DESIGNING A SCIENCE MOBILE LEARNING SCENARIO THAT IMPLEMENTS INQUIRY-BASED LEARNING TO ACHIEVE BETTER INQUIRY SKILL

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Abstract

Learning science demands an authentic learning experience with direct experiential learning. Science lesson at school, particularly physics, is expected to create learning activity that could facilitate students' experience and construction of science understandings through inquiry-based learning. Mobile technology could facilitate learning across context and promote students' inquiry skills. For that reason, there is a necessity to design a novel science instructional strategies which could promote inquiry skills through mobile learning. This study focuses on designing an effective science mobile learning scenario to promote learners' inquiry skills and asking science teachers their views as informant about the implementation of that learning scenario. This research takes a Design-based research approach to design learning scenario which implements inquiry-based learning and integrates a mobile technology (*Arduino Science Journal App*). The learning scenario employs inquiry-based learning and situated learning activity where students are given the opportunity to do a real-time data collection method. Results indicate a common belief of science teachers that inquiry phases were represented in the learning scenario and mobile learning is clearly support the idea of how physics characteristic match well with *Arduino Science Journal App*. Accordingly, to better the design in future work, several recommendations were suggested which mainly focus on pedagogical factors, including (i) comprehensive classroom management; (ii) revisit the previous lesson; (iii) the need to include experiment and; (iv) additional deeper learning for a more meaningful physics lesson.

Keywords: inquiry skills; science mobile learning; learning scenario

1 INTRODUCTION

Learning Science has distinctive characteristics that distinguish from other subjects. Science itself is the result of theory and human inquiry through experimentation. Science curricula policy in some countries agreed on the notion that inquiry is a major theme in science education (Abd-El-Khalick et al., 2004). For instance, National Science Education Standard (NSES) in the USA released standards in science education that outlines that inquiry is vital to science learning and as students are actively involved in developing their understanding by integrating scientific knowledge using their critical and logical thinking (National Research Council, 1996). These standards comprise what students need to do and understand to be scientifically literate at different grade levels. In conjunction with this standard, another country like Indonesia, in the latest middle school curriculum in 2013 also emphasis the curriculum on inquiry-based learning with scientific learning approach (Indonesian Ministry of Education and Culture, 2018). This curriculum mainly focuses on developing knowledge-based on authentic learning experience with direct experiential learning. These two examples imply that Inquiry skills are important as they could shape students thinking into creating and innovating scientific knowledge.

Accordingly, learning science at school is expected to create learning activity that could facilitate students' experience and construction of science understandings and inquiry skills through inquiry-based learning. However, implementing inquiry-based learning present challenges to both educators and learners. The challenges comprise of how to structure science teaching so, it accommodates the goals of understanding scientific inquiry, enhances the learning of science concept and emphasis on the learner's mental activity to make a connection to current scientific knowledge. Learning science requires observations and experiential learning about the way the world works (Bybee, 2007).

Reiser et al., (2001) argue that to overcome those challenges in which students will be able to experience learning and bridging new concepts and the knowledge they already have requires a strategy to expand the learning opportunities for students using new technologies. Previous approaches that have been done so far are the development of some new technological supports for inquiry-based learning, such as thinker tools to accommodate science accessible to all students, BGuILE for guided inquