ORIGINAL ARTICLE

Internet of Things (IoT) in Medical Imaging: a Case Study on the Utilisation of Mobile Application Among Medical Imaging Students

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ABSTRACT

Introduction: As the technology nowadays is booming, many mobile applications related to medical imaging are accessible to help radiographers and students with many beneficial information and education. Regardless of the great acceptance of mobile devices in these modern years, knowledge about the utilisation of medical imaging apps among medical imaging students in UITM is rather limited. Thus, this study was conducted to assess the utilisation of mobile applications in medical imaging among students. **Methods:** Online questionnaire which covers socio-demographic data and assessment on the mobile application usage was distributed in Google form to 183 Medical Imaging students, UITM Puncak Alam. Data obtained were analysed using t-test and ANOVA. **Results:** The level of utilisation of mobile applications in medical imaging among medical imaging students in UiTM Puncak Alam is low with only 44.26% (81) of them really utilised the apps for education purposes. It is shown that more than half of the students (55.74%) have not used the medical imaging apps before this. Only level of study and clinical attachment experience show significant difference in the apps usage among the students. **Conclusion:** The level of utilisation of mobile applications in diagnostic imaging among medical imaging students in UiTM Puncak Alam is low.

Key words : Internet of things, Mobile health, Mobile learning, Medical imaging

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INTRODUCTION

The Internet of Things (IoT)
Industrial revolution 4.0 or shortly known as IR 4.0 has gain interests from various parties since the first time it was introduced by the German government in the year of 2013 (1). The goal of this strategic initiative is to transform industrial manufacturing through digitalization and exploitation of new potential technologies (1). Internet of Things (IOT) is one of the resultant technology of IR4.0 from the fusion of physical and digital world.
The Internet of Things (IoT) refers to network of physical objects that contains embedded technology to communicate and sense or interact with their internal states or the external environment (2). A "thing" or object in IoT is basically any item in human's daily life which is smartly enhanced to communicate each other through the technology of internet by physically and virtually at any time and any place (3).
Smartphone, tablets and current mobile devices are considered as IoT devices since they are embedded with a range of built-in sensors which produce large volume of data in structured and unstructured form (4). These devices are also equipped with a variety of connectivity technologies, which allow them to connect and interact with other devices and sensors (4).

Mobile apps and mobile health (mHealth)
Applications or can be simply called "apps" are generally software programs that have been designed and upgraded to operate on a computer or mobile devices to accomplish certain functions (5). A mobile operating system (Mobile OS) is a set of software that coordinates all activities of mobile devices and provides a platform for users to communicate with other programs

or applications (6). The examples of the mobile operating system include Apple iOS, Google Android, Blackberry OS, Microsoft's Windows Phone OS, and many more that are believed to come into the new decade (7).

The widespread popularity of mobile phones technologies has expanding the possibilities of utilising mobile devices and wireless network in healthcare field, which also called as mobile health or mHealth (8). The presence of medical mobile device apps has been paved by the amazing technologies such as faster processors, smaller batteries and effective open-source operating systems that could run complicated functions (9). These apps were mostly designed by means of providing resources that has potential to improve the outcomes and ease healthcare practitioners and students.

In clinical area, mHealth shows benefits in improving symptoms and peak flow variability in asthma patients and chronic pulmonary diseases symptoms; heart failure symptoms, management of chronic disease, reducing deaths and hospitalization and improving quality of life; glycemic control in diabetes patients; and improving BP in hypertensive patients (10).

Mobile apps and mobile learning (m-Learning)
Mobile devices, such as smartphones and tablets with wireless technologies play an important role in teaching and learning (11). They serve as virtual platform for learners to engage with learning activities in a more flexible and convenient way (12). The utilisation of these mobile devices in education for learning purposes is termed as mobile learning (m-Learning)(13). Mobile devices can be used as an effective learning tool due to the mobility and approachability of the devices which give opportunity for students to study and access learning material anytime and anywhere, easily and independently(13).

A survey done on nursing students reported that the usage of mobile apps has benefited them in term of better access of educational materials, improve their knowledge and confidence level, and reduced anxiety level during clinical training (14). Another study done on medical students in the United States found that the use of mobile apps could save their times, improve the care of their patients, and improve diagnostic accuracy (15).

Level of mobile apps utilisation among students
Even though there are abundant of smartphone ownerships among higher education students in these recent years, but the influence of learning through mobile operating system had not succeeded to power on in many universities (16). A study found that among two hundred nursing students who have reported owning a smartphone, only less than half of them used mobile learning apps (14). This means that even the university students nowadays were well-facilitated by such modern devices, the usage of mobile operating in learning initiatives is still quite low.

