to influence the students' attitudes toward technology in mathematics.

The distributions of TM scores between the two groups have overlapping interquartile ranges and whiskers. This suggests the need for further exploration of students' views regarding attitude toward technology in mathematics. Likewise, the distributions of TC scores between two groups also have overlapping interquartile ranges and whiskers and indicates that further investigation of students' perceptions with regard to confidence with technology needs to be carried out. The qualitative analysis from open-ended questions explained later in the paper (refer Section 8) complements the above quantitative analysis to offer finer aspects on students' views in regard to their engagement with technologies.

Furthermore, there are no significant differences between students from Group I and Group II either in MM ($U = 2{,}043.5$, $z = -0.228$, $p = 0.82$, $r = -0.0195$) or MC ($U = 2{,}002$, $z = -0.419$, $p = 0.675$, $r = -0.0358$). The medians of MM scores for students in both groups are similar (median = 15) and are above cut-off (12). This indicates that the students in the two groups have a high level of motivation in mathematics. The medians of MC scores for students in both groups are also similar (median = 16) and are above the cut-off, thereby indicating that the students in the two groups demonstrate high levels of confidence in mathematics.

7.2 Students' attitudes toward technology in mathematics based on gender differences

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 toward technology in mathematics for boys and girls in different aspects. Our findings too suggest some gender differences. 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 2). 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 MM, TC and MC.

Figure 3 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 percent of boys scoring 14+ and only 25 percent of the girls. This result indicates that boys hold a more positive attitude toward the use of technology in mathematics, compared to girls. Barkatsas *et al.* (2009) too report similar results.

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.

7.3 Correlation between the four subscales

To examine the extent to which the four subscales associated with one another, a non-parametric measure of the correlation, Kendall's τ_b was employed (Field, 2013). Table II indicates the

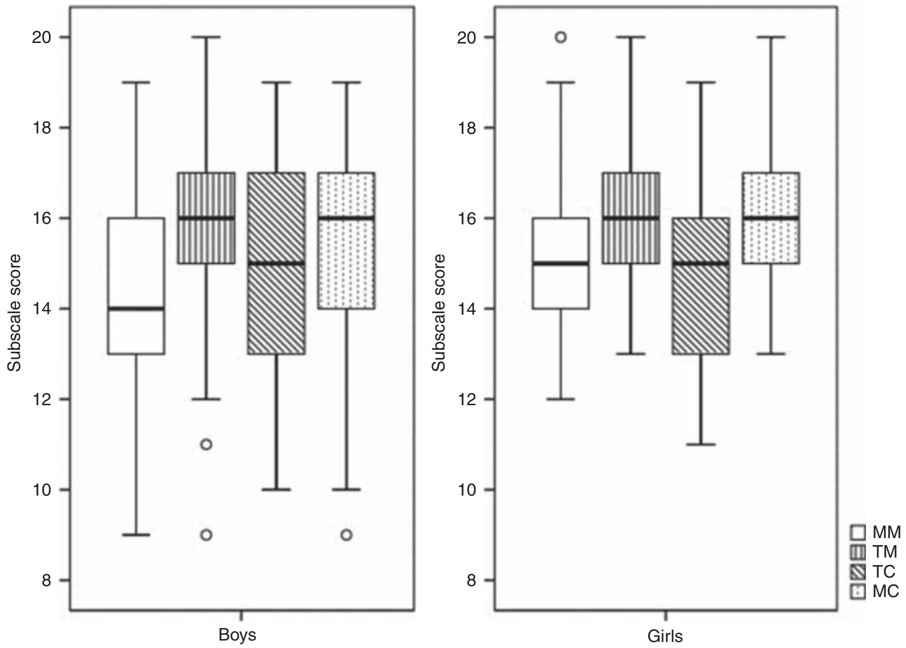

Figure 2.
The ATM scores of subscales by gender for Group I students who were studying in small groups

