“Mobile learning for high-school mathematics as a path to better sustainability in a fast-changing society: an exploratory study from Vietnam”

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MOBILE LEARNING FOR HIGH-SCHOOL MATHEMATICS AS A PATH TO BETTER SUSTAINABILITY IN A FAST-CHANGING SOCIETY: AN EXPLORATORY STUDY FROM VIETNAM

Abstract

The use of mobile learning, or M-learning, has been increasingly appreciated by educators due to its sustainability potential in different facets such as finance (i.e., affordable cost) and flexibility (i.e., time and pace of learning). However, it may not be effective in all situations. This study explored the feasibility of using M-learning for students' self-study of mathematics in the context of Vietnamese high schools. Using 542 student and 40 teacher responses to two surveys, the study showed that the use of M-learning might not be feasible for students' self-study of mathematics due to difficulties related to accessing mathematics websites, the quality of mathematics website content, students' low level of self-learning ability and learning disengagement. This study suggests that the use of M-learning may contribute to the sustainability of education; adopting it should be based on a critical examination of contextual factors, especially students' self-learning ability and engagement. M-learning can be promising and beneficial to students due to its capability to equip students to prepare for the fast-changing and technological-driven world. Educators have increasingly appreciated the use of M-learning, because it becomes more affordable and flexible. Nonetheless, there is still a question about near-future adoptions of M-learning due to unavailability of and inaccessibility to quality contents from trusted maths websites. The propensity of student engagements in M-learning is also an important issue for future research.

Keywords sustainability, M-learning, mathematics, high-school students, SDG4

JEL Classification I25, O33, O32, O31

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INTRODUCTION

Mobile phones have become an essential part of young people's life nowadays. Therefore, many educators have attempted to make good use of these devices for improving students' learning experience, creating a new trend in education called mobile learning or M-learning. According to Mcconatha, Praul, and Lynch (2008), M-learning is employed through the use of small computing mobile devices such as smartphones and small handheld devices. Others simply consider M-learning ad an extension of distance learning (Al-Emran, Elsherif, & Shaalan, 2016) or e-learning (Alzaza & Yaakub, 2011). More broadly, Matias and Wolf (2013) see that M-learning not only includes mobile device-based learning, but also the learning that is mediated across multiple contexts using portable mobile devices.

Since its arrival, M-learning has been used in different levels of education, but mostly in mathematics, language, engineering and computer

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science (Crompton, Burke, & Gregory, 2017; Hwang & Tsai, 2011; Sabah, 2016). This learning approach affords students the opportunities to connect informal virtual learning experiences with formal ones, increasing their overall learning experiences (Motiwalla, 2007). With M-learning, students can access course materials, share ideas and attain formative evaluation and feedback, and obtain guidance from educators (Ciampa, 2014; Milošević, Živković, Manasijević, & Nikolić, 2015; Valerie M. Crawford, 2007), and thus quality of learning would be enhanced accordingly (Klimova, 2019). From a financial perspective, M-learning would also be a solution for students to access to affordable education; which, in turn, results in enhancement of equity issue (Latchem, 2018). In brief, previous literature expected that M-learning, along with another type of ed-tech solutions such as e-learning, would contribute to the sustainability of education in both quality and finance aspects.

However, the effectiveness of this learning design should not be taken for granted, because it is dependent on several factors. In a recent study, Sabah (2016) found that students' perceived usefulness and perceived ease of use, as well as the influence of others, could drive students' intention to use M-learning. Sabah (2016) also found that availability of M-services and mobile limitations (Internet speed, screen, and keypad of the device, etc.) were the biggest obstacles of M-learning. Students' ability to handle mobile devices, level of mobile usage, and frequent use of M-learning were further identified as determinants that can influence students to adopt M-learning. Students' perceived usefulness, ease of use and their self-efficacy in using M-learning have been consistently reported to be influential on students' intention to adopt M-learning across different countries (Althunibat, 2015; Sabah, 2016; Park, 2009). Even when all of the conditions above are satisfied, it seems that the effectiveness of M-learning would also require a high level of student engagement, especially when it is used as a complementary channel to enhance students' learning experience. Without student engagement, which may be associated with their beliefs about the benefits of using M-learning and expectations of others, that purpose will not be achieved regardless of the availability of mobile devices, M-learning services, and their M-learning literacy (for example, see Heflin, Shewmaker, & Nguyen, 2017).

