FRAMEWORK OF BEST PRACTICES FOR UNIVERSITY STUDENTS' MOBILE LEARNING IN STEM SUBJECTS

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ABSTRACT

This study investigated the students' experience and impact of using Science, Technology, Engineering, and Mathematics (STEM) related subjects for mobile learning or mLearning. In this study, mobile learning student-generated activities (SGA) focused on Malaysian universities as a developing country. The study approach was a qualitative case study based on mobile technology usage through 18 focus group discussions amongst students in Malaysia from 10 universities. The students participated voluntarily, and a purposive sampling approach was used. This study examined the students' perspectives using STEM mobile learning through activities created by students in Malaysian universities. The data were analysed using thematic analysis approach. The findings established factors or themes derived from data on the impact of mobile learning for STEM activities created by students in mobile learning from 10 Malaysian universities. The mobile learning framework of best practices emerged from understanding the impact of the research themes from students' experiences.

KEYWORDS

Mobile Learning, Universities, Malaysia, Developing Country, Activities, STEM, Students' Experience, Perspectives, Themes, Factors

1. INTRODUCTION

The application of mobile learning is becoming increasingly widespread across many industries, including those in the Science, Technology, Engineering, and Mathematics (STEM) sector (Crompton & Traxler, 2016). Similarly, mobile learning strategy can benefit students majoring in STEM fields because it encourages students to interact with technology using contemporary teaching methods (Alrahmi et al., 2021). This study focused on STEM-related subject areas in developing countries (Tang et al., 2021). Meanwhile, mobile learning could facilitate learning in a contextualised environment (Mohammadi et al., 2020) amongst university students in Malaysia (Ariffin, 2018). Furthermore, this strategy incorporated the study of STEM disciplines in educational institutions from developing countries, such as those found in Malaysia. However, very little has been done in previous studies on developing Asian nations, particularly in understanding mobile learning activities performed by students in STEM fields (Ariffin, 2018). Therefore, this study aimed to get insights into the STEM domains of mobile learning (Adov et al., 2020) from students, mainly to understand students' experiences in a developing country like Malaysia to contribute from developing perspectives. Previously, a limited studies were done to collect local students' voices, particularly on STEM mobile learning for developing nations.

1.1 Limitations

Additionally, not all subjects of STEM were covered, as the nature of this study was to garner in-depth perspectives from selective universities and classes that voluntarily participated. There were some limitations, whereby the study did not cover all the universities in Malaysia due to its in-depth nature. This study focused on public universities, whereby most students were from rural areas, middle-class and low-income family.

1.2 Definition

STEM education is defined as studying and teaching in the domains of science, technology, engineering, and mathematics. On the other hand, this research looked at topics associated with STEM (Mutambara & Bayaga, 2021) in Malaysian universities, such as health promotion, e-commerce, multimedia, artificial intelligence, information technology and society, and three-dimensional animation. Student-generated activities (SGA) involve activities of users in mobile learning (Pachler et al., 2010) that create digital content using mobile devices (Mutambara & Bayaga, 2021; Dyson, 2016), which originated from learning from experience (Kolb, 1984). Moreover, in this study, SGA promoted a digital learning environment, whereby students were digital content producers and consumers, co-creating, collaborating, and sharing their work with other students. Additionally, using their own mobile devices in doing their assignments that related to STEM subjects.

1.3 Study Purpose

The study is aimed at investigating the students' perspectives in Malaysian universities about SGA in the fields of STEM. The main research questions is: What are the students' perspectives using mobile devices in SGA for their STEM subjects? Likewise, SGA has the potential to produce more digital material and engage students in mobile learning. As a result, this study is aimed at analysing and categorising students' opinions towards mobile learning SGA. In addition, this research classified the aspects for students in conjunction with SGA (Ariffin, 2016) in STEM disciplines.