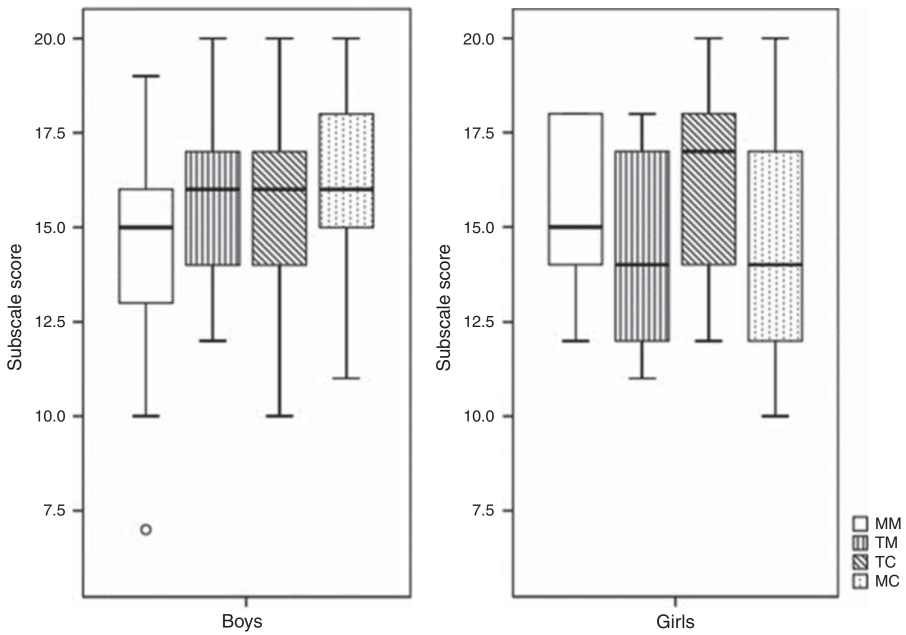

Figure 3.
The ATM scores of subscales by gender for Group II students who were using one-to-one devices

Table II. Interdependence of the ATM scores of subscales

School group		TM	TC	MC
Group I	*MM*			
	All	0.119	0.200*	0.130
	Boys	0.111	0.267*	0.179
	Girls	0.120	0.111	0.075
	TM			
	All		0.215**	0.204*
	Boys		0.270*	0.010
	Girls		0.154	0.399**
	TC			
	All			0.189*
	Boys			0.086
	Girls			0.298**
Group II	*MM*			
	All	0.298**	0.180	0.307*
	Boys	0.224	0.095	0.278
	Girls	0.483*	0.270	0.437*
	TM			
	All		0.130	0.567**
	Boys		−0.083	0.595**
	Girls		0.414*	0.453*
	TC			
	All			0.213
	Boys			0.371
	Girls			0.118

Notes: $n = 137$. *,**Correlations are significant at the 0.05 and 0.01 levels (two-tailed), respectively

correlations between the subscale scores (i.e. MM, TM, TC and MC) for students from the two school groups, and also for boys and girls separately.

The entries in Table II indicate that attitudes toward technology in mathematics for students who worked in small groups with shared devices (i.e. Group I) were positively associated within TC ($\tau_b = 0.215$, $p = 0.007$) and MC ($\tau_b = 0.204$, $p = 0.012$). Attitude toward technology in mathematics for boys in this group was correlated positively with TC ($\tau_b = 0.270$, $p = 0.023$). This finding is in agreement with other studies (Pierce *et al.*, 2007; Vale and Leder, 2004). It can be explained that boys valued technology positively to assist them in the process of learning mathematics. The higher level of TC of boys, the more positive is their attitude toward learning with technology. In addition, TC of boys was significantly associated with MM ($\tau_b = 0.267$, $p = 0.024$) as TC increased, MM increased. For girls, the attitudes were associated with MC ($\tau_b = 0.399$, $p = 0.000$). The result is consistent with the findings of Vale and Leder (2004) but the significant positive correlation is in the opposite direction to the (significant negative) correlation found by Pierce *et al.* (2007). In our study, we see the girls valued technology as a medium to support their mathematics learning. The technology assisted them with mathematical reasoning and made mathematics easier to understand, which in turn increased their MC. In addition, TC subscale for girls was correlated positively with mathematical confidence ($\tau_b = 0.298$, $p = 0.006$). It indicates that when TC of the girls increased, their mathematical confidence also increased.

For those students who used one-to-one devices (i.e. Group II), the correlations of four subscales of the ATM are somewhat different. In comparison to students in Group I, attitude toward technology for learning mathematics was strongly correlated with MC ($\tau_b = 0.567$, $p = 0.000$). Further, the correlations between the two subscales found for boys was strong ($\tau_b = 0.595$, $p = 0.000$), while for the girls it was moderate ($\tau_b = 0.453$, $p = 0.019$). Interestingly, for the girls, attitude toward technology was not only associated positively with MC but also with TC ($\tau_b = 0.414$, $p = 0.035$) and MM ($\tau_b = 0.483$, $p = 0.015$). These results were in contradiction to the correlation found in the Pierce's *et al.* study. This can be explained by the fact that the girls in this group of schools predominantly expressed positive attitudes to the use of technology in mathematics. The girls perceived that technology use made mathematics more coherent, which lifted up their TC, MC and increased their motivation. Further, for the girls, MM was also associated positively with MC ($\tau_b = 0.437$, $p = 0.024$). It means that if motivation increased then MC increased.