In Vietnam, M-learning has recently been introduced and adopted across different educational providers. The Ministry of Education and Training also recommends that schools across the country should use information and communication technologies (ICT) to enhance their teaching-learning activities. However, there have been only a few studies about how ICT is being used in Vietnamese schools (Le et al., 2019). To help narrow that research gap, this article will report an exploratory study about the feasibility of using M-learning to foster Vietnamese students' self-study of Math in two high schools. The study showed that despite technological availability, M-learning is not very feasible to apply in Vietnamese high-school contexts for students' self-study of Math due to difficulty in accessing Math websites, quality of Math website content, student disengagement, which was fundamentally caused by their low level of self-study ability. Despite its exploratory nature, the study lays the foundation for future studies which examine student engagement when designing learning mode using M-learning to ensure feasibility and effectiveness.

1. LITERATURE REVIEW

1.1. Student engagement and learning outcomes

Student engagement has lately received due attention from educators and researchers, because it has been found to affect students' learning outcomes. It is defined as "the range of activities a learner employs to generate – sometimes consciously, other times unconsciously – the interest, focus, and an intention required to build knowledge and skills" (Toshalis & Nakkula, 2012, p. 16). Others consider it as "time and effort students devote to educationally purposeful activities" (Radloff & Coates, 2010, p. 1). It has also been defined as "participation in educationally effective practices, both inside and outside the classroom, which leads to a range of measurable outcomes" (Harper & Quaye, 2009, p. 2).

Student engagement can be seen in three dimensions: behavior, cognition, and emotion. The behavior dimension can be demonstrated in students' adherence to rules, involvement in learning, and participation in extra-curricular activities (Fredricks, Blumenfeld, & Paris, 2004). Cognitive engagement dimension is frequently described in association with students' self-regulation and effective use of deep learning strategies (Fredricks et al., 2004), as well as their characteristics such as motivation, self-efficacy, and expectations (Shane R. Jimerson, Emily Campos, & Jennifer L. Greif, 2003). Affective or emotional engagement dimension is showed in students' sense of belonging (Libbey, 2004), as well as immediate emotions, such as enjoyment and interest in the task (Furlong et al., 2003). The affective dimension distinguishes students with intrinsic motivations from those with extrinsic motivations. The former is motivated to engage cognitively and behaviorally out of their passion and interest in the learning, whereas the latter is motivated to attain tangible results such as scores and certificates.

Several researchers also investigate student engagement in the opposite direction: student disengagement or alienation (Johnson, 2005; Macfarlane & Tomlinson, 2017; Mann, 2001). This may occur in the form of students' refusal to comply with behavioral expectations such as coming to class punctually, politely accepting grades and feedback, or enthusiastically participating in in-class learning activities (Macfarlane & Tomlinson, 2017).

Many studies have shown that social context contributes to student engagement levels. For example, Mann (2001) identifies that disciplinary power, academic culture, and an excessive focus on performativity can cause student disengagement. Similarly, Thomas (2002) argues that institutional habitus, which is social and cultural practices that favor the dominant social groups in an institution, may lead to poor retention of non-traditional students. Initial experience with a new learning culture may cause cultural and learning shock to several students, which may also cause student disengagement (Christie, Tett, Cree, Hounsell, & McCune, 2008; Krause & Coates, 2008; Thomas, 2002).

Student engagement is a key contributor to quality learning outcomes. Research has evidenced that student engagement is associated with higher grades and school completion rates context (Fredricks et al., 2004; Wang & Fredricks, 2014; Wang & Holcombe, 2010). Their engagement also appears to associate with the perceived institutional or school context (Fredricks et al., 2004; Wang & Fredricks, 2014; Wang & Holcombe, 2010). For example, in a longitudinal study, Wang and Holcombe (2010) examined the relationships among 1,046 middle school students' perceptions of the school environment, school engagement, and academic achievement. They found three dimensions of school engagement: school participation, sense of identification with school, and use of self-regulation strategies. Students' perceptions of the school environment were found to influence their academic achievement directly and indirectly through the three types of school engagement. Likewise, Konold, Cornell, Jia, and Malone (2018) tested whether the authoritative school climate, which has high structure and student support, can nurture student engagement and whether these factors are associated with higher academic achievement. Using a multilevel multi-informant structural model on a sample of 60,441 students and 11,442 teachers in 298 high schools, the researchers found that both structure and student support in authoritative schools were associated with higher student engagement in schools. They also found that student engagement was directly associated with academic achievement.