The level of utilisation of mobile applications among medical imaging students in International Islamic University of Malaysia is somewhat unsatisfactory (17). A survey found that instead of utilising the educational apps, students tend to extensively use mobile apps in their personal lives engaging with social networking sites, music and social media with (18). This indicates that the usage of mobile apps learning's potential is yet to be fully aware.

It was reported that there were 381 radiology-related apps in the Apple Apps Store, which fall under different categories including reference apps, learning and teaching apps, viewing apps, information systems apps and patient education apps (19). Despite the emergence of apps in the field, the knowledge about the usefulness of medical imaging apps especially among medical imaging students in Universiti Teknologi MARA (UiTM) is rather limited. So, this study is conducted to assess the utilisation of mobile applications in medical imaging among medical imaging students in UiTM Puncak Alam.

MATERIALS AND METHODS

Study design and population
This cross-sectional study was carried out among diploma and first-degree students of Medical Imaging in UiTM Puncak Alam. The study data were collected data during semester of March-July 2020.

Research Instrument
An adapted questionnaire (17) was used to serve as assessment tool, by using English language. It is divided into two parts. The first part aims to collect sociodemographic details of the respondents. It comprised of questions regarding respondents' gender, level of study, semester, experience in clinical practice and their Cumulative Grade Point Average (CGPA). The second part assess the level of utilisation of mobile applications (apps) in medical imaging among medical imaging students. It consists of six multiple-choices questions on apps usage among students, and three sets of 5-points Likert scale questions regarding students' opinions, perceptions and the benefits of medical imaging apps. Each of the likert rating scale was formulated with their own points (Strongly disagree – 1, Disagree – 2, Uncertain – 3, Agree – 4, Strongly agree – 5).

A pilot study was conducted among a small group of medical imaging students which were randomly selected (N=20) to check for the reliability of the questionnaire. This method helps to detect any potential problems with the design or layout of the questionnaire. The reliability of the questionnaire was evaluated using the Cronbach's alpha test. The Cronbach Alpha's was calculated as 0.7. The Cronbach's alpha significant value in between (0.71–0.91) indicated as a good measure of reliability or internal consistency of the questionnaire (4). Hence, it can be concluded that the questionnaire had an

acceptable internal consistency.

Sampling and data collection

The sample size was calculated using sample size calculator, Raosoft, Inc. It is an online software that consists of a database management system with good strength and reliability. It can be accessed from raosoft.com/samplesize.html. The sample of the study is based on the 95% confidence level and 5% accepted error. The response distribution applied was 50% and the recommended sample size for this study is 183.

The questionnaire was then distributed to full-time undergraduate medical imaging students (n=183) in UiTM Puncak Alam through online Google Form. The results obtained from Google Form were automatically recorded in the Excel spreadsheet and retrieved to Statistical Package for Social Sciences (SPSS) software for data analysis.

Statistical analysis

SPSS software version 21.0 was used to analyze the data obtained from the survey with statistical significant accepted at p-value less than 0.05. Descriptive analysis was used to describe the socio-demographic characteristics of the sample.

To evaluate the significant difference between sociodemographic details and the utilisation of mobile apps in diagnostic imaging among medical imaging students, Shapiro-Wilk test was used to check for the normality of data distribution. Assumptions of using independent t-test and ANOVA were met as the Shapiro-Wilk test results indicate that data are normally distributed in each group (p>0.05). Therefore, parametric test, which are independent t-test and one-way analysis of variance (ANOVA) were used.

RESULTS

Socio-demographic characteristics

Out of 183 participants, 14.8% (27) were male and 85.2% (156) were female. 63.9% (117) of the respondents were degree students and majority of the respondents (82%) had undergone internship in clinical practice. Most of the them (62.3%) were having CGPA in the range of 3.00 - 3.49.

