Challenges of Integrating Mobile Technology into Mathematics Instruction in Secondary Schools An Indonesian Context

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Challenges of Integrating Mobile Technology into Mathematics Instruction in Secondary Schools: An Indonesian Context

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ABSTRACT

Implementing mobile learning in curriculum-based educational settings faces challenges related to perceived ethical and learning issues. This study investigated the affordances of mobile technologies to support mathematics instruction by teachers. An exploratory study employing questionnaires and semi-structured interviews revealed that, while mathematics instruction can be augmented with mobile learning, the majority of schools in Indonesia have banned student use of mobile phones in classrooms. Teachers are concerned about the improper use of mobile phones that could impact their students' mental well-being and distract them from learning. Most teachers perceive mobile technologies to be disruptive and seem reluctant to use them for teaching delivery. However, teachers are eager to experiment with digital technologies within mathematics instruction. Our findings suggest infusing alternate technologies that fit better with the school's teaching and learning environment. This includes web-based applications that can run on different digital devices ranging from desktop computers, laptops, and tablets, to mobile phones. We propose setting up communities of practice for mathematics teachers to share their instructional repertoire on integrating digital technologies within the classroom.

KEYWORDS

Mathematics learning; mathematics teacher; mobile devices; mobile learning

A regulation (Reference Number 68 in the curriculum year 2013) of the Ministry of Education and Culture (MoEC) of Indonesia states that all subject disciplines (including mathematics) are to be integrated with technology (MoEC, 2013). Teachers are required to develop the necessary skills to integrate technology into classroom instruction. To achieve this, mathematics teachers require appropriate guidance and support. Specifically, this study looked at the mathematics discipline to explore how mobile technology is used as an aid to deliver mathematics concepts.

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Technological devices deliver a range of functionalities, such as rich graphical interfaces that provide visual representation of logical evidence suitable for enhancing the process of teaching and learning mathematics, and computational capabilities to motivate and support problem-posing activities (Abramovich & Cho, 2015; Niss, Blum, & Galbraith, 2007). Including technologies in presenting mathematics concepts helps create an environment where students engage with mathematics in a meaningful way (Jung & Conderman, 2013; Lew & Jeong, 2014). The National Council of Teachers of Mathematics (NCTM) acknowledged that technology can be leveraged effectively by teachers if they know how to make good use of technological tools as mediators (NCTM, 2011). Therefore, a good understanding of how the technological platform grounds the underpinning teaching pedagogy and assists in delivery of the curriculum content is essential (Koehler, Mishra, & Yahya, 2007). Technology can then be used as an intervention to improve student learning skills across different teaching and assessment strategies.

Despite policy expectations and the proven value of technological tools in the mathematics classroom, the majority of teachers in Indonesia lack adequate technology skills (Copriady, 2014). The results of the national examination of teachers' competency in Indonesia, conducted online in 2011 and 2012, also corroborate this evidence. The national average score in 2012 was 47.84/100, far from the passing grade of 70/100. This low result, however, does not reflect on a lack of teaching experience; rather, it illustrates that teachers lack awareness, particularly in terms of understanding the necessary technicalities in online examinations (Yusri & Goodwin, 2013). The Centre for Information and Communication Technology in Education and Culture reported that, although the use of information technology has been part of the curriculum at all school levels, no specific instructional hours were allocated at the primary level while about 1 to 5 hours per week were allocated at the secondary level (Pannen, 2014; UNESCO-UIS, 2014). In 2013 Indonesia schools indicated a willingness to integrate technology into their curriculum (MoEC, 2013), but a survey conducted by UNESCO-UIS (2014) revealed low technology use in teaching along with poor infrastructure support. Consequently, integrating technology into the school curriculum in Indonesia is still far from meeting the desired expectations.