All these show that student engagement is critical for students' learning outcomes. However, their engagement should not be taken for granted, but would be affected by both personal factors, learning environment, and even culture. Therefore, in designing new ways of learning, student engagement issues should be paid due attention to ensure quality learning outcomes.

1.2. M-learning as a measure contributing to the sustainability of education

Sustainability of education has identified as a key background for the development of socio-economics. In 2015, the United Nations identified 17 Sustainable Development Goals (SDGs) with 169

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targets in total, of which there are one goal (SDG4) and ten targets about the education sector. Recent research has shown that M-learning could help increase students' learning experience (Milošević et al., 2015; Sung, Chang, & Liu, 2016), thus, resulting in the enhancement of sustainability in education. One of the high-profile studies was (Milošević et al.' (2015) work summarizing the benefits of M-learning as follows:

- interaction: students can synchronously or asynchronously interact with the teacher and their friends;
- portability: mobile devices are lighter than books to carry and allow students to take notes, type text, record sound, and even videos;
- cooperation: it enables easier cooperation among students, even in remote locations;
- engagement: students now like to use mobile devices;
- practicality: students can study whenever they have time;
- equity: it can provide equal learning opportunities to all students;
- speed: it takes a lot of time to prepare traditional learning materials; materials for mobile learning can be prepared, stored, and reused relatively quickly;
- retention of knowledge: mobile learning is a powerful learning tool that provides quick reminding and adding materials to already learned;
- cost: it reduces the cost of printing literature compared to the traditional learning mode;
- management: it enables to tracking student learning behaviors.

Unfortunately, there are also some disadvantages to using M-learning. There should be M-learning services that develop and design online learning resources and activities for students to learn. These activities must be interesting and conducive to learning to retain students. Likewise, students need to possess mobile devices, which efficiently allow them to access the online learning materials in diverse forms: text, video, audio, interactive games, etc. Without a device that can show these forms of information/data, it will hinder a student from effective learning (N. Ibrahim, Salisu, Popoola, & T. Ibrahim, 2014). Also, due to their small sizes and limited battery life, mobile devices may cause difficulties for students to learn. The Internet speed and students' abilities to use the device, as well as the M-learning service/websites, would also affect their engagement with this form of learning. Price is also a problem, since mobile devices with better features are usually expensive, and fee for accessing M-learning platforms should also be taken into account.

All of the mentioned disadvantages, on the one hand, may affect the feasibility of using M-learning as it depends much on the availability of technologies and users' skills in using it. On the other hand, the advantages could only be achieved with student engagement, on top of technological prerequisites. Naturally, students often feel confused when they are exposed to a new way of learning. If they fail to manipulate mobile devices, navigate the websites to look for learning resources or engage with an online learning activity, or poor quality of the text, image, and sounds on their mobile devices would discourage them from embracing the new learning mode. Disconfirmation experienced in the learning process was also known as a predictor for poor student loyalty (Pham, Lai, & Vuong, 2019). In the same vein, if M-learning is used as a channel for self-study, it also requires students to be able to self-direct their learning and to learn independently with enthusiasm. Otherwise, they may not achieve the expected learning outcomes.

1.3. The context of using M-learning in Vietnamese schools

Vietnam is a middle-income country in Southeast Asia with appropriately 90 million people. It is among the societies with the fastest chance thanks to the growing ICT industry. Recent socio-economic development not only improves its people's quality of life, but also affords them the opportunities to possess modern gadgets, including the latest luxurious mobile devices such as the iPhone.

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It is estimated that in 2017, there are about 84% of the population in key cities, 71% in secondary cities and 68% in rural areas were using smartphones (Vietnam News, 2017). According to Statista, there were 45.5 million Vietnamese participating in Facebook, and this figure is expected to reach 52.4 million in 2025 (Statista, 2019). Although high-school students are commonly expected not to use mobile phones in the classroom, it is observed that out of the school, almost all students own a mobile phone, a laptop, or a notebook.

In response to the MOET's call for applying ITC into teaching and learning (for example, MOET, 2018), several schools have experimented M-learning, and the private organization has started to provide M-learning services, especially in natural science subjects and English. Websites, where students can access learning materials, are also abundant. For example, for Mathematics, students can get access to diendantoanhoc.net, toanhoc247.edu.com, luyenthi123.com, mathvn.com, etc. These are considered the most prestigious websites for self-study of Mathematics, which attract tens of thousands of students due to quality Mathematics lessons and exercises.

