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Matriculation students' usages and its driving factors in mobile learning for Chemistry

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ABSTRACT

The study identified how Malaysian matriculation students employ mobile devices for learning Chemistry, and the driving factors that influence their use of mobile devices for learning Chemistry. A qualitative case study approach was adopted in this study, in which interviews and student journals were the main instruments used for the data collection process. The study was conducted in a matriculation college, and all students were invited to participate in the study voluntarily. A total of 17 students who were actively using mobile devices to learn Chemistry were selected for individual and face-to-face interviews. The data were analyzed in a three-stage process to inductively identify the themes. The analysis revealed that matriculation students used mobile devices for referential and collaborative learning activities. They preferred to search the relevant learning resources on the web, and learn collaboratively with their peers or lecturers. Meanwhile, the driving factors of these mobile learning practices were primarily due the ability of mobile learning to overcome their learning difficulties, convenience, as well as the ability to provide a better user experience in the digital age. The findings of this study suggest that the mobile device is a viable social constructivism pedagogical tool for learning Chemistry. The lecturers and management of matriculation colleges can use the findings of this study as a basis to promote the adoption of mobile learning for Chemistry in the digital age.

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1. INTRODUCTION

Chemistry is often perceived as a difficult subject due to the abstract nature of its concepts, which require students' ability to connect and represent three conceptual levels, namely macroscopic, submicroscopic, and symbolic levels [1]. The obstacles and misconceptions that students faced in understanding Chemistry concepts furthered affect their interest and learning achievements [2]. However, technology has been integrated since the nineteenth century to facilitate teaching and learning in the classroom [3]. Mobile technology in the education context in turn, has recently offered portability, ubiquitous connectivity, and immediacy of communication for learning [4]. It supports a wide range of educational uses in the formal and informal context, such as accessing e-learning platforms for learning materials and information, completing in-class tasks and homework assignments as well as contextual learning using mobile applications [5].

The use of mobile technologies in learning is commonly known as mobile learning [6]–[8]. There are many terms used to describe mobile learning, such as mobility, access, immediacy, ubiquity, convenience, and contextuality [6]. It denoted that mobile learning as an extension of electronic learning that utilized wireless devices to support learning at anytime and anywhere [7]. Meanwhile, Borba *et al.* [9] argued that mobile learning not only involved the use of portable and handheld devices, but also the affordance to learn in different contexts through interactions with people, content, and devices.

Previous studies indicate that the use of mobile technologies, such as augmented reality, animations, electronic laboratory notebooks, immersive virtual reality, modelling, online tutorials, simulations, student response systems, videos, virtual laboratories, and wiki software, could bring promising benefits for learning Chemistry [3]. For example, mobile virtual reality laboratories may increase students' motivation, critical thinking skills, and understanding of complex Chemistry concepts, due to the ability of stimulating real laboratories in a virtual environment [10]. Alternatively, educational games in mobile learning that integrate the elements of exploration, designing, and collaboration, can be used to help students to improve their understanding in Chemistry concepts contrary to the conventional teacher-centered method [11].

Even though previous studies have indicated the benefits of adopting mobile learning in Chemistry, the use of mobile devices to support students' learning has led to mixed results. There were both positive and negative feedback related to the use of mobile devices for educational purposes among the secondary school students. The positive feedback was ease of access to learning content had helped students in solving their homework. However, students were dissatisfied with several features of the educational applications, such as poor interface organization as well as lack of functionality and information provided in applications [12]. In addition, the use of smartphones for learning activities did not improve university students' academic achievement. In turn, multitasking activities on their mobile phones, such as texting in class, were detrimental to their learning [13].

Constraints and misuse of mobile devices for learning are other major concerns reported in numerous studies. These constraints could be categorized into physiological, pedagogical, and technical. For instance, excessive use of mobile devices might cause adverse effects on a student's health such as tiredness, stomach pains, blurred vision, eye irritation, insomnia, stress, and severe headaches. It also led to some behavioral problems and changes in mood, such as impatience and aggression, less concentration in class, increased rate of absenteeism, and tardiness [14], [15]. Use of mobile devices for non-learning activities might distract student attention, and could disturb the lecturer and other students [16].