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 boys and girls relate to technology use for mathematics learning. The next section analyses students' views from open-ended questions to explain further on how students shape their attitudes.

8. Qualitative analysis of the survey data

The responses of open-ended questions have been organized and differentiated by gender and then examined using content analysis, that is 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 first 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. Student responses (from both closed- and open-ended questions) have been subjected to further analysis based on gender differences.

Qualitative data gathered from the questionnaire were analyzed to identify the themes 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. Four main themes emerged from students' responses in the use of technology in mathematics: affective factors which influenced students' attitudes toward TM classrooms, challenges faced by students when using technology in schools, teachers' pedagogical skills and student expectations with technology (see Table III).

8.1 Views from students studying in small groups with shared devices

In this section, we will outline the perceptions of students in Group I who were studying in small groups while learning mathematics with technology. Teachers from these schools used collaborative learning to manage the lack of availability of technological devices. The teachers arranged the students into small groups of two to four students, dependent on the

Theme	Meaning/indicators	No. of references
Affective factors which influenced 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
Students' expectations and desires for technology usage	Increased technology use in classrooms The continual improvement of apps	24

Table III. Coding of the four main themes and its meaning of responses to the four open-ended questions number of the students who brought their personal 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 toward 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 or for doing mathematical measurement.

Table IV gives some exemplars of responses in regard to the use of technology in mathematics lessons by boys and girls in Group I.

Boys' views as seen in Table IV indicate that technology positively reinforced their overall learning in mathematics and increased their engagement which attracted boys to the learning process. High engagement with technology in mathematics classrooms was also evident in the girls' responses. Their 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 have also indicated that the use of technology in mathematics enabled them to learn technological skills; however, these views depended on the app.

In contrast to the boys who held more positive views toward the use of technology in mathematics, a number of girls expressed dissatisfaction with the way technology was being employed in mathematics classrooms (refer Table V). Some girls have been very explicit in stating the reasons on what caused them to disengage from the learning process with technology use in learning mathematics. As is evident from their comments in Table V, much of this dissatisfaction was related to the style of the teaching delivery (e.g. lack of instructions, fast delivery) and with the lack of devices.

These views provide reasons on why some girls preferred to learn in the traditional way. 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 have described how a few girls preferred to use pen and paper instead of using technology. Nevertheless, girls' views have indicated the importance of teachers having appropriate pedagogical skills to manage the use of technology as a teaching aid. Proper skills will enable teachers to create an environment in which all students are engaged and feel supported to apply new learning skills. At the same time, they inferred that good pedagogical skills will enable teachers to select management strategies which reduce

Gender	Comments
Boys	[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
	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]
Girls	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
	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

Table IV.
Group I: typical responses supporting the use of technology in mathematics lessons

Girls	Comments
Negative comments regarding the way technology is employed	All students should be guided first how to use laptop [especially programs used in the learning activities] appropriately
	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
Reasons for their dissatisfaction	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 practice the apps

Table V. Group I: responses from girls expressing dissatisfaction towards use of technology in mathematics lessons

behavioral problems and allow them to manage classroom time effectively. One girl highlighted the availability of devices as sometimes problematic. In this regard, Vale (2006) too has suggested teachers need to find ways to bridge the gap for their students.

8.2 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. Girls stressed aspects that made mathematics more pleasant and useful. Table VI gives exemplars of some comments made by boys and girls supporting the use of technology in mathematics learning.

Although most students have positive feelings about the use of technology in mathematics, two girls and a boy remained less convinced (refer Table VII).

Gender	Comments
Boys	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
Girls	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 practice in solving realistic mathematics problems [posted in Socrative—a web-based student response system]

Table VI. Group II: typical responses supporting the use of technology in mathematics lessons

Similar 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.

8.3 Challenges in the use of technology in mathematics

At all schools, 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 some of the problems caused by these factors are given in Table VIII.