One of the biggest challenges for the use of M-learning could be students' self-study ability. In a Confucian heritage country, students often rely on their teachers to direct their learning (Nghia, Phuong, & Huong, 2018; Thanh, 2010). Teachers often hold much power in the classroom and decide almost everything related to students' learning (Tran, Le, & Nguyen, 2014; Nguyen, 2017). Even when students are not happy, they are expected to keep silent and follow the teachers. That learning environment suppresses students' ability to conduct learning in their way effectively. In the same vein, it is increasingly reported that Vietnamese students do not meaningfully engage with their learning, but only superficially participate in it for high scores (Nghia et al., 2018). Therefore, when it comes to using M-learning for their self-study, they may not fully engage with it if teachers are not around. As discussed earlier, this situation would limit the effectiveness of M-learning.

However, these are only my individual observation. There has virtually not been any study that explores the feasibility of using M-learning in Vietnam. Therefore, it is vital to examine this issue before implementing M-learning in Vietnamese high schools. This can help reduce unnecessary waste and increase the chance of success for the implementation of M-learning in this context.

2. RESEARCH METHODS AND DESIGN

This article is drawn from a research project about the M-learning for Mathematics in Vietnamese high schools, which was conducted between 2013 and 2016. In this article, the researcher will report the feasibility of using M-learning for self-study of Mathematics among year 12 students in the current context of Vietnamese high schools. The research question was: How feasible is it to use M-learning for students' self-study of Mathematics in the current context of Vietnamese high schools? A quantitative approach was used to find answers to the research questions, because it would generate descriptive statistical results that could better illustrate the issue under investigation.

The researcher looked for data in the following dimensions to assess the feasibility of M-learning implementation as a complementary channel for students' learning of Mathematics:

- students' accessibility to M-learning (possession of mobile devices, Internet connection, etc.);
- students' ability to use mobile phones (i.e., their mobile phone literacy);
- students' self-study ability and behavioral engagement with learning Mathematics after class.

A total of 524 year 12 students and 40 Mathematics teachers in two high schools, which were based in Thai Nguyen province, were involved in this study. An elite high school and a 'normal" high school were purposefully chosen to represent two different types of high schools in Vietnam. The former is comprised of students with average learning abilities, whereas the last includes high caliber students who were selected carefully with a competitive entrance exam. Although there were private high schools, the researcher observed that it was

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not much different from the 'normal' high school; therefore, it was not included to save time and cost.

Data were collected by two paper-based surveys, one for students and one for teachers. The surveys were sent to all year 12 students and Mathematics teachers of the two selected schools. By the deadline, 524 responses from the students and 40 responses from the teachers were received. The survey was developed based on previous small talks with students about their experience with M-learning, the literature, and the researchers' experience. In the survey, students were asked to indicate their motivations for self-study of Mathematics, their engagement with that self-learning, their use of mobile phones for self-learning of Mathematics, and obstacles of their self-learning of Mathematics using mobile devices. Teachers were asked to assess students' awareness of self-study, factors influencing students' self-study behaviors and their beliefs about whether or not to use M-learning to foster students' self-study of Mathematics.

Data were analyzed descriptively using frequencies and percentages, which were ranked in a descending order to accentuate the most significant variables. Where applicable, a comparison of differences in the results between groups of students of the two schools is highlighted. Although this type of analysis is simple, it is effective to answer the research questions.

3. FINDINGS

3.1. Students' accessibility to M-learning and their skills in using mobile phones

Our survey at two high schools in Thai Nguyen province showed that among 542 year 12 students, 526 of them (97.04%) owned a mobile phone. Among these students, 87.45% reported that their mobile phones could get access to the Internet properly (Table 1).

The results also showed that their ability to use mobile phones was proficient. However, they used their phone for different purposes (Table 2). As a whole, the results showed that students seemed to use their mobile phones for general communication and entertainment purposes much more frequently for learning purposes, especially for self-study of Mathematics. Although there were differences in the percentages of using mobiles phone for communication and entertainment purposes between students of the gifted and normal high

Table 1. The number of year 12 students in Thai Nguyen province with a mobile

Names of school	A	B		C	
		Frequency	Percentage	Frequency	Percentage
Thai Nguyen High School	250	236	94.40	198	79.20
Thai Nguyen Gifted High School	292	290	99.32	276	94.52

Note: A – the sample size, B – the number of students with a mobile phone, C – the number of students with a mobile phone that can access the internet.