The presence of technology has made teaching and learning mathematics easier (Eng, Han, & Fah, 2016). The advancement of feature-rich mobile technologies as well as the emergence of new theories in mobile learning have raised a lot of attention to the way mobile technologies can transform and reconstruct educational practice (Crompton & Burke, 2014). However, using mobile technology for learning has raised some ethical issues and concerns as well (Thomas, O'Bannon, & Bolton, 2013). For instance, many teachers have expressed concern about using mobile devices in their classrooms, since they may distract students from engaging responsibly in learning activities (Dyson, Andrews, Smyth, & Wallace, 2013; Keengwe, Schnellert, & Jonas, 2012). Consequently, many schools have banned students from using mobile devices (Thomas et al., 2013). It is important therefore to understand mobile learning challenges as well as their capabilities.

This paper investigates teachers' attitudes toward using mobile technologies, particularly the use of mobile phones at schools in Indonesia to understand teacher perceptions regarding the potential of or challenges to be faced with using mobile technologies for teaching and learning mathematics. Two research questions are posed:

1. To what extent are mathematics teachers using their own mobile devices either in their daily activities or in schools?
2. What challenges do teachers face in implementing mobile technology for teaching and learning mathematics?

Review of literature

Technology offers enormous potential for teachers to change and develop their teaching practice (Leach, Ahmed, Makalima, & Power, 2006). Traditionally in many mathematics classrooms, teaching involves a one-to-many role where one teacher explains and leads a discussion for a given problem to many students. In contrast, however, technology can potentially enhance mathematics teaching and learning (Lew & Jeong, 2014), incorporating interaction to individualize instruction and engage students (Maddux & Johnson, 2005). Using appropriate technological tools, students can individually interact and experiment with subject specific applications to aid their understanding of the subject as they contribute to classroom discussions.

Mobile technology for learning: Potentials and challenges

Various definitions have been used to describe the term *mobile learning*. According to Park (2011, p. 79), "The use of mobile or wireless devices for the purpose of learning while on the move" can be described as mobile learning. O'Malley et al. (2005, p. 7) defined mobile learning as "any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies." Sharples, Taylor, and Vavoula (2007, p. 224) defined mobile learning as "the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies." However, mobile learning is not limited to the mobility aspects of mobile devices. Some researchers have described mobile learning with regard to the students' experience of learning with these devices. According to them mobile learning can provide opportunities by accessing learning resources and collaborating with people, even at a fixed location (Kukulska-Hulme & Traxler, 2005; Parsons, Ryu, & Cranshaw, 2007; Traxler, 2007).

In this study, mobile learning is related to learning opportunities offered with interactive mobile devices where a learner accesses resources at a fixed location or while on the move. Therefore, mobile devices comprise any handheld device capable of multiple functions, including but not limited to accessing the Internet,

running applications, listening to music, taking pictures, and recording audio/video. Examples include a mobile phone, a smartphone, a tablet, a laptop, a notebook, or similar devices. A number of embedded features in mobile devices can be beneficial for teaching and learning activities, supporting communication and enhancing collaboration between and among students and teachers, thereby providing a dynamic learner-centered educational environment (Aubusson, Schuck, & Burden, 2009; Looi et al., 2010; Thomas et al., 2013). In addition, mobile devices can enhance learning within some authentic real-world context and cultural setting to allow learners to personalize their own learning (Naismith, Lonsdale, Vavoula, & Sharples, 2004; Parsons, 2014).

Although mobile learning has promising potential, opportunities for mobile learning do not come without challenges. Mobile phones in the classroom have been perceived as disruptive to teachers. A ringing phone is considered the most common classroom disruption and may negatively impact student performance (Thomas et al., 2013). Teachers also have concerns about students using mobile phones for cheating and collusion in which students text answers during exams, take pictures of exam papers to share with friends, store answer keys to be consulted in exams, or find answer sources via the Internet during exams (Dyson et al., 2013; Keengwe et al., 2012). Students may also use their mobiles for inappropriate activities such as sexting (Thomas et al., 2013), which may lead to harassment and cyberbullying (Siegle, 2010).

Affordances of mobile devices for mathematics learning

The goal of teaching mathematics is to enhance student competency to successfully deal with new situations containing explicit or implicit mathematical challenges (Niss, 2015). This goal can "only be reached by having students start from situations that [need] to be mathematized" (De Lange, 2003, p. 87). Nevertheless, many difficulties that students face are in connecting the mathematics they learn in school to situations and problems occurring on a daily basis (Sawaya & Putnam, 2015). The proliferation of mobile devices and their applications have provided access to real-world data and contexts for solving mathematics problems, allowing teachers to make connections between mathematics and real-world situations.

In considering what mobile devices offer to support connection between mathematics and real-world situations, White and Martin (2014) proposed four basic practices that augment mobile learning. The first basic practice is *capturing and collecting* information relevant to learning activity. Information can be obtained by recording auditory and visual content, and documenting numerical, text, and location coordinates using cameras, microphones, or a global positioning system (GPS)(Sawaya & Putnam, 2015). The second basic practice is *communicating and collaborating* via phone, text, email, and social networks. Mobile devices enable learners and teachers to have two-way communication synchronously or asynchronously as part of a learning activity (Berking & Haag, 2015).They can also be used to gather various information including images, videos, e-books, and websites.

Learners and teachers can then evaluate the information obtained through discussions (Sawaya & Putnam, 2015). Using information and providing reviews of it can be identified as the third basic practice, *consuming and critiquing*. The fourth basic practice relates to content creation such as editing images and videos, sketching designs, producing podcasts, posting articles to blogs, and so forth. The practice of developing and producing content is called *constructing and creating*. In addition to these four basic practices, Sawaya and Putnam (2015) added a practice specifically related to numerical calculation. Mobile devices allow learners and teachers to input data and perform computations by using various types of calculator applications. Obviously, these computational functions are found in other devices such as desktop computers and calculators, but the emergence of mobile devices makes them more easily accessible. The practice related to processing numerical data is referred to as *computing*. None of these basic practices are unique to mobile devices.

Methods

This study employed both quantitative and qualitative methods in collecting, analyzing, and integrating data to understand the perceived potential and challenges in using mobile devices (Creswell, Fetters, & Ivankova, 2004) in Indonesian schools. The research team comprised educators in fields related to teacher training, mathematics education, and information technology. Quantitative methods were employed through a survey that was subjected to statistical analysis. This 20-item survey included both closed and open-ended questions. Further, qualitative data collected through open-ended survey questions and semi-structured interviews were aimed at understanding teachers' experiences in using mobile devices either in daily activities or in the mathematics classroom. Further interviews were conducted with school teachers to gain insight into current issues in school environments regarding mobile teaching practices and to assess teacher readiness to use available technologies.

Participants

The study was conducted in a municipality in central Indonesia that had 462 mathematics secondary teachers. Sample size of the survey was determined by a formula proposed by Yamane (1967, p. 886): By using Yamane's formula with a margin of error of 0.05 the sample size was 214 teachers. In this study, 213 teachers from 129 different junior high schools participated, which is very close to the target number. Participants were 61.5% (131) female and 38.5% (82) male. Further, most teachers were from an urban area (195, or 91.5%), with only 18 (8.5%) from a rural area. Moreover, most participating teachers (157, or 73.7%) had a teacher's certificate from the teacher certification program (i.e., a program designed by the government of Indonesia to establish a quality benchmark for both in-service and pre-service teachers; Jalal et al., 2009).

After analyzing survey data, we selected a purposive sample of 15 mathematics teachers for further interviews. We wanted to understand these teachers' overall school and classroom experiences with regard to mobile teaching and learning. Each interview took approximately 20 minutes. Four teachers were interviewed face to face at their schools, while 11 teachers who were busy with school-related work were interviewed by phone. In this paper, the teachers are identified by their user codes (T1, T2, and so forth).

Data collection and analysis

Quantitative data gained from the survey were first coded and then analyzed using descriptive statistics. The results were used to understand the experiences of respondents in using mobile devices in teaching and learning. The interview data were wholly transcribed and analyzed in the Indonesian language. Categories were identified by dividing each type of the gathered data into segments and examining these segments for similarities and differences. Each response was coded to a number of categories. After coding the responses, the categories that had the most responses were marked as prominent. The next step was to determine which categories were related and whether any patterns and trends could be identified. Once the more prominent categories were identified, they helped identify trends to give a holistic view of the potential and challenges faced by teachers who used mobile technology for mathematics instruction.