Knowledge of medical apps among students

There was a slight different in the frequency of medical apps' knowledge among students (Table I). 50.3% (92) of the respondents did not know about medical imaging apps, while 49.7% (91) have knowledge about medical imaging apps. 19.8% of the students knew about the apps through their friends, 17.3% by searching the apps through website and 15.2% found the apps in the mobile apps store (Figure 1). 12.7% of them also found the apps through social media such as Facebook, Instagram, and Twitter. Meanwhile, the least source known was by the mass media such as the television, radio, and newspaper (3.6%).
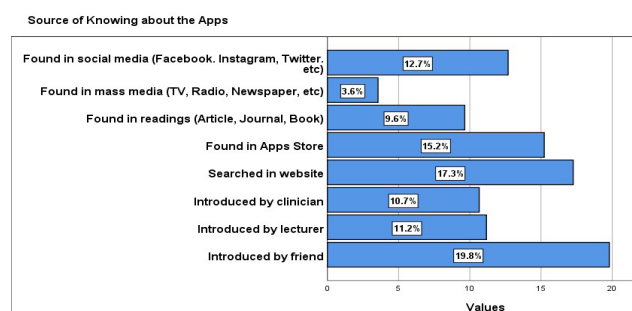

Source of Knowing about the Apps

Fig. 1: Source of knowledge regarding medical imaging apps

Table I: Knowledge of medical imaging apps and apps usage among students

Demographic details	Descriptions	Count (N= 183)	Knowledge of medical imaging apps		Apps usage among students	
			Yes (n=91)	No (n=92)	Yes (n=81)	No (n=102)
Gender	Male	27 (14.8%)	10 (5.5%)	17 (9.3%)	10 (5.5%)	17 (9.3%)
	Female	156 (85.2%)	81 (44.3%)	75 (41.0%)	71 (38.8%)	85 (46.4%)
Level of study	Diploma	66 (36.1%)	27 (14.8%)	39 (21.3%)	23 (12.6%)	43 (23.5%)
	Degree	117 (63.9%)	64 (35.0%)	53 (29.0%)	58 (31.7%)	59 (32.2%)
Experience in clinical	Yes	150 (82.0%)	85 (46.4%)	65 (35.5%)	75 (41.0%)	75 (41.0%)
	No	33 (18.0%)	6 (3.3%)	27 (14.8%)	6 (3.3%)	27 (14.8%)
Year of study	1st year	24 (13.1%)	8 (4.4%)	16 (8.7%)	7 (3.8%)	17 (9.3%)
	2nd year	44 (24.0%)	18 (9.8%)	26 (14.2%)	16 (8.7%)	28 (15.3%)
	3rd year	62 (33.9%)	28 (15.3%)	34 (18.6%)	25 (13.7%)	37 (20.2%)
	4th year	53 (29.0%)	37 (20.2%)	16 (8.7%)	33 (18.0%)	20 (10.9%)
Cumulative Grade Average Point (CGPA)	Below 2.0	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	2.0 – 2.49	2 (1.1%)	1 (0.5%)	1 (0.5%)	0 (0%)	2 (1.1%)
	2.5 – 2.99	26 (14.2%)	10 (5.5%)	16 (8.7%)	10 (5.5%)	16 (8.7%)
	3.0 – 3.49	114 (62.3%)	55 (30.1%)	59 (32.2%)	49 (26.8%)	65 (35.5%)
	3.5 – 4.00	41 (22.4%)	25 (13.7%)	16 (8.7%)	22 (12.0%)	19 (10.4%)

Apps usage among students

Among those who knew about the apps, only 81(44.3%) of students used medical imaging apps (Table I). It is indicated that more than half of the students (55.7%) had not used medical imaging apps before this, though some of them might have known about the apps' existence. The frequency of apps usage is significantly higher in

degree students (mean (M) =0.51) than diploma students (M=0.32); with p-value (p) = 0.011. The standard deviation (SD) were 0.469 and 0.502 respectively.

Those with clinical experience is significantly higher in apps usage (M=0.49, SD=0.502) compared to those with no clinical experience (M=0.21, SD=0.415); with p < 0.001. There is no significant difference between frequency of apps usage between male and female (p=0.416), and also between CGPA (p=0.125).

Figure 2 shows the apps that had been used or encountered by the students. Radiographic Positioning & Related Anatomy apps was spotted to be used by majority of the students (18.4%). This followed by
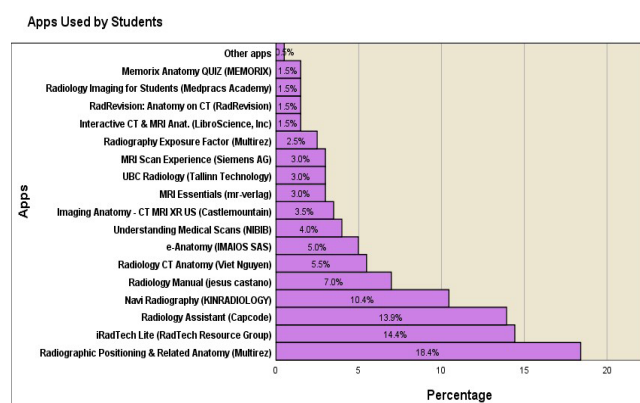

Fig. 2: Details about the apps used by the students

iRadtech Lite (14.4%), Radiology Assistant (13.9%), and Navi Radiography (10.4%). The least used apps by the students were Interactive CT & MRI Anatomy, RadRevision, Radiology Imaging for Students, and Memorix Anatomy with each of them having 1.5% of usage only.