Table 2. Students' use of mobile phones

I use a mobile phone for...	High school (*N* = 250)		Gifted high school (*N* = 292)		All (*N* = 542)	
	F	P	F	P		
Basic functions (call, text message, take photos,...)	198	79.2	276	94.5	474	87.5
Accessing the school's website and emails	163	65.2	276	94.5	439	81.0
Exchanging information about assignment via messages	140	56.0	257	88.0	397	73.2
Watching online movies	183	73.2	193	66.1	376	69.4
Exchanging information about assignment via Facebook	131	52.4	244	83.6	375	69.2
Reading online news	154	61.6	182	62.3	336	62.0
Listening to online music	183	73.2	242	82.9	260	49.8
Exchanging information about Mathematics assignment via Facebook	32	12.8	148	50.7	180	33.2
Learning in Mathematics websites	61	24.4	105	36.0	166	30.6
Exchanging information about Mathematics assignment via messages	32	12.8	95	32.5	127	23.4
Participating in online Mathematics courses	21	8.4	9	3.1	30	5.5

Note: F – Frequency, P – Percentage.

schools, students seemed to converge in their behaviors related to self-study of Mathematics. All of these activities were rated at the least frequent in their use of the mobile phone. These findings suggest that students were not engaged with using their mobile phones for self-study of Mathematics.

3.2. Students' self-study ability and behavioral engagement

Data from 410 responses out of 524 students (114 others could not arrange a time to answer the whole survey questionnaires and decided to withdraw from the study) showed that students were motivated to self-study mainly to achieve a high score or to solve Mathematics exercises (Table 3). The percentage of participants who chose these two motivations were much higher than the other two motivations: (i) to systematically remember Mathematics theories and (ii) to diversify their knowledge of Mathematics. These findings suggest that students had more extrinsic motivations for their Mathematics learning than intrinsic motivations. This can be a barrier for their self-study using M-learning, especially when it is not endorsed by teachers or linked to tangible benefits.

Table 3. Students' motivations of self-study of Mathematics

Motivations for self-study of Mathematics	All students (*N* = 410)	
	Frequency	Percentage
To attain a high score in Mathematics tests	334	81.5
To do Mathematics exercises better	291	70.1
To remember Mathematics theories systematically	134	32.7
To enrich their Mathematics's knowledge	77	18.8

Indeed, data showed that students were not engaged with the self-learning of Mathematics after class. Almost 88% of them spent less than one hour on learning Mathematics on their own (Table 4).

Table 4. The amount of time that students spent on self-study of Mathematics

Self-study amount of time	All students (*N* = 410)	
	Frequency	Percentage
Less than 30 minutes	160	39.02
Between 30 minutes to one hour	198	48.29
More than one hour	52	12.68

Within that limited amount of time, they demonstrated their level of engagement to different extents, which also showed their ability to self-study (Table 5). It was recognizable from the results that students engaged with self-learning when it was associated with their compulsory learning activities and with teachers' commands. The majority of them spent time reading again what their teacher taught in class (71.12%), reviewing the way to solve a particular Mathematics problem that was taught in class (68.04%), or doing Mathematics exercises that their teacher assigned (60.73%).

Meanwhile, a low percentage of students spent time on activities that derived from their passion for learning Mathematics or to expand their mathematics knowledge and skills. For example, 27.31% of them looked for materials to expand their knowledge on the Mathematics topic taught in class, 20.73% did exercises in the Mathematics workbook (without teachers' requirement), and 8.29% challenged themselves by solving Mathematics problems in previous Mathematics olympiads. Having said so, it was found that more than one-third of the students engaged with Mathematics learning after class to enrich their Mathematics solving skills by reading reference book (41.21%), look for and solve Mathematics exercises similar to what have been taught in class (31.95%) or solving Mathematics exercises in the Mathematics University Entrance Exam Workbook (28.78%).

These findings indicate that several students were dependent on their teachers' instruction even in their self-learning, which is consistent with their extrinsic motivations above. However, there were also students who could self-direct their learning to achieve better Mathematics learning outcomes, despite a low number of them.