1.4 Value of Digital Content Produced Locally for STEM Fields

In Asia, mobile learning is frequently considered a relatively recent approach to accessing education in this new millennium. For example, mobile learning makes education more accessible for students, allowing them to follow their learning needs according to their schedule and access it whenever convenient (Mutambara & Bayaga, 2021). Similarly, mobile learning has a promising future in enhancing education in Asian countries. However, limited studies for STEM can be applied to mobile learning within the framework of Malaysia's educational system as a developing country. Ariffin (2018) highlighted a limited study conducted in this field of STEM in Malaysia for mobile learning, and the findings indicated that no one cares about it. Consequently, there is a stigma about learning STEM subjects, as it is more difficult to understand and learn. In the context of Malaysia, there is greater availability of western digital content than local digital content, notably for subjects related to STEM. Therefore, this study compared the contents from foreign countries with contents produced locally in Malaysia, which made learning STEM subjects difficult for students in Malaysia (Ariffin, 2018).

1.5 Efforts by the Local Government of a Developing Country

The enrolment of students in Malaysia, who are pursuing degrees in STEM fields is not encouraging for several years. Compared to the government's target of having 60% of students primarily in STEM subjects, a scientific survey conducted in Malaysia in 2015 found that only 21% of students were enrolled in STEM courses. However, Terkowsky et al. (2016) stated that using mobile technology devices in STEM education enabled students to learn actively and creatively, while enhancing their grasp of various topics. The Malaysian education system supports STEM education. According to the Malaysia Education Blueprint 2013–2015 (2015), the low awareness about learning STEM subjects was to be blamed for the falling enrolment numbers and quality of outputs achieved by students in the fields of STEM.

1.6 Theoretical Pedagogy

In mobile learning, one of the strategies is the constructivism theory, which emphasises learning from experience. According to Kolb (1984), the pedagogical approach comprised four different teaching and learning strategies and established the experimental learning theory (Kolb,1984; Ariffin, 2018). During this time, Yin (2018) concentrated his efforts on conducting research based on phenomena associated with mobile technology in an education case study. Moreover, the study of experiential learning through mobile learning was relatively new to Malaysian students. Consequently, the teaching and learning process was more inventive and engaging with mobile learning than the traditional face-to-face approach, which was more acceptable. Meanwhile, the current emergence of learning in advanced countries adapts and adopts new technology (Parsons & MacCallum, 2021). Students develop their activities using mobile devices rather than sitting passively during experiential learning. This learning approach also applies to SGA, emphasising student-centred learning through mobile devices in the students' respective courses (Dyson, 2016). In a similar context, despite the difficulties inherent to the Malaysian context, there are chances for student-led activities to develop digital content for learning purposes (Ariffin, 2016). On the other hand, students can easily access and develop their digital multimedia content using multimedia functionalities built into their mobile devices. The students produced assignments using mobile devices as part of mobile learning. The active learning method in student activities was successful (Ariffin, 2016; Dyson, 2016). It exhibited a strong comprehension and enthusiasm for university learning linked with mobile learning, and was extensively employed worldwide. The overwhelming majority of evidence indicated that mobile devices provided teachers with support for instruction, given that all pupils have smartphones (Tang et al., 2021). Additionally, these mobile learning strategies encouraged learning activities outside or beyond school hours by utilising the students' mobile devices (Ariffin, 2018).

1.7 STEM Learning in Student-Generated Activities

In developed countries, STEM for mobile learning (Traxler & Crompton, 2016) has the potential to be expanded to SGA for STEM topics, in the Malaysian context. Students in Malaysia are demonstrating an increased level of expertise in the utilisation of mobile devices for educational pursuits. However, students tend to avoid STEM courses and are unmotivated to learn about them. Students entrance to universities for STEM courses has yet to accomplish a satisfactory level of enrolment, particularly in Malaysia. In Malaysia, STEM subjects are gaining more attention using mobile learning. For example, a few types of research were conducted in Malaysia on STEM topics related to mobile learning. Consequently, Nithia et al. (2015) stated their evidence of research, even though it was not considered in Malaysia to STEM and mobile learning. Therefore, there are opportunities to investigate STEM-related courses in Malaysia by implementing mobile learning to facilitate the creation of digital material by students. As a result, mobile learning that incorporated mobile SGA (Ariffin, 2018) might be one solution to the problem of getting students interested in STEM education.

