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The Pilot Implementation using an Adapted Technology Acceptance Model to Evaluate an Innovative Use of Smartphone for Scientific Investigation Programme in Tertiary Education

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Abstract: This study reports research on the pilot implementation of a new educational programme integrating smartphone technology with scientific investigation through an innovative method of mobile technologies enhanced learning. Smartphone technology has the potential to serve as an excellent tool for students to conduct scientific investigation and learn scientific concepts. A newly-developed educational programme was first pilot and carried out by 37 pre-service science teachers in an education university. Evaluation employed a quantitative method with additional qualitative data determined using a adapted Technology Acceptance Model (TAM) questionnaire survey and open-ended questions to collect data on students' perceptions and implementation issues. The survey findings showed that student teachers agreed with the suitability of educational values with the use of smartphones for performing science investigation. Negative comments and suggestions for refinement were also identified. Thus, we have refined our programme for further applications in secondary schools.

Keywords: smartphone technology; scientific investigation; mobile technologies enhanced learning

1. Introduction

The educational system in the 21st century focuses on the 4Cs, namely critical thinking, creativity, communication and collaboration. Educators need to produce students and pre-service teachers able to think critically and creatively, and with the ability to communicate and collaborate using modern technology. Communication and collaboration can be implemented easily and effectively via technology. Recently, study through mobile learning has become a contemporary research topic which "can offer new opportunities for learning that extend within and beyond the traditional teacher-led classroom" (Sharples, Arnedillo–Sánchez, Milrad, & Vavoula, 2009, p. 233). Moreover, Chan et al. (2006) suggested that seamless learning with mobile devices may enable learning experiences in a number of various learning environments. Therefore, the implementation of mobile learning or to be specific smartphones in the teaching and learning offers a lot of benefits to both the teachers and students. Mobile learning utilizes the learner's spare time from any place at any time (Motiwalla, 2007), and conduct scientific experiments (Vogt & Kuhn, 2012). However, the use of smartphones also leads to certain challenges such as problems with connectivity, battery life, and network issues. All the challenges need to be overcome for a media-enhanced learning environment that can engage students in the learning process. In this study, smartphone technology can be feasibly used as a handy tool to carry out certain scientific investigations. Thus, this study aims to present research findings on educational values and the acceptance of science learning among student teachers after a scientific investigation of the innovative use of smartphone devices.

2. Problem Statements

Recently, numerous findings on mobile technology research and development have revealed that these technologies play a crucial role in science and technology (Sharples et al., 2009; Hwang, Tsai, Chu, Kinshuk, & Chen, 2012). However, most published papers focus on technical issues of development and lack innovative application and evaluation of students' motivation in science learning as well as acceptance of smartphone-based science learning. Thus, little evidence has been found to verify whether this technology can be applied or used to facilitate and assist student's acceptance in science learning. As a result, smartphone devices are important for experiential and real-time interactive science learning environments in which students can perform, observe, respond and share selected experiments (Hwang, et al., 2012; Tho, Lee, & Baharom, 2018). Such a hands-on learning environment via mobile technology enables science students to easily perform real-time experiments almost anytime and anywhere. It will also overcome students' boredom by the conventional or "Cookbook" experiment with manual data collection and graph plotting. As a result, this innovative learning environment can be applied to overcome problems related to limited class time, "Cookbook" experiment and accessibility.

3. Research Questions

- What are the perceptions of the student teachers in terms of the adapted Technology Acceptance Model (TAM) for this educational programme?
- What are the views and major problems encountered of the student teachers about performing scientific investigation through the innovative use of smartphones?
- How can student teachers' opinions be used to improve this educational programme for performing scientific investigation through the innovative use of smartphones?

4. Research Methodology

4.1 Research Design

Quantitative method with qualitative data with two research designs: design and development and also survey design had been used in this study. In other words, this study consists of both development and evaluation of an educational programme. For development, the student worksheets and teacher guide manual were designed and prepared by the researchers using Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model as well as funds acquired through the university research grant. Concerning the scientific investigation, the strengths of the experimental operations include the smartphone itself with the help of free applications (apps) software such as Physics Toolbox Suite apps (created by Vieyra Software, 2016) which can be easily downloaded from the Google Play Store. As a consequence, a test-run of the two programmes was conducted, with consecutive refinement of the learning materials and activities.