Results

Based on analysis of the results of questionnaires and interviews, we present the results in two subsections to answer the two research questions: The subsection Leveraging Mobile Technology Affordances refers to research question one, *To what extent are mathematics teachers using their own mobile devices either in their daily activities or in school?* The Challenges in Using Mobile Learning for Mathematics Instruction subsection refers to research question two, *What challenges do teachers face in implementing mobile technology for teaching and learning mathematics?*

Leveraging mobile technology affordances

Before we asked the teachers about their experiences in using mobile devices either in daily activities or in school, we inquired how many teachers currently used mobile devices and whether they used more than one mobile device. Findings revealed that over half of the teachers owned smartphones (124, or 58.22%), tablets (28, or 13.15%), and Internet-enabled basic phones (23, or 10.80%). However, some teachers (40, or 18.78%) did not have mobile phones with Internet capabilities. Further, we inquired how often teachers currently used mobile devices to support their daily activities. Almost half (104, or 48.83%) reported that they mostly used

mobile devices for texting or sending messages. Some teachers (82, or 38.50%) occasionally used mobile devices for social networking activities and some (51, or 23.94%) used them for all sorts of social and computing activities. Teachers (85, or 39.91%) further used mobile device for activities related to email. These findings show that mobile devices are mostly used as tools for communication and collaboration among teachers. Following are some of the teachers' responses to the survey: "I use mobile phone only to keep in touch with my family and friends" (T29). "Anytime I need to communicate with my friends, I use my mobile phone" (T61).

Furthermore, most of the teachers with mobile devices also used them for consuming information such as reading content files (106, or 49.77%), searching for information (100, or 46.95%), and listening to music or watching videos (122, or 57.28%). The teachers commented that they sought relevant information from the Internet via mobile phones to get the latest information to supplement information obtained from books:

> I usually use my mobile phone at home to find any information from other sources when I could not find them in the books. (T72)

> At school, I use my mobile phone for searching materials that do not exist in the books and also seeking for mathematics-related questions for practices. (T87)

In terms of affordances of mobile devices as tools for constructing and creating, few teachers (23, or 10.80%) used them for creating and uploading content (e.g., image, video, etc.) as a general practice. However, some (96, or 45.07%) said that they did this occasionally. Regarding the basic practice of capturing and collecting information using mobile devices, some teachers (96, or 35.21%) responded that they occasionally used their devices to view maps to get driving directions to required locations by using GPS-enabled mobile apps. Table 1 represents teachers' activities (in percentages) in their day-to-day use of mobile devices.

Next, we asked teachers about their experiences in using mobile devices for mathematics instruction. The survey revealed that only 31.9% (68) of the teachers used mobile devices in teaching and learning activities. They used mobile learning in all sorts of activities either indoors (28, or 13.1%) or outdoors (19, or 8.9%) as well as in either formal (24, or 11.3%) or informal (3, or 1.4%) settings.

Table 1. Teachers' activities in the use of mobile devices

Activity	Never (%)	Seldom (%)	Occasionally (%)	Always (%)
Social networking	28.64	8.92	38.50	23.94
Reading content files (e.g., e-book, article, etc.)	27.69	10.33	49.77	12.21
Accessing emails	28.64	15.02	39.91	16.43
Texting messages	21.12	4.70	25.35	48.83
Searching for information	22.06	1.88	46.95	29.11
Viewing maps and getting driving directions	35.68	24.88	35.21	4.23
Creating and uploading content (e.g., image, video, etc.)	32.39	11.74	45.07	10.80
Playing games	38.50	28.64	27.70	5.16
Listening to music or watching videos	23.47	11.74	57.28	7.51

With respect to the use of mobile devices in mathematics classrooms, teachers shared many experiences.