Table 5. Mathematics self-study activities that students often do after class

Activities	All students (*N* = 410)	
	Frequency	Percentage
Read what was taught in the class again	292	71.12
Review methods to solve a Mathematics problem that was taught in the class	279	68.04
Do Mathematics exercises that the teacher assigns	249	60.73

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Table 5 (cont.). Mathematics self-study activities that students often do after class

Activities	All students (*N* = 410)	
	Frequency	Percentage
Do Mathematics exercises that are similar to those in the textbook	131	31.95
Solve problems in the Mathematics University Entrance Exam Workbook	118	28.78
Read to expand knowledge about what was taught in the class	112	27.31
Voluntarily do exercises in the Mathematics workbook	85	20.73
Use what I have learned to solve problems in the Mathematics olympiad	34	8.29

Almost three-quarters of them feel that their self-learning was the most effective if there was on-the-spot teachers' support (71.7%), one-fifth of them felt confident with their self-learning with teachers' asynchronous support (20%), whereas only 8.29% believed that they could study effectively without teachers' support (Table 6).

Table 6. Perceived form of effective self-study

Self-study forms	All students (*N* = 410)	
	Frequency	Percentage
Self-study with teacher's synchronous support	294	71.7
Self-study with teacher's asynchronous support	82	20.0
Self-study independently	34	8.29

3.3. Teachers' and administrative staff's evaluation of students' self-learning ability

From teachers' and the admin staff's perspective, the majority of students were aware of their responsibilities of self-learning. However, they believed that students' awareness was not adequately clear (51.92%). Just above a quarter of them believed that their students were fully aware of their responsibilities of self-learning.

The teachers and admin staff also reported that students' engagement with self-learning derived from four factors. Most of them believed that students engaged with learning when they were assigned by their teachers, followed by their wish to pass the university entrance exam, their superficial learning attitudes, and their wish to gain Mathematics knowledge and skills that suit their learning needs.

Teachers were also asked about the feasibility of using M-learning for self-study of Mathematics of Vietnamese high-school students (Table 9). More than half of the teachers (55.0%) believed that it would not be feasibly used with students' positive learning outcomes; 32.5% of them believed that it could be sued, but the impact on students' learning outcomes was unsure. Only 12.5% of the teachers believed that this would be a feasible measure for self-study of Mathematics, and the outcomes would be positive.

Table 7. Teachers' evaluation of students' self-study awareness

Levels of awareness	Mathematics teachers (*N* = 40)	
	Frequency	Percentage
Unaware	8	20.0
Partly aware	21	51.5
Fully aware	11	27.5

Table 8. Teachers' evaluation of factors influencing students' self-study of Mathematics

Factors influencing their engagement with Mathematics self-study	Mathematics teachers (*N* = 40)	
	Frequency	Percentage
The teacher assigns exercises to them	30	75.00
Mathematics is a subject in their university entrance exam	28	70.00
Superficial learning attitudes	11	27.50
They want to gain knowledge and skills of their needs	10	25.00

Table 9. Teachers' opinions about the use of M-learning for students' self-study of Mathematics

Opinions	Mathematics teachers (N = 40)	
	Frequency	Percentage
Should not be used	22	55.0
Can be used, but the effectiveness is unsure	13	32.5
Can be used and it will positively impact students' learning	5	12.5

DISCUSSION AND CONCLUSION

This study aimed to explore whether M-learning can be feasibly used as a channel for Vietnamese high-school students to self-study Mathematics. The feasibility was examined through (i) students' accessibility to M-learning services, (ii) their ability to use mobile phones, (ii) their self-learning ability and behavioral engagement with self-study. Generally, the results indicated that it would not be very feasible to use M-learning for students' self-study of mathematics without paying due attention to improving students' self-learning ability and engagement.

The results showed that the majority of students involved in this study possess a mobile phone, however, not all of them (approximately 12.6%) can get access to the Internet where they would search for a suitable Mathematics website to engage with their self-study. On top of that, the cost to access Mathematics self-study websites discouraged many students from participating in this modern learning mode. The Internet speed also disheartened those who attempted to look for an additional learning channel using M-learning. Therefore, not all students could get afforded the accessibility to M-learning, as noted in Sabah (2016). If Vietnamese schools and teachers request students to engage with this learning mode, they should also take into account learning equity issues as not all students are financially able to pursue M-learning. Using M-learning may disadvantage students coming from low socio-economic backgrounds.