4.2 Sample

Two groups of semester 5 student teachers taking science education programme at a faculty of an education university were selected using single-stage cluster sampling. A total of 37 student teachers were involved and surveyed in this study where 21 respondents from Programme 1, and 16 respondents from Programme 2. They were asked to participate in the evaluation process of this educational programme as the student teachers' views and suggestions were highly important, because they studied various science education, technology, and teacher training courses. Furthermore, this study gave them the opportunity to practice the innovative use of Smartphone for scientific investigation, and this idea could be applied in their future teaching and learning at school. To comply with the educational research code, student teachers were required to complete and sign a consent form for voluntary participation in this research.

4.3 Instrument

A research instrument was adapted, and used, namely post-survey questionnaire with open-ended questions was adapted and modified from Technology Acceptance Model (TAM) (Davis, 1989; Teo, Wong, & Chai, 2008; Tho & Yeung, 2016). Adapted TAM is used to seek a concern about how a user accepts and uses a certain technology (Davis, 1989; Teo, Wong, & Chai, 2008). In fact, both perceived usefulness and perceived ease of use are expected to lead to positive attitudes and intentions to accept and practice on particular information technology (Davis, 1989).The questionnaire instrument included survey items on four categories of adapted TAM including perceived usefulness (four items); perceived ease of use (four items); behavioural intention (two items); and attitudes (four items) which were based on a Likert scale from 1-strongly disagree to 4-strongly agree. Open-ended questions were used to collect student teachers' learning experiences (Tho & Yeung, 2016). To ensure content validity and reliability, the questionnaire and open-ended questions were reviewed and criticized by a panel of research experts who examined the content and language used.

4.4 The Flow of Educational Programme and Data Collection

In this educational programme, an innovative way to apply the smartphone through technology-enhanced learning in science education had been developed using ADDIE model. The related scientific investigation via smartphone devices can be performed primarily depends on the smartphone built-in sensors with the help of free application software. There are three different stages in this programme as highlighted in Figure 1 a), namely the briefing, designing and performing simple science investigation and presentation. Figure 1 b) briefly outlines the science activities with the help of smartphone device in the elevator by facilitator and student teacher. After sharing and consolidation, the related post-survey was administered. Then, we refined the design and development of the research based on the results obtained.

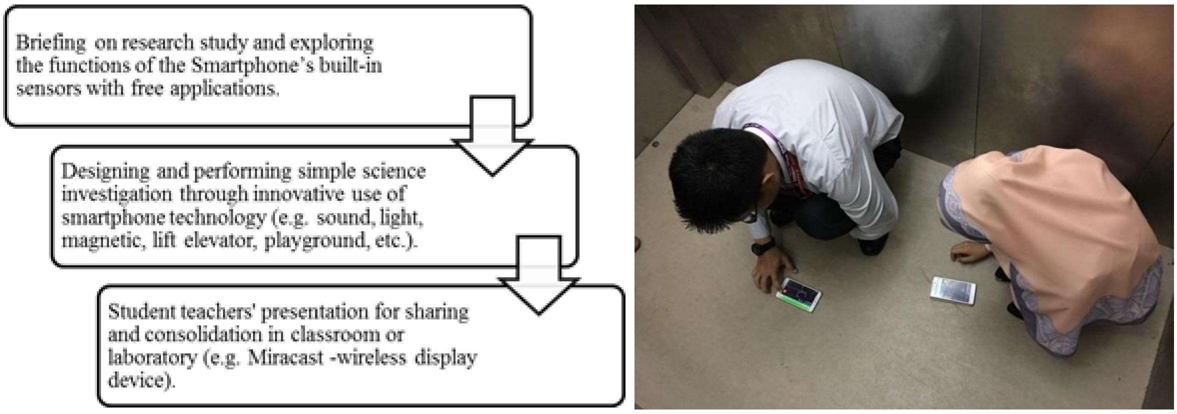

Figure 1. a) Schematic Diagram of Programme; b) Determine the Apparent Weight in a Lift Elevator

4.5 Data Analysis

For quantitative data analysis, the data from the survey was input into the statistical analysis software. Then, the mean scores and standard deviation were calculated. Furthermore, the independent samples t test was used to analysis the survey data. The independent samples t test was applied to examine the differences between two groups of programme. The significant difference was accepted or rejected in any category at the .05 significance level.