Conversely, technical constraints are mainly related to the features of mobile devices such as battery life, memory, screen and keypad size, standardization and interoperability, network speed and reliability [17]. A short battery life makes learning impractical to be carried out for long hours while on the move [18], whereas limited memory impedes the use of multiple applications or functions simultaneously on smartphones [19]. In terms of the misuse of mobile devices, the recent curriculums were not created or modified to accommodate mobile learning. Some subjects were found to be incompatible to the mobile learning approach [20]. Subsequently, some educators still doubt the pedagogical advantages of mobile technologies to support students' learning [21]. There is also a growing tendency of unethical issues among the students due to the misuse of mobile devices, such as cheating in exams, hacking personal information, accessing inappropriate web material and improper communication [22].

Mobile devices have the potential to be used as viable tools to facilitate teaching and learning. For example, texting and talking with someone was the most frequent smartphone use amongst university students, followed by checking social media, and internet browsing [23]. Similarly, the undergraduate students in allied health program used their mobile devices for seeking information, taking pictures, watching videos, and peer communication via social media or text messaging [24]. Moreover, students in one Malaysian university mainly used their smartphones for communicating with others by texting [13].

Based on the current trend of mobile device usage among students for learning, there was a need to better understand the underlying factors associated with these behaviors [13]. Previous studies also indicated that there are several key factors contributing to the adoption of mobile learning in the educational context, which can be categorized as technical, pedagogical, economical, and human factors [25]. However, more studies were required to investigate learners' perception and use of mobile devices for learning, and the factors affecting their mobile learning practices [25]. These underlying claims and issues have led to the appropriate research gaps to be addressed in this study. Moreover, the mobile learning research that focused on Science subjects, such as Chemistry in particular, is very limited in the Malaysian context. Most of the research studies focused on language learning and distance education [26]. Therefore, this study aimed to identify how Malaysian matriculation students employed mobile devices for learning Chemistry. It shed light on the types of learning activities and factors that led to their adoption of mobile devices for learning Chemistry. The findings of this study could be used by administrators and lecturers for instructional development and improvement in the digital age.

There were two main objectives in this study: i) To identify the types of mobile learning activities carried out by matriculation students for learning Chemistry; and ii) To identify the factors that influenced mobile learning activities among matriculation students for learning Chemistry. The following research questions guided this study: i) What are the types of mobile learning activities carried out by matriculation students for learning Chemistry? ii) What are the factors that influenced mobile learning activities among matriculation students for learning Chemistry?

2. RESEARCH METHOD

The qualitative case study was adopted in this study. It identified how Malaysian matriculation students employed mobile devices for learning Chemistry. It is chosen due to its ability to develop a dynamic and comprehensive view of the experiences regarding a specific situation or phenomenon. Of the various types of qualitative methods available, the one best suited to obtain students' views was the case study method which enables the researcher to gather data from a variety of sources, in order to provide better insight into a case [27]. Moreover, the case study method used to examine how and why the selected matriculation students adopted mobile learning in authentic contexts.

The study was conducted in a matriculation college located at the northern part of Peninsular Malaysia. A purposeful sampling method was adopted to select students who could provide in-depth information about their mobile learning practices in Chemistry. Firstly, they must have access to an internet-enabled smartphone with a personal mobile data plan to perform mobile learning in Chemistry. The ownership of a personal mobile data plan was vital because it enabled students to actively adopt mobile learning without depending on the free wireless network in the college. Secondly, they must actively adopt mobile learning in Chemistry.

The data collection consisted of two phases. At the beginning of the study, all students in the selected matriculation college who offered to participate in the study voluntarily were briefed about the objectives of the study. Initially, 84 students were interested and willing to participate in the journal writing, which was the first phase of data collection to record their mobile learning practices for Chemistry. However, only 17 students who actively adopted mobile learning in Chemistry, were purposely selected for the second phase of data collection which consisted of individual interviews. The students had written at least 15 entries in their journals during the first phase of data collection. Next, these students were personally contacted to get their consent for conducting the face-to-face interviews.

Two types of instruments, interviews and student journals, were employed in this study. A semi-structured interview, guided by several open-ended probing questions, was able to provide maximum opportunity in eliciting students' views [28], [29]. Meanwhile, a semi-structured student journal that consisted of open-ended questions was developed, in order to record their activities and problems encountered throughout the learning process. In terms of mobile learning activities, they were asked to record the person, places, time and duration of their use of mobile devices for learning Chemistry. They were also asked to reflect about the factors that contribute and challenge these mobile learning activities. The use of a structured diary was deemed unsuitable for this study because it used to keep track of specific items quantitatively, such as the exact time range, place and type of activities conducted [30]. However, a semi-structured journal could provide greater freedom for the students to reflect about their mobile learning practices. Upon completion of these instruments, they were reviewed and checked by experts who have vast experiences in qualitative research, and were familiar with the use of instructional technologies for learning, such as mobile learning.