Table II: Frequency and purpose of usage

Times of apps usage	Frequency	Percentage
Once a week	1	1.2%
Twice a week	2	2.5%
More than twice a week	4	4.9%
Once a month	1	1.2%
Only when needed	73	90.1%
Purposes of using apps		
To revise knowledge	60	28.8%
To prepare for presentations	32	15.4%
To search for information	61	29.3%
To guide in clinical practice	55	26.4%

It is shown that majority of students use the apps only when needed (90.1%) (Table II). Only 1.2% of them used the apps once week. Meanwhile for the usage purposes, majority of them use the apps to search for information (29.3%) and revise knowledge (28.8%). 26.4% of them also used the apps as a guidance in clinical practice. Only 15.4% of them utilised the apps for presentation preparation.

Mean score for students' opinions, students' perception and benefit on medical imaging apps usability.

It is found that the students were quite uncertain about the medical imaging apps' usability (Table III). There is no significant difference in the score for students' opinion on medical imaging apps usability with gender, level of study and clinical experience (p>0.05).

The mean score for students' perception towards medical

Table III: Mean score for opinions on apps usability, perception and benefits of medical imaging apps

Opinions on apps usability	Mean score
I found the app is unnecessarily complex.	3.10
I think that I would need the support of a technical person to be able to use the app.	3.14
I thought there was too much inconsistency in the app.	3.03
I found the app is very difficult to use.	2.86
I needed to learn a lot of things before I could get going with the app.	3.34

Perceptions about medical imaging apps	Mean score
Medical imaging apps are important tools for medical imaging studies.	3.89
The content of medical imaging apps is simpler and more concise than medical imaging books.	3.75
The use of medical imaging apps can complement medical imaging books.	3.81
Medical imaging students should use medical imaging apps on their mobile devices.	3.85
The use of medical imaging apps can improve the healthcare delivery in clinical settings.	3.85
The use of medical imaging apps can improve in the aspect of patient care.	3.81
The interface of medical imaging apps makes the delivery of contents effective.	3.82

Benefits of medical imaging apps	Mean score
Information is easy to access anywhere/anytime.	4.11
Reduce time to look for information.	4.04
Accurate and updated information.	3.69
The use of information in the apps helps to reduce errors during clinical. (e.g.: procedural error, imaging parameter error etc.)	3.83
Provide concise information.	3.83
Ease of learning and understanding of information	3.93
Helps in improving academic performance.	3.91

imaging apps is quite positive (Table III). Though not many students had used the medical imaging apps, many of them still thought that the apps are important tools for medical imaging studies. There is no significant difference in the score for students' perception towards medical imaging apps with gender, level of study and clinical experience (p>0.05).

Most of the students agreed on the benefits that medical imaging apps could offer (Table III). They agreed that medical imaging apps could provide easy access at any times and could save time in searching for the information they needed. It is reported that only benefits mean score has significance difference with the socio-demographic details which are level of study and clinical experienced. Benefits mean score for first degree students is statistically higher (M=3.98, SD=0.5318) than diploma students (M=3.77, SD=0.5703). There is also a significant difference (p=0.03) in benefits mean score for clinical experienced students (M=3.96, SD=0.4837) and non-clinical experienced students (M=3.65, SD=0.7560).