For qualitative data analysis, the open-ended data was input for coding into the Qualitative Data Analysis (QDA) Miner Lite free software, and themes according to open-ended questions comprising advantages and disadvantages (First part), knowledge learning, problems encountered, improvement suggestions and topic recommendations (Second part).

5. Findings and Discussion

5.1 Educational Programme Through Innovative Use of Smartphone

For the designing simple scientific investigation in the second part of the educational programme, several meaningful indoor or outdoor science activities had been designed by student teachers under the supervision of facilitators. Several examples of science activities included investigate the relationship between light intensity and distance (indoor); investigate the relationship between magnetic field strength and distance (indoor); investigate the apparent weight in the elevator (outdoor); determine the velocity of sound in air (indoor); Sound pollution (outdoor).

5.2 Survey and Open-ended Data

For the four categories on perceived usefulness, perceived ease of use, behavioural intention and attitudes according to the educational programme, the mean scores (Likert scale 1-strongly disagree to 4-strongly agree) range between 3.14 to 3.54, and the mean score for each category was above the scale of 3 for agreeing with the survey items. The Cronbach's alpha reliability coefficient of the survey was 0.75. Table 1 shows the mean scores obtained from the student teachers' survey and it was acceptable to adopt the classical test theory for the present data analysis. In Table 1, the student teachers from Programme 1 constantly rated higher in the survey items compared to student teacher from Programme 2, except for the behavioural intention category. However, there were no significant differences found by the independent samples t test between these two programmes. Overall, the findings have revealed that student teachers agreed with the educational values inspiring this educational programme through innovative use of Smartphone. In addition, the lowest overall mean score given by student teachers is perceived ease of use category. It was anticipated that the student teachers need more guidance and time to familiarise themselves with this educational programme, as the technique is new to them.

Table 1

Mean scores (with SD in Brackets) of Student Teachers' Response on Survey Items and N is the Number of Participants

Category	Programme 1 (N=21)	Programme 2 (N=16)	Overall (N=37)
Perceived Usefulness	3.53 (.35)	3.47 (.54)	3.51 (.43)
Perceived Ease of Use	3.21 (.39)	3.14 (.55)	3.18 (.46)
Behavioural Intention	3.29 (.51)	3.44 (.63)	3.35 (.56)
Attitudes	3.54 (.32)	3.52 (.51)	3.53 (.41)

In the first part of the open-ended questions, the data collected from student teachers were analysed for positive and negative themes as shown in Table 2. In general, those qualitative data are consistent with the findings obtained by previous researchers who indicated some advantages and disadvantages of using smartphone for educational research and developmental work. Hence, this educational program involving the innovative use of smartphone has the potential to improve their practical skill, with the intention of preparing student teachers to apply this approach in their future career in education. The second part of the open-ended questions is the student teachers feedbacks on their opinions on studying the educational programme were collected in Table 3. Student teachers found these are interesting, saving time and providing accurate results. They were able to perform the scientific investigation anyplace. These responses were consistent with the survey results and the first part of the open-ended questions.

Table 2

Two Open-ended Questions to Assess Student Teachers' Opinions Concerning Advantages and Disadvantages in General on Using Smartphone to Perform Science Investigation (N=37)

Open-ended Question	Insightful Comments*
Advantages	Easy to conduct scientific investigation (14); Performing scientific investigation at anywhere (11); Interesting (8); Saves time (8); Performing scientific investigation anytime (7); Low cost (7); Provides accurate result (4); Use apps without Internet connection (4); Able to create more experiments (3); Able to gain knowledge (3)
Disadvantages	Smartphone with limited built-in sensors (20); Less guiding notes (9); Battery may drain too fast (6); Expensive to buy smartphone with more sensors (5); Require Internet to download apps (5); Hanging/lagging problem (3); Too depending to smartphone (3); Disruption by other apps (2); Incompatible apps (2); Tend to do other thing like surfing Internet, Facebook, etc. (1)

* The comments sorted from most common to least common (with frequencies given in brackets).