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

Table VII. Group II: responses expressing dissatisfaction toward the use of technology in mathematics lessons

Gender	Comments
Boys	[There is] nothing special [with technology-mediated learning]
Girls	In my opinion, using technology means we have to work twice
	I think nothing is interesting [about technology-mediated learning]

Table VIII. Group I and II: challenges faced by students in the use of technology during mathematics lessons

Challenges	Comments
Poor internet connectivity	At first, 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
	Provide good wireless connection to help those who do not have internet data plans.
Device issues	[…] the mobile phone gets hung up; the battery is also running out
App issues	The [Socrative] app is often stuck
	[Socrative suddenly] being logged out [because the internet connection is lost] and I have to complete the mathematics exercise [from the beginning again]
Lack of instructions	[When using Socrative] I have to wait for the teacher initiating the application before doing the mathematics exercise

8.4 Students' expectations in the use of technology in mathematics

Students' responses revealed expectations and desires for technology usage in mathematics. Their comments indicate that students want technology to be frequently used in mathematics classes. Students are keen to understand how to use the technology and become more familiar with its features, which in turn will make students have better classroom experiences. Dündar and Akçayır (2014) acknowledge that students who have more experience in using technology (e.g. computers) develop more positive attitudes toward technology. Students added that the applications to which they were introduced to in classrooms should be continually deployed to help them improve their performances. Students' expectations are listed in Table IX.

As is evident from the student comments, some of the applications used in teaching contained bugs which impacted their performance when used on mobile phones, so were not optimal. Dündar and Akçayır (2014) too ascertain that often technical problems make it difficult to use technology in classrooms. Overall, we found that students considered that the use of applications would advance their learning process.

9. Conclusions 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; aspects which are important for students in learning mathematics with technology. This aligns with what Galbraith and Haines (1998) argue that positive attitudes on the part of students contribute to effective outcomes. They view that if students have positive attitudes 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 TM were evident in schools where the availability of devices was limited. Boys expressed more positive attitudes toward 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 toward the use of technology in mathematics which is not surprising. However, boys and girls showed no significant difference in their overall attitudes to technology. Both revealed positive feelings about TM. However, there remained a few students less convinced. Previous studies

Expectations	Comments
Increase the frequency of technology use in classrooms	The applications should be frequently used during the mathematics learning
	The teachers should use technology more frequently in their teaching [so that] the students will understand more about the use of technology appropriately
	This technology-mediated learning method should be conducted at least once a week
Improve app technology	I hope this technology is getting advanced
	This application [Socrative] needs more improvements because it has still some weaknesses
	The applications should be more developed to avoid error/slowing down [of mobile phone]
	Improve the applications that help the students in doing their works

Table IX. Groups I and II: student expectations regarding the proper use of technology during mathematics lessons 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). Leyva (2017) cautions researchers on taking a biased view of male superiority in mathematics achievements while conducting a gendered inquiry in mathematics learning. To define gendered trends in mathematics learning, researchers should take account of socio-mathematical norms such as school factors (e.g. instruction), socio-cultural factors (e.g. academic expectations from boys vs girls) and other socio-economic factors (e.g. status) that may influence student performance. This research was conducted in two school groups, where in one school group the classroom instructions were delivered to students having personal devices while in the other group students worked in small groups with borrowed devices. The participating schools were located in two socio-economic regions (i.e. rural and urban). Therefore, this gendered study draws on socio-mathematical norms described by Leyva to help improve our understanding on overall student attitudes, learning strategies and participation with technology for mathematics lessons.

This study confirms that learning individually using one's own devices opposed to learning in groups where a device is shared amongst few members of the group has an impact on overall student participation. Using one's personal devices brings a sense of belonging and nearness while engaging with the device, opposed to hesitation and lack of ownership when using someone else's device. Earlier literature has endorsed teaching strategies that promote socialization through group learning especially in mathematics classrooms (Bekele and McPherson, 2011). However, our findings have revealed that although group learning fosters cooperative learning, but having one device amongst the group restricts how students can engage with the device. 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. Students' expectations and desires for technology usage are also worth considered in optimizing the ongoing process of technology integration in mathematics.

Government resources in developing countries are restricted by their low economies; therefore, they provide limited infrastructural support for education- or health-related services to their societies, more so, in rural areas (Srivastava and Shainesh, 2015). Using technology for education purpose is still a rarity in Indonesia. Education-related gender studies deserve particular attention as they inform governments of developing countries to consider growth and expansion plans within this sector (Samarakoon and Parinduri, 2015). Currently, there is very little research on gender issues which has led to a lack of gender sensitive policies in Indonesia (Jong, 2017). Our study contributes to the literature on issues related to inequitable distribution of resources in five schools spread across rural and urban settings, and on gender perceptions toward TM lessons.

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 the 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 how teachers integrate learning technologies within mathematics instruction, especially in schools where access to devices are often limited. We also need to investigate ways which can contribute to students' learning of mathematics in rich and meaningful ways in school environments having limited technological resources.

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