Limitation faced by students
Figure 3 shows that 26.1% of students faced slow Wi-Fi or internet connection as the limitation to use medical imaging apps. This is followed by having small size of screen (20.6%), slow loading time (19.0%) and expensive costs of apps (9.4%). Poor user interface was identified as the least percentage for limitation to use medical imaging apps by the students (6.9%).
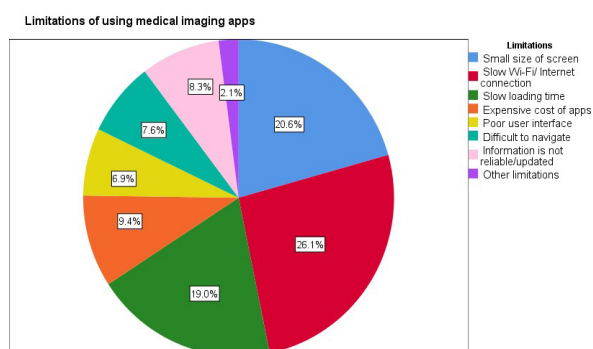

Fig. 3: Limitations faced by students

DISCUSSION

Level of utilisation of mobile applications in diagnostic imaging
Based on the survey done in this study, it is found that more than half of Medical Imaging students in UiTM Puncak Alam did not know about the existence of medical imaging apps across the world of mobile apps technology. This finding agrees with a study conducted among students in International Islamic University of Malaysia (IIUM) which reported that only two-third of them were aware about the existence of medical

imaging apps (17). This is possible because most of the students still favoured physical books or notes to any technology-based learning (20). It could be that due to this normality, the students were less exposed to the vast technology in mobile learning. In addition, there is still low awareness among university staff on the implementations of mobile learning (21). The exposure from university staff or educators also plays important role in introducing to the students about the usage of mobile learning apps. This is because students gain their knowledge primarily from their teachers as they always experienced two-ways communication in the lecture hall or classes.

Most of the students aware about the apps after introduced by their friends (19.8%). It can be signified that the awareness about the apps existence is primarily relied on peers' influence or social interactions among friends. The influences from other individuals such as lecturers, clinician and others should be more persuaded so that the existence of medical apps can be recognised and accepted.

Awareness about medical imaging apps among students revealed lesser acceptance concerning the usage of the medical imaging apps. Among 91 students who knew about the apps, 81 of them really utilised the apps for education purposes. It is shown that more than half of the students had not used the medical imaging apps before this. This coincides with a finding of a study which identify that majority of health applications on smartphones are still underutilized (22). Considering that almost all university students have accessed to the mobile devices, it is appropriate if the usability of mobile learning apps can be reinforced into the learning venture.

However, through the open-ended question to those who did not use the medical imaging app, most of the respondents said that they did not actually exposed to the presence of the medical imaging apps. Few of them also preferred referring to their physical books and notes when studying or revising. This is aligned with the research done by Millar & Schrier who stated that the students in the West Coast University in USA prefer printed textbooks compared to the electronic ones (20). People simply like books more as they are familiarised with the old school habit of studying and reluctant to change the habit (23). It may be because they were afraid of missing any important points about the topic they are studying. Moreover, they were eventually able to understand information better in printed form for texts that were more than one-page long (24). This incident might be due to the disruptive effect that scrolling the small screen could possibly cause.

Apps used, frequency, purposes of usage
Being asked about the apps that had been used by the students before this, Radiographic Positioning and Related Anatomy by Multirez won the vote. This app is free accessed and installed by more than 10,000 people on the Google Play store. It offers many topics regarding

radiography from the basic principles to specialised procedures such as dental and mammography. The students possibly chose this app because printed textbooks might have elaborated the information of positioning and procedure in a very long and difficult terms. Therefore, this app developed a more simplified way of explanation about the topics and provide better comprehension. This is very beneficial to those that need a quick review or having not much time to retrieve information.

Unfortunately, pertaining to the frequency of the app's usage, majority of the students only used the medical imaging apps when needed. This result agrees with another study conducted regarding the e-textbooks usage which reported that 47% of the students in the university setting had only used them in the past twelve months (20). This could be due to unfamiliarity of the students with the features of medical imaging mobile apps. Since majority of the students did not have knowledge about the apps, thus they didn't know the benefits that the apps could provide and how to utilise it optimally.

For the purposes of using the apps, most students voted to search for information and revise for knowledge. Many of them also chose the apps to guide them in the clinical practice. This study agrees with another study who also received a positive feedback from the nursing students regarding to the usage of apps during their clinical training (14). This eventually proves that the medical imaging could also assist the student during their internship as they do not have many chances to revise their physical textbooks due to their practical learning.

Students' opinions, students' perception and benefit on medical imaging apps usability

It is found that the students were quite uncertain about the medical imaging apps' usability. A possible factor explaining the uncertainty of usability could be that students do not have enough exposure and experience using the apps. This is supported by a study conducted in Universiti Sains Malaysia (USM) which explained that moderate usability among the respondents was due to limited experience of using educational mobile apps and also unfamiliarity with the app (25). Consequently, students will get higher score in usability level if they use the learning system more often (26) .