Also, students seemed to adopt the ability to use mobile phones quickly. However, they often used their phone for basic functions such as calling or texting, or for entertainment purposes rather than for learning. About two-thirds of the students exchanged information about assignment via Facebook, but the number of those engaged with self-learning Mathematics via the mobile phone was limited. These findings were aligned with previous studies where students were found to behave differently with mobile devices instead of learning (Althunibat, 2015; Sabah, 2016; Park, 2009). However, students' not using mobile phones to access to Mathematics websites could be due to their unawareness of the availability of quality Mathematics websites. This suggested that if M-learning to be used for students' self-study of Mathematics, school leaders and teachers would need to recommend students relevant websites, which could attract students with new knowledge or exercises rather than just repeating the textbook content. This also indicates that M-learning service providers should pay more attention to designing their website that allows meaningful learning activities, interactive learning activities, game-based learning opportunities or real-life situations that invite students to use Mathematics knowledge skills to solve instead of simply solving theory-based Mathematics puzzles. Culturally, this finding also demonstrates the cultural additivity phenomenon, which suggests Vietnamese culture is quick to add new values, but often without careful consideration (Vuong et al., 2018).

Moreover, students' self-learning ability appeared to be the most challenging for using M-learning for their self-study of Mathematics. Results from both teachers and students' survey consistently showed that Vietnamese high-school students were very much dependent learners, a longstanding issue of education in Vietnam (Tran et al., 2014; Nghia et al., 2018). Only 8.29% of the students believed that they could study independently without a teacher. After class, the majority of students would revise the lessons that they were taught, often less than one hour per day, rather looking for opportunities to expand their knowledge on the topics. Many of them only participated in self-learning activities due to their teachers' assignment. Several students could direct their self-study; yet, it appeared to be out of their extrinsic motivations of increasing their chance to pass the university entrance exam or to get a high score. Therefore, they seemed not to behaviorally engage with their learning due to their superficial learning attitudes and lack of awareness of their responsibilities of self-study for improving their own Mathematics knowledge and skills, as their teachers reported. A lack of behavioral engagement also questions the other dimensions of engagement: cognitive and affective engagement (Fredricks et al., 2004). Unfortunately, this study did not explore these two dimensions of engagement, which should be explored further by future studies.

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Regardless of the mentioned limitation, the findings raise a big concern about the effectiveness of using M-learning for students' self-study of Mathematics. Without an adequate level of self-learning ability and engagement, students would not be able to use M-learning for such a purpose. Therefore, students' awareness of the importance of learning for themselves and practical skills for self-learning should be nurtured and developed before implementing M-learning for Mathematics self-learning. To increase their learning engagement, Vietnamese high schools may wish to create a school environment that meets students' expectation, as described in Wang and Holcombe's (2010) longitudinal study. Feeling good about learning and having a sense of belonging would trigger students' passion for learning, which is the foundation of intrinsic motivation and trigger engagement (Furlong et al., 2003; Libbey, 2004). Likewise, creating an authoritative school climate with high structure and student support can nurture student engagement (Konold et al., 2018). This could be applicable in Vietnamese high-school context, because students there are often strictly monitored by their teachers and supervisors, but there has been a lack of student support service, especially in terms of self-learning skills. The situation explains why Vietnamese high-school students are often obedient and dependent learners. Effective student learning support service would hopefully increase students' self-learning ability, and within both authoritative and student-oriented school environment, students will become more engaging. Only then will M-learning be used for students' Mathematics self-learning.

In short, mobile learning or M-learning can be promising and trendy. As the world is shifting to Industry 4.0 and 'computational entrepreneurship' (Vuong, 2019), the ability to use M-learning effectively will also help students preparing for the fast-changing and technological-driven world. Furthermore, the use of M-learning has been increasingly appreciated by educators due to its sustainability potential in different facets such as finance (i.e., affordable cost) and flexibility (i.e., time and pace of learning). However, it seems that in the current context of Vietnamese high schools, the adoption of it would not be very much feasible, as more than half of the teachers noted. Difficulties in accessing the Mathematics websites, the content of these website, students' habits of using mobile phone, and their self-study ability and learning engagement must be considered and studied thoroughly by scientists to avoid wasteful science and help education policy makers ensuring a feasible and effective implementation of this new mode of learning (Vuong, 2018). This study did not explore students' perception of the ease of use and usefulness of M-learning. Future studies should explore these dimensions when exploring the feasibility of using M-learning in an educational context, because they may be associated with student engagement with this learning mode.

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