The findings indicated most of the student teachers did not experience difficulties. But, they still faced disruption from limited built-in sensors, noise disruption for sound experiment, lack of understanding of raw data and insufficient guiding notes. Therefore, they suggested that participants obtain enough guidance from the facilitators in future implementations. Furthermore, some negative points were unavoidable such as lagging and battery problem. Two insightful suggestions were collected: purchasing more built-in sensors smartphone and creating more interesting activities related to physics topics. Thus these data are consistent with the research and development in physics topic obtained by earlier researchers, such as Tho et al, (2018); Vogt and Kuhn (2012).

Thus, it is noted that a number of negative comments and suggestions were also listed for educational programme refinement. Those negative points of the programme are inevitable nevertheless it can be improved or resolved with suitable refinement in the design and development of the educational programme. Generally, comments from the open-ended questions were consistent with the first part of the open-ended questions and survey results. Hence, the student teachers acknowledged and accepted the values of the educational programme through the innovative use of smartphones.

Table 3

Four Open-ended Questions in The Second Part to Assess Student Teachers Opinions Concerning the Educational Programme (N=37)

Open-ended Question	Particular Perceptive Comments*
What have you learned from the scientific investigation through the use of Smartphone?	Learn to use smartphone for scientific investigation (15); Easy to conduct scientific investigation (15); Fun and interesting (9); Saves time (3); Provides accurate results (3); Performing scientific investigation anywhere (1)
Have you encountered any problems concerning the programme while doing the scientific investigation? If so, briefly describe the problem(s).	No problem encountered (14); smartphone with limited built-in sensors (9); Disruption by the surrounding environment (4); Problem with data analysis (4); Less guiding notes (3); Hanging/lagging problem (3); Battery may drain too fast (1); More apps need to be installed (1); Can't perform all kind of experiments (1)
If you were given another chance to do the scientific investigation again, please suggest some ways for improvement?	Give more guide of scientific investigation (14); Purchase a smartphone with more sensors (6); Create more interesting activities and experiments (5); Update android version and apps (4); Provide high speed Internet (3); Reduce disruption by surrounding environment (2); Smartphones need to be fully charged (1)
Please suggest a feasible science topic or activity that is possible to apply the scientific investigation through the use of Smartphone.	Related to force and motion including velocity, acceleration, free fall, momentum (11); Related to sound and wave experiment (10); Light experiment (7); Magnetic experiment (6); Rotational motion (1); Thermodynamic experiment (1); Measuring height using barometer sensor (1)

* The comments are sorted from most common to least common (with frequencies given in brackets).

6. Educational Implications, Refinement, Conclusion and Future Work

The findings of this study illustrated that the new educational programme through innovative use of smartphone has a significant potential for application of outdoor or indoor science practices in the university level as a complement to scientific investigation. The significance requirements for applying mobile technologies into education are widely discussed and supported by previous research studies (Motiwalla, 2007; Sun, Looi, Wu, & Xie, 2015). Based on the analysis, there are three key implications of this study for the future development and school-based implementation of this new educational programme. First, the refined educational programme could be used for empowering and supplementing science teaching and learning practices beyond the limitations of normal lectures in university. Second, open-ended data revealed that specific consideration need to be given to the educational programme training and guidance particularly using smartphone for collecting experimental data (Kirschner, Sweller, & Clark, 2006; Tho & Yeung, 2016). This is likely caused by implementing of new programme which is different from their normal learning process and therefore a more comprehensive guide in procedures need to be established before implementing this to secondary classroom. Lastly, the refined programme was successfully integrated to the secondary science education including several feasible topics in science subjects. To date, there have been rather limited indoor and outdoor science investigations for secondary level particularly in Malaysia. Thus, student teachers can apply this approach in their future teaching career in schools.

Based on the analysis of survey and open-ended data collected, we refined the programme by 1) preparing several reasonable price of China smartphone products with more built-in sensors during future implementation; 2) preparing high volume of power bank for charging smartphone devices; 3) preparing and giving clearer educational programme operating guidelines in the form of manual and video clip; 4) modifying present programmes and creating more exemplars for each built-in sensor; 5) integrating with the secondary science or physics syllabus with the aim that the student teachers can apply this programme in their future learning and teaching in schools. In conclusion, the findings of this study illustrated that the new educational programme through innovative use of smartphone has a significant potential for application of outdoor or indoor science practices in the tertiary level.

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