The mean score for students' perception towards medical imaging apps is quite positive. Though not many students had used the medical imaging apps, many of them still thought that the apps are important tools for medical imaging studies. Most of the students agreed on the benefits that medical imaging apps could offer. This positive attitude might be due to the fact that they are the generation that born and grown up using the technology of mobile devices (27). They agreed that medical imaging apps could provide easy access at any times and could save time in searching for the information they needed, since speed and accessibility are the main concern of younger generation (28). Thus,

they believed that the use of mobile apps might help them in their studies well.

The significant difference of apps usage among students

The level of study and clinical experience show significant difference in the app's usage. Degree students tend to use medical imaging apps more compared to diploma students. This outcome is aligned with another research who found that higher education students showed a high level of interest in having the opportunities to learn more through mobile apps (29). This could possibly happen due to their more detailed syllabus needing them to review so many topics at one time regarding medical imaging subjects. Most of the student in first-degree level had also experienced clinical practice hence they appreciate the presence of medical imaging apps more during their clinical times.

For CGPA, there was no significant difference noted in the utilisation of medical imaging apps. It is expected that more students with better CGPA will have higher level of apps usage for educational purposes. But in this study, it is found that the usage of apps was relatively the same among the students even with different CGPAs. It could be that the students have their personal preferences in learning alternatives regardless their performances. This result contradicted with another study conducted who found out that the students who utilised mobile apps learning has better academic performance (30).

In contrast, there is a study which discovered that the more students used their mobile devices for learning activities, the lower their CGPA (31). It is possible because when students utilised mobile phones in learning process, the information is normally transmitted one-way as there is no direct teaching engaged. Therefore, it is recommended that a teacher or instructor is involved to facilitate the apps usage to prevent students from being distracted or confused during the learning process. Depending on the apps itself could be troublesome as the apps function sometime might do not work properly. Wi-Fi network might go down or the user interface might encounter some glitch, so it is possible that the students will be left at loss if the technology of the apps does not work.

It is reported that only benefits mean score has significance difference with the level of study and clinical experienced. First-degree and clinical experienced students tend to agree more on the benefits of medical imaging apps usability compared to the diploma and non-clinical experienced students. Those who are in their diploma and still had not experience clinical training might have not been exposed to the importance of mobile learning due to the lack experience, hence they convey less interest. Majority of students trusted that mobile learning apps were essential tools for the undergraduate's studies (32). They also stated that the apps could offer simpler, faster, and reliable sources for clinical guidelines, knowledge, and skill. From here, it can be shown that the mobile learning apps have potential in assisting students in their studies as well as

their clinical trainings.

Limitation faced by students regarding mobile apps

When it comes to the limitation faced by the students regarding the apps, majority of them highlighted the problem of having slow Wi-Fi connections. This is followed by having the small size screen as the limitation for not choosing to use apps or as problems when using it. It could be that their eyes got tired easily by looking at small screen for a long time and prefer deeper comprehension through textbooks (23).

Another study conducted on mobile learning limitations confirmed that the problems in apps usage were primarily caused by the device and network characteristics (33). They also emphasized that the students and instructors or lecturers were not ready yet with the adaptation of new technologies. Some also might have trust issues regarding to the apps content in term of its trustworthiness. This shows that in-depth strategic planning for education with mobile apps collaboration needs to be established. The app developers might also play their roles in investigating students' concerns, needs, and preferences to improve the applicability of mobile apps in education or tutoring.

STRENGTH AND LIMITATIONS OF THE STUDY

The strength of this study is that it involved a large number of students (183) as compared to the similar previous study conducted in IIUM (17) which only used 38 respondents. Furthermore, the respondents of this study were from different level of study which are diploma and first degree.

The limitations faced during conducting the study is that the questionnaire was distributed as per online form due to the coronavirus outbreak. So, any problems faced by the respondents could not be consulted directly but only through social platform. This study also did not involve part-time or extended students, so the data is only applicable to the full-time students. The part-time students might indicate different outcomes as they faced different environment and situation.

CONCLUSIONS

In conclusion, the level of utilisation and appreciation of mobile applications in medical imaging among medical imaging students in UiTM Puncak Alam is low. First degree students and those with experience in clinical practice utilize and appreciate mobile applications in diagnostic imaging well. It is recommended in the future to include flexible learning mode students and also students from other universities for more reliable findings.

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