As the data collection and analysis were concurrent, the interviews were transcribed into verbatim transcripts immediately after each interview was completed. Pseudonyms, such as Student 1 (S1) and Student 2 (S2), were assigned to each student as an ethical consideration, so that their identity would be kept anonymous. In addition, the three-stage process of coding in-depth semi-structured interview transcripts recommended by Campbell *et al.* [31] was adopted. The first stage was to develop a coding scheme, or codebook, by open coding techniques. After the initial coding scheme was developed, the second stage, namely the evaluation of interrater reliability was conducted. The reliability of the initial coding scheme was assessed using Cohen's kappa. The Kappa value of 0.77 indicated that substantial agreement was obtained among the raters during the coding process [32]. The third stage of coding was the deployment of a coding scheme to code all transcripts in the study. Here, the researcher could code the remaining transcripts and the second rater could check the codes, and vice versa. However, the addition of new codes to the coding scheme was allowed throughout the coding process, since the transcripts were coded inductively. Meanwhile, member checking and peer debriefing were conducted to maintain the trustworthiness of the study. The students were asked to read and edit the interview transcripts, in order to ensure the accuracy and credibility of their views. Peer debriefing was conducted among the raters during the analysis to comment, critic and validate the codes, subthemes and themes used.

3. RESULTS AND DISCUSSION

The analysis of students' mobile learning activities for chemistry were categorized into two themes: referential and collaborative learning activities. Meanwhile, the factors that influenced mobile learning activities were difficulties in learning, convenience, and user experience.

3.1. Referential learning activities

Looking up resources on the web was the most favored learning activity among the students in learning Chemistry. Majority of the students preferred to search for information using various types of search engines and websites such as Google and Wikipedia to enhance their understanding of Chemistry. The following statements supported this finding:

> *"I used my phone to search about ways to calculate the equilibrium constant and dissociation constant of a weak acid."* (S7)
> *"Sometimes I search for information related to Chemistry from Google or Internet."* (S8)
> *"I look for the answers in my study. Like how to answer questions in tutorial and past year. I have searched for topic seven, that is related to the calculation using ICE table."* (S14)

Additionally, most students preferred to watch YouTube videos as their main source of reference for learning Chemistry. They watched the videos when need detailed explanation about the problem encountered in their learning. The following comments clarified this finding:

> *"Watching a few video(s) about hybridization and overlapping through YouTube. Watching (a) video about intermolecular forces."* (S10)
> *"Learning… video also. I like to watch video(s) on explaining about the topic. When I read, I don't really understand. I have to watch the video then can understand."* (S4)
> *"YouTube. Search... such as … for example topic equilibrium. If (I) do not understand (I) then search YouTube. Learn what is equilibrium. Then, (I) can understand from YouTube."* (S16)

It implied that the matriculation students in this study utilized web resources, such as searching for related or additional information in Chemistry when they had difficulties in learning. Similar findings were found in several previous studies, such as the university students used to perform a variety of tasks using mobile phones. However, the on-the-go seeking of information using mobile phones was their predominant mobile learning method [24]. Moreover, matriculation students perceived that the animation and visual explanations offered by video, especially YouTube videos, were essential in helping to explain abstract Chemistry concepts. Video offers both the audio and visual stimuli that make learning more interesting and motivating [33]. It also caters to the different learning styles of students by allowing them to view, rewind and replay the learning contents as many times as needed, and in anytime and anywhere [34].

The use of mobile devices for selecting, viewing and processing information was categorized as a learners' cognitive support activity for knowledge construction [5]. As such, matriculation students' mobile learning activities such as searching for information on the web and watching YouTube videos, are not merely a form of knowledge delivery as indicated by Patten, Sánchez, and Tangney [35]. Concurrently, students need to actively select the appropriate learning resources, such as articles and videos on the web, organize them into a coherent representation, and integrate them into their existing knowledge. It involves a coordinated collection of processes that facilitates the matriculation students' learning of Chemistry. This learning activity is well situated within the constructivist learning theory. It asserts that learning is an active and meaningful process, in which learners need to construct their personal meaning to the new knowledge obtained, and assimilate it into their existing knowledge [36].

3.2. Collaborative learning activities

Making conversation and conducting discussions were the main types of collaborative learning activities among the students in this study for learning Chemistry. They performed conversations and discussions with fellow students, or between students and lecturers. The students would discuss with their peers whenever they encountered problems in learning. Additionally, WhatsApp was their most preferred mobile instant messaging tool to converse and discuss with peers after the formal lesson.

> *"There is always discussion in WhatsApp. Discuss with friends about Chemistry."* (S1)
> *"Else I will ask my friends. (Laugh) What is this… if I cannot answer the question, I will snap the question and ask my friends. How to solve it."* (S2)
> *"I ask through WhatsApp."* (S6)

"We formed (a) WhatsApp group for the class. So, we will ask one another or discuss our problem in WhatsApp. We will snap photo(s) of the difficult problems and post in WhatsApp group." (S8)

Students also shared information. The answers of an assignment among classmates' discussion in the form of photos and videos via their mobile device. The following interview results clarified this finding:

"Sometimes I snap the answer. Ask my friends to send the answer. I look at it, then I will try to do (it) myself. I will try to understand her answer before I do it myself. It's like sharing the answer." (S15)
"If I found one video, and I understood it, then I will share in WhatsApp group." (S6)
"For example, if there is any information from the lecturer, any idea about the study from other students, I will snap and upload in WhatsApp group… We will check the answer given by the lecturer, or shared by other students in the WhatsApp group. We have created one special WhatsApp group for our tutorial class, just for the sharing purpose." (S8)

This finding provided an interesting insight that collaborative learning activities, such as discussion and information sharing via social media, had infused into students' daily mobile learning practices. This conformed to the findings of previous studies that most students preferred to communicate with others when learning, because collaborative learning environments helped them to learn better and to solve complex tasks correctly [37]–[40]. Similarly, the integration of mobile applications in an inquiry-based learning approach offers communication, collaboration and self-learning opportunities that could improve students' achievement as well as knowledge and skills in scientific processes [41].

Matriculation students also conversed and discussed with their peers via WhatsApp when they encountered problems in their learning. WhatsApp was the most popular mobile instant messenger amongst university students in Asian countries [42]. In addition, WhatsApp groups are an effective collaboration platform to share learning materials among students [43]. The finding also supports sociocultural theory that presumes knowledge construction is a social learning activity. Mobile learning provides an opportunity for support and reflection of both learning content and processes, which is essential to support and facilitate learners' knowledge construction [44].

3.3. Difficulties in learning

Shortcomings in learning by students was one of the contributing factors that led to the adoption of mobile learning in Chemistry. It was mainly due to the difficulties in understanding the Chemistry concepts, and being unable to comprehend the lesson in the classroom. The following quotes clarified the findings:

"Mostly in chapter(s) like molecular geometry. It's difficult. Because I need to imagine how the molecule is formed." (S9)
"Yes, because I did not understand what I learn(ed) in lecture." (S16)
"I google what I don't know. For example, definition, meaning, how to do. All of it. But I mostly google for the calculation. Because I am weak in calculation." (S16)

Students also revealed that their peers were unable to assist when they had difficulties in learning. This might be due to several reasons, such as difficulties in getting instant help from peers, especially late in the evening. However, they could overcome this hurdle by searching for information on the internet using their mobile devices.

"When it's not in my textbook or lecture notes and if my friends don't know it. I ask the internet." (S4)
"After the class. We cannot meet. Like after eleven o'clock, we cannot go out already. So, I will google from (the) internet." (S7)
"It's only two in my room. But my roommate is seldom in the room. Nobody to ask. The only solution… Google." (S13)

The adoption of mobile learning among matriculation students was driven by the ability to overcome their difficulties in learning either due to knowledge shortcomings or being unable to obtain support from peers. Reading textbooks was found by matriculation students to be unattractive and ineffective in helping them to comprehend abstract Chemistry concepts. They preferred videos and mobile apps that are able to visualize the abstract Chemistry concepts using three dimensional animations. This finding is supported by the views of several previous studies that visualization tools such as videos have a prevalent impact over the written text in promoting the learning of abstract concepts, such as Chemistry concepts [45].

3.4. Convenience

Most of the students indicated that the use of mobile devices provided an added convenience to their learning process. The required information could be easily searched using their mobile device versus searching for information in hardcopy resources such as books. They preferred to obtain information by just a simple click, rather than searching page-by-page in books.