> I use the Quipper School [a web-based application]. For example, I give an instruction to them like this: "Ok everyone, I have posted a homework [consisting of 10 multiple choice questions related to the material taught today] in the Quipper School; you have one week to complete them; just take a look at your own account." Then, they are able to do the work in one week [since to complete this homework, students will require computers/mobile devices to answer the multiple choice questions posted in the Quipper School]. One week after, I can immediately check the results. I can also determine which students are in upper, middle, and lower level. (T10)

> I even applied this method [mobile learning] in my classes. I even asked the 9th-grade students to bring their mobile phones and I gave them a web address where they were able to do some exercises and they could also match their answers by looking at the discussions of national exam made by the government. Besides, I also applied this method for the 8^{th}-grade students. [Using a mobile application] we placed some points [in a GPS-enabled map]. Students were then asked to approach these points by following a map, and in each point there was a mathematics real-world problem to be solved. The result was they were very interested in this kind of activity. (T6)

These views indicate that the teachers perceive mobile phone use in instruction to be beneficial. The affordances of mobile technology enable teachers to enrich the overall learning experience as they create innovative teaching and learning strategies for delivering mathematics instruction.

> I usually use my phone to see if there are any emails. I often get much information about online training from the email. … Sometimes I use it to find some terms in mathematics via Google, and sometimes I also seek some materials to motivate the students at the beginning of the learning, so they will feel excited before the actual learning takes place. (T6)

Challenges in using mobile learning for mathematics instruction

The affordances of technologies (mobile devices) can bring a sense of positive and negative perceptions to teachers on how their use will impact their environment (classroom teaching instruction)(Gibson, 1977). On one side, benefits afforded by mobile devices in classrooms, like bringing in new technology interfacing capabilities, are positive; on the other side, mobile devices also afford challenges such as changes to instructional practice. Teachers were asked to identify the challenges in using mobile learning in mathematics instruction. Based on the survey, 58.2% (124) of teachers responded that they considered that mobile phones would disrupt the class (e.g., phones ringing during class, texting and checking incoming phone messages). The second challenge related to cyberbullying and sexting (106, or 49.8%), followed by cheating (87, or 40.8%). One teacher opined:

> I think the parents' awareness about bringing the mobile phones into the school is caused by uncontrolled pornographic contents, but in my opinion if they [teachers] are able to control and monitor their students carefully, these unwanted problems might not happen. Therefore, the students should hand in their mobile phones to the homeroom teachers. … In this way we can anticipate and resolve many negative impacts for them. (T4)

Some schools have banned mobile phones. At the beginning of each new academic year the school holds a meeting for all parents and presents the school's policies, one of which is that children (especially freshmen) are not allowed to bring mobile devices to school. The parents are asked to sign an agreement stating that they will comply with the school's policy.

> In my school the students must not bring their mobile phones. … This prohibition is written in the school's rules which are delivered explicitly [in the meeting with the students' parents] and they are asked to sign a form of willingness that their kids will obey this rule. (T6)

> Particularly for the freshmen, during PPD [the new students' orientation], we made the rules. There were some agreements between us and their parents. There was an item stating that the students must not bring their mobile phones. The reason [for this rule] was also stated [in that meeting] and it had finally become one of the rules. (T1)

These comments indicate that the schools impose restrictions whereby students are not permitted to bring mobile phones to school, which could be a reason why teachers are reluctant to use mobile phones in classroom teaching. With such restrictions in place, teachers are not able to apply creative teaching methods. Prohibiting mobile phones at school thus limits teachers in expressing themselves in the exploration of mathematics concepts using mobile technology.

Apart from the teachers' concern about using mobile devices within instruction, findings showed that the limited availability of technology (e.g., students do not have mobile devices and schools have insufficient/do not have mobile devices) was also a barrier to implementing mobile learning. When questioned some teachers (70, or 34.3%) confirmed this to be a challenge:

> The challenge [of mobile learning] is that not all students have an Android phone or a smartphone. (T8)

Another challenge described by teachers was the limited availability of wireless connectivity in schools. To initiate mobile technology in instruction, wi-fi has to become ubiquitous. However, not all schools have good wi-fi connection and even when they do, the connection often covers only a few areas. Two teachers voiced this issue:

> [The wi-fi signal] does not cover the whole [school] area, but is only available within a certain area. (T3)

> The second challenge is the overload of wi-fi network use, leading to slower access time in loading resources [from the Internet]. (T5)

In this regard, we found that poor wireless connectivity is another hindrance to implementing mobile learning. These findings are similar to those of Muir (2013), who suggested that, although there are various Internet data packs offered by companies, mobile learning implementation is costly.

With respect to ethical issues that led to the ban on mobile phone use in schools, two teachers shared their recommendations:

> The representatives of the school committee, … of the students' parents, … of the guidance and counselling, and … of the classroom teachers should discuss this rule [using mobile phones for learning] together to find the best solutions. Then, after this discussion, we will be able to execute the discussion results in the learning process. (T4)

> In my personal opinion, if the students are very excited in using mobile technology in the learning process, [the] first thing to do is consulting or coordinating with the homeroom teachers, preceptors of intra-school organization, and of course … the school principal.… After that, all stakeholders [must] agree on what [was] just delivered, and we also need to tell the parents. We make a notification letter that up from now, the students are allowed to use their mobile phones for … learning. (T6)

These teachers share similar views that mobile learning can still be implemented in teaching and learning activities by involving all stakeholders, and by adjusting school policy to relax restrictions on mobile devices. These findings are similar to those of Dyson et al. (2013) who suggested that this involvement will encourage ownership of the policies at all levels.

The readiness of teachers toward mobile learning is also a positive step in making this endeavor successful. One teacher expressed a similar view:

> The first challenge is about the teachers' readiness. All teachers must be more progressive in preparing the learning materials. The second is monitoring the students [during the mobile learning process], and the last is the learning process must be conducted as creatively as possible. (T10)

Readiness in this view can be interpreted in terms of the skills teachers possess and the extent to which teachers feel comfortable in using mobile devices for teaching. Therefore, in this regard, to determine readiness toward mobile learning three aspects should be considered; namely technological, pedagogical, and psychological (Stockwell, 2008). These three aspects will help teachers resolve any concerns that might develop during actual implementation.

Discussion and recommendations

This study has provided insights into how mathematics teachers view the potential of mobile devices as instructional tools to support out-of-school or in-school activities in Indonesia. The current study has also investigated the challenges teachers face with implementing mobile technology into mathematics classrooms.

Teachers' personal use of mobile devices

The data showed that most teachers own mobile devices and some have more than one. The teachers leverage the affordances of mobile devices to get driving directions using GPS-enabled mobile apps. However, many teachers do not use their mobiles for teaching and learning activities, but rather for out-of-school activities. The majority use mobile devices for communication and collaboration either with family or peers, such as for texting, social networking, and email exchanges.

The presence of mobile devices has widely transformed the way teachers connect with one another. Two-way communication can easily be performed either synchronously or asynchronously. Text messages, social media, and email are forms of communication that make it easier for teachers to stay in touch with distant peers.

Apart from facilitating communication, mobile devices offer ease of accessing information. To supplement the textbook, some teachers use mobile devices to search relevant information from the Internet to get the latest information regarding subject content. The teachers reported that they use mobile devices to create content (e.g., edited images, videos, sketches, podcasts, posted articles, etc.) and to upload the content to public media or private storage. Mathematics-related questions are sought to enhance student learning (e.g., embedding problems in maps, posting homework online, and providing students instant feedback on right and wrong answers). This illustrates that the teachers also use their mobile devices for professional purposes. When the teachers are able to select information that fits their needs, they can analyze, synthesize, and personalize that information for technology-enabled subject delivery.

Therefore, the argument can be made that the teachers can make effective use of their mobile technology for teaching purposes (Overbaugh & Lu, 2008; Zhang, Trussell, Tillman, & An, 2015). For those who had implemented mobile learning in mathematics classes, they viewed mobile devices as useful instructional tools; although they admitted that they could be more creative and innovative in delivering mathematical content with this technology. The opportunities are there; we simply need to identify the best route to overcome any challenges.

Ethical considerations to mobile device use

Adopting mobile technology in education raises some ethical issues and concerns (Dyson et al., 2013). This study examined ethical considerations that might arise when students bring mobile phones into classrooms (e.g., distractions from learning, cyberbullying, sexting, and cheating). More than half of the teachers perceived that mobile devices can be a distraction in classrooms and almost half were concerned about cyberbullying and sexting. Some teachers were also concerned about cheating. Lack of technology resources also was viewed to be a hindrance in implementing mobile technology in education. More than one fourth of the teachers confirmed this view. These issues indeed were cited most often for teachers' reluctance to use mobile learning within instruction.