2. METHODOLOGY

This is primarily a qualitative study, using case study approaches adapted from Ariffin (2018), that aims to gather in-depth information to find participants' perceptions of mobile learning related to STEM disciplines. The occurrences seen in the case study served as an impetus for the research, and brought perspectives (Yin, 2018). This research utilised a method of data collection, known as focus group discussion (Mertens, 2010) to acquire students' opinions regarding mobile learning application in STEM fields.

No	Grp	Uni	Subject	Pre	Post
1	FG1	A	Health Promotion	10	9
2	FG2	B	E-Commerce	13	11
3	FG3	C	Multimedia	4	3
4	FG4	D	Artificial Intelligence	6	6
5	FG5	A	IT & Society	6	6
6	FG6	E	3D Animation	6	6
7	FG7	F	Computer Science	6	6
8	FG8	C	Weight Lifting	9	7
9	FG9	G	Bio Chemistry	6	6
10	FG10	H	Game Design	7	7
11	FG11	I	Robotic	6	7
12	FG12	J	Educational Tech	6	6
13	FG13	I	Discreet Math	7	6
14	FG14	A	Health Promotion	10	5
15	FG15	A	Health Promotion	3	7
16	FG16	C	Rehabilitation	6	6
17	FG17	K	Cosmetic Eng.	6	6
18	FG18	H	Structure Program	6	6
Total Number of Students				123	116

Note: FG = Focus Group,

Figure 1. Participants

Figure 1 provides the participants' details for this study. The students were recruited voluntarily and involved with subjects associated with STEM. Most of them were tertiary-level students in Malaysian public universities.

2.1 Procedures

There were two stages in this study, which included the stages before and after SGA. In the first stage, 18 focus group discussions were held at 10 universities. The purpose of these focus group discussions was to get in-depth insights into the effects, which previously gained mobile learning experience had on the study of STEM subjects. For instance, the participants communicated using mobile devices, and only a tiny percentage participated in activities that used SGA to learn about STEM-associated subjects. As shown in Figure 1, the study incorporated 18 unique focus groups held across 10 distinct educational institutions or universities in Malaysia. The researcher suggested that the academics included student-created multimedia activities in their teaching to enhance the student's learning experiences. Furthermore, the students were instructed to use their mobile phones to complete their homework for disciplines related to STEM. After the brief introduction of mobile learning activities for STEM, the typical length of time for each interview ranged between 30 minutes and an hour. The semi-structured questions were adapted from the mobile learning literature by Ariffin (2016). These questions were inspired by student-generated experiential learning activities based on research by Dyson et al. (2008) that used experiential learning (Kolb, 1984). On the other hand, data from the interviews were analysed by utilising the thematic analysis method (Braun and Clarke, 2006), and organised by NVivo software. Some examples of semi-structured questions that were used for this study were as follows:

- How did the students utilise mobile devices for activities related to STEM mobile learning student-generated content?
- Which benefits of mobile learning the STEM student-generated activities are in the process of learning STEM subjects?
- What difficulties did students face when carrying out these student-generated mobile learning activities for STEM subjects?

Participants in this study should have a subject associated with one of the STEM fields (science, technology, engineering, or mathematics). Consequently, all participants from 18 different focus groups and 10 universities located in Malaysia contributed to the study voluntarily. In a nutshell, 123 students participated in phase one, whereas 116 students participated during the stage before SGA. Figure 2 shows the research process. In this study, the fields of study associated with STEM included Health Promotion, E-Commerce, Multimedia, Artificial Intelligence, IT & Society, 3D Animation, Computer Science, and Weight Lifting. Likewise, subjects such as Bio-Chemistry, Game Design, Robotics, Multimedia, Education Technology, Discreet Math, Health Promotion Rehabilitation, Cosmetic Engineering, and Structured Programming, were also included.

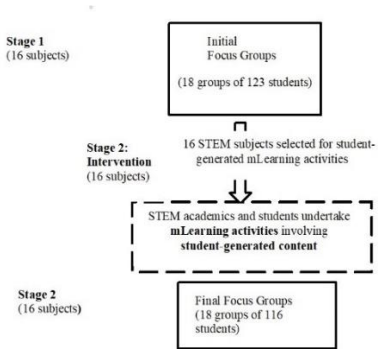

Figure 2. Various Stages of Research in STEM Fields

This article elucidated the findings of a study that focused on the perspectives of students, who participated in mobile learning for STEM courses at universities in Malaysia. These phases included Phase 1, which took place before the students participated in content activities. Furthermore, Phase 2 took place after the students participated in multimedia activities. During this round of activities, the students created STEM-related multimedia content.

2.2 Thematic Analysis Process

A series of repetitive steps, whereby the meaning of data was analysed and interpreted in developing the theme analysis (Myers & Avison, 2002). The factors were extracted from the data through a method, known as theme analysis. Braun and Clarke (2006) emphasised that to conduct thematic analysis, one should be familiar with the transcripts, initialised the code, and grasp the topics. Additionally, the participants' responses were collected by an audio recorder. The researcher provided a Malay language transcription of the audio (Bahasa Melayu or Bahasa Malaysia). To produce an accurate transcription, the researcher needs to listen to the audio recorder more than once. The original recording was in Bahasa Malaysia and translated into English language. Furthermore, the codes were identified from the interview statements. Consequently, if required, the combination of codes was categorised and reorganised in developing the themes (Saldaña 2009). Likewise, Auerbach and Silverstein (2003) came to a similar conclusion, stating that the coding phases were nonlinear processes that might reverse, bringing about changes in coding, and theme processes as topic generation moves forward. Modifying the topics aligns with how the data may be interpreted, and the study corresponds with the thematic background (Braun & Clarke 2006). Finally, the mobile learning findings were organised into a few broad categories, and topics from which the factors or themes were derived.

3. FINDINGS

Table 1. Framework of Emerging Factors from the Best Practises

	Emerging Factors from the Research
1	Affordances of mobile devices for individual use and consumption
2	Affordances for educational usage
3	Challenges of mobile phones for education
4	Affordances of mobile learning, particularly for SGA
5	Mobile learning achievement
6	Opportunities and requirements for overcoming challenges associated with mobile learning
7	Usability of mobile devices

3.1 Affordances of Mobile Devices for Individual Use and Consumption

The first aspect that was discovered was referred to as 'affordability for personal usage of mobile devices'. This element showed that mobile devices could be utilised for daily activities and according to participants' lifestyles, notably in the multimedia function of mobile devices, and utilisation of social media for communication purposes. Some examples were:

> "Because I enjoyed making video calls, WhatsApp programme was one of my favourites to use." (Pre, FG13, S3)

3.2 Affordances for Educational Usage

This topic focused on the significance of mobile devices in education, highlighting their wide range of applications, in particular blended digital online learning, and application of social media platforms for educational reasons. An example:

> "YouTube, Google Chrome, and Google Translate are the three Google products I used constantly." (Pre, FG2, S13)

3.3 Challenges of Mobile Phones for Education

This topic focused on the challenges that arise while attempting to use mobile phones for educational purposes, and access digital content while participating in educational activities. An example:

> "The price is high, but with the quota and internet speed that does not make it worth it." (Pre, FG9, S6)

3.4 Affordances of Mobile Learning, Particularly for SGA

The fourth consideration was 'affordability of mobile devices for mobile learning', particularly concerning SGA. Within this topic, participants reaped the benefits of the influence and results that mobile learning content created for student-driven activities. After participating in SGA, the participants showed vital awareness of using mobile learning in STEM than their understanding before participating in SGA. An example:

> "Makes it easier for the learner to gain knowledge through the process of revising or completing assignment." (Post, FG9, S3)

3.5 Mobile Learning Achievement

Additionally, 'mobile learning achievement' emerged as the fifth criterion. This topic presented the results of mobile learning digital content generation based on SGA that used the multimedia capabilities of mobile devices. An example:

> "The video was such a pleasant and enjoyable experience." (Post, FG4, S3)

3.6 Opportunities and Requirements for Overcoming Challenges

The phrase 'opportunities and requirements for solving mobile learning challenges' is the sixth factor. This issue focused on the prospects and opportunities that mobile learning presents for lowering the barriers to mobile learning. This was by giving students more agency in creating digital material by utilising mobile devices multimedia capabilities. An example:

> "… I can do it." (Post, FG7, S4)

3.7 Usability of Mobile Devices

The capacity to use mobile devices is the seventh criterion to consider. Users discussed their difficulties and worries regarding usability issues while using mobile devices to participate in SGA. This topic emphasised the significance of mobile devices practical use for educational purposes. Some examples were:

> "Doable for anybody and everyone." (Post, FG4, S6)

"It is a form of independent study that may be done at any time and in any location. Mobile learning allows us to obtain information even if we stay in an unfamiliar location without the need to locate the information in a book." (Pre, FG7, S6)

> "...via mobile learning, everyone has the same rights to get this mobile learning since it is accessible, and that there are no restrictions to the boundaries for you to gain the education and access information." (Post, FG5, S1)

4. DISCUSSION

This section discusses the contribution of mobile learning best practices for STEM in a developing country, such as Malaysia (Yin, 2018). Furthermore, this study shed light on the fact that mobile learning encompasses a broader range of topics, including those in the STEM domain when applied in a local, regional setting. On the other hand, this study utilised the experiential learning approach (Kolb, 1984) for the development of a sustainable mobile learning environment in the production of multimedia digital content that embeds to improve the learning of STEM subjects within the context of case studies in Malaysian universities.

4.1 Students Empowerment Implementation

According to the study findings, the students felt more equipped to work on their projects amongst other students when they utilised mobile devices for SGA learning from experience (Crompton & Traxler, 2016). The students were more engaged rather than sitting passively, and produced projects of high levels for subjects related to STEM. As a result of developing the digital content for their group assignments, they improved their knowledge in the respective subjects, and acquired skills in creating digital multimedia (Dyson, 2016; Tang et al., 2021). Additionally, as part of their work assignments, the students should create STEM-related digital multimedia content for the projects. Consequently, they had a more profound comprehension of complex topics, such as STEM as a result of working on the projects using SGA approach for local universities in the Malaysian context.

4.2 Bring Your Own Device (BYOD) for Student-generated STEM Activities

The students acquired the role of digital content creators for the entire SGA when 'bring your own device' (BYOD) strategies were implemented. This study enlightened them that they might become digital content creators with relatively little guidance from their instructors (Ariffin, 2016). Nevertheless, they produced high-quality STEM digital content using BYOD by working collaboratively with their group. This study also found that the students had a greater awareness of using their own mobile devices, such as smartphones, for access to educational purposes (Mutambara & Bayaga, 2021). In particular, the students were more aware of using their mobile devices for SGA in STEM subjects.

5. CONCLUSION

In this research, mobile learning elements garnered from students' perspectives in Malaysia gave new insights. Specifically, this research focused on mobile learning SGA for STEM in developing countries within Malaysian universities. The students benefited from the BYOD policy, as it made the subject matter of STEM more meaningful and easier to comprehend. Future research could investigate other fields, such as

creative industries for SGA. Likewise, SGA involves creativity, and therefore, phenomena in STEM topics related to IR 4.0 and creative industries may be further researched.

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