> *"If you read the book, first you need to find which topic is it in, because usually the information is related to a topic. Then I (need) to find that, then go through one by one, find each word. If I google search, it searches by the word, is specified by the word, so easier."* (S7)
> *"(Reading a) book is a bit difficult. For my case, I will snap the book and put in my phone. Then I can read it from my phone. It's easier to read from phone than book."* (S9)

Some students also described that information found from the internet was an alternative source of reference when books were unavailable. It happened during learning on the move, or during the holidays at their hometown. The findings are supported by the quotes:

> *"Because sometimes I am in the library and forgot to bring any books."* (S12)
> *"Didn't bring book to home. In case you have no book with you, it is easier as we can just search anywhere with mobile."* (S13)

The preference of students to search information using mobile devices over books was due to their convenience and flexibility. The flexibility to learn without time and place constraints became the desire for most mobile learners [39]. For instance, the use of mobile devices is beneficial to health care students due to the availability and accessibility of books, informational resources and journal articles in their programs and careers [39]. The use of mobile devices to access course materials among the students in distance learning environments was mainly driven by its flexibility and convenience [46].

3.5. User experience

The multimedia capabilities presented by mobile learning also made it more appealing to the students in this study. Most students cited that the more attractive presentation offered by mobile learning created a fun and relaxing learning environment. The audio-visual effects in videos improved their focus and retention in learning Chemistry.

> *"Sometimes the video also got animation. They put effort in the video. And looks nice. Yes, it attracts."* (S4)
> *"I am happy learning chemistry by using my mobile device or my smart phone because I can learn with fun while watching YouTube video. Yes, I found that learning chemistry by using mobile device is more fun than reading books."* (S16)

Alternatively, some students claimed that privacy contributed to their decision to use mobile devices for learning Chemistry. Quiet and undisturbed conditions were their most preferred learning environment, which could minimize distraction or the possibility of losing focus during group discussions.

> *"I like to learn alone. Work alone. So, I also prefer to be alone in learning. I found that mobile learning best suits my need(s). It allows (me) to learn alone."* (S1)
> *"Discussion(s) make me feel uncomfortable, because my friend(s) will ask many questions during discussion. I preferred to learn alone. I am familiar with this learning method. I dislike crowded. If crowded, it is a form of distraction. I can't concentrate and like to talk to others. So, I prefer using mobile."* (S17)

The findings of this study suggested that students were attracted by the colorful images and attractive sounds in videos, which made them stay focused throughout the learning process. The appealing learning environment enabled the students in this study to learn Chemistry in a relaxing and enjoyable manner, which became a key driver towards mobile learning adoption. This suggestion is also supported by previous study indicating that primary and secondary students became curious and desirous of getting immersed in the learning process if the learning medium was appealing [47].

The preference for privacy in learning among the students is another interesting finding in this study. Despite promoting interaction and collaboration in learning, the majority of the students disliked the distractions that occurred during the use of mobile devices. However, the use of mobile devices for learning Chemistry also met their expectations in terms of providing a quiet and undisturbed environment for learning. It was claimed that meeting student's expectations was the main factor for the success of mobile learning in the digital age [48]. From the perspective of innovation diffusion theory, if an innovation, such as mobile learning adoption, was consistent with the learners' beliefs, existing values, experience, and current needs, it would positively influence the learners' intention to accept the innovation [49].

4. CONCLUSION

The study revealed that mobile devices help with students in comprehending abstract Chemistry concepts through searching relevant learning resources on the web and learning collaboratively with their peers or lecturers. It also found that the adoption of mobile learning amongst students is driven by its ability to overcome their learning difficulties, convenience, and providing a better user experience in line with the digital age. It contributes a better understanding about the mobile learning activities among matriculation students in the ages of 18 to 19 years. Matriculation lecturers should design learning activities that make use of the strength of mobile devices and the learning patterns of students. On the other hand, the matriculation lecturers can design student-centered learning activities that promote a collaborative learning environment. For example, classroom discussions can be extended after the formal lesson via WhatsApp, which is the most popular mobile instant communication platform used by students. Apart from that, various types of collaboration tools can be adopted to enhance students' active participation and interaction in learning. These include the use of classroom response systems (such as Kahoot, Socrative, and Clickers), blogs, and discussion boards.

Mobile device is a viable social constructivism pedagogical tool for learning Chemistry. Consequently, the lecturers should be trained in both constructivist and social constructivist learning theories that utilize mobile devices to engage students in collaborative learning. It is crucial for lecturers to possess sufficient knowledge, both pedagogical and technological, to act as change agents in the midst of educational reforms due the advancement of mobile technologies. In addition, the management of institutions should allow the strengthening of education quality by providing support for the lecturers to reform their teaching practices. The lecturers and management of matriculation colleges can use the findings of this study as a basis to promote the adoption of mobile learning for Chemistry in the digital age.

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