These challenges need to be addressed if mobile technology is to be used more effectively by teachers and their students. Regarding technology availability issues, Thomas et al. (2013) recommended that teachers allow students who have mobile phones to work collaboratively with those who do not and that the school procure mobile phones to facilitate student use in classrooms. With regard to ethical concerns, some teachers recommended that all stakeholders be invited to discuss the policy. Involvement of all stakeholders refers all those affected by the policy as well as those who will enforce it (Dyson et al., 2013). In fact, the ethical issues arise as a

result of concerns about inappropriately using mobile devices. Therefore, teachers must encourage students to process information obtained while using their mobile phones only for learning mathematics concepts. Further, teachers should encourage students to be responsible and take positive actions toward their own learning, rather than avoiding technology due to perceived harmful and unethical issues. In line with what some teachers have delivered with mobile technology, despite these challenges, teachers have been able to assign study tasks to students and allocate homework online.

Instead of forbidding students to bring their mobile phones to school, there should be another strategy that introduces specific steps to restrict inappropriate use among students. As stated by one teacher, rather than banning phones completely, the school can control inappropriate use by requiring students to hand in their devices to the homeroom teachers. Students can then use their devices when required, such as during mathematics instruction. However, the school would now be responsible for the safe keeping of these devices.

Conclusion and implications for future research

The findings affirm that mathematics instructions can be augmented with mobile learning; however, the majority of schools prohibit the use of mobile devices in classrooms. Most teachers also perceive mobile devices as a disruptive technology. Moreover, many teachers confirmed that schools have insufficient facility with regard to mobile technology. Further, limited access to mobile devices in schools constitutes the main hindrance to adopting mobile technology, making teachers reluctant to use it in teaching and learning.

While environmental challenges have restricted the use of mobile devices within mathematics instruction, there are compelling reasons for doing so. Our findings suggest that classroom teaching be infused with alternative technologies for instruction, especially those that fit better with the current social situation of schools in Indonesia. These could include web-based applications that can run on all digital devices ranging from desktop computers, laptops, tablets, and phones. While teachers are eager to experiment with technology for classroom teaching, the difficulties in using mobile devices can undermine their full potential. This has implications in tailoring teachers' skills with technology to underlying school educational goals and priorities. Appropriate teacher training programs help teachers to improve their technology skills and to manifest pedagogical knowledge.

While these are initiatives to be considered by the school, the teachers' professional development can also be enhanced by initiating an online community of practice as a means for informally learning and sharing technology-enabled teaching experiences with peers. Communities of practice have proven successful (Schlager, Fusco, & Schank, 2002) by enabling teachers to enhance knowledge through a collaborative learning process (Hoadley, 2012; Kirschner & Lai, 2007) and to critically reflect on their own practices to improve their instruction (Kirschner

& Lai, 2007; Yang, 2009). Our findings indicate a gap in using mobile technology for mathematics instruction (e.g., few teachers use mobile technology for analytical thinking and problem-solving purposes, while the majority use it for content delivery). Moving forward, we propose building a closed online community of practice. Joining the online community would be totally voluntary. It is hoped that it would provide a platform for discussions on already-in-place and new teaching practices, as teachers informally share their views on applying mobile (and more broadly digital) technology in classroom instruction. This will provide a way for teachers to reconstruct their teaching delivery practices to help bridge the current gap as they integrate mobile technologies into mathematics classroom instruction.

The findings of this study are not without limitations. Study participants were mathematics teachers who attended a teacher workshop. Because this study was limited to those teachers, it does not give attention to other teachers who did not attend, which limits the generalizability of this study. Therefore, conclusions made here must be considered in the context of this study. Finally, further research on students' attitudes toward technology for learning mathematics also is crucial. Teaching and learning is a two-way process, and we need to know students' attitudes toward using technology to promote their mathematical thinking and reasoning. To put forward an effective technology-enabled teaching practice, we first need to focus on individuals (both students and teachers) within their social context, which in turn should lead to broader mobile/digital learning strategies and contribute to the design of instructional tools and the development of teaching repertoires for the mathematics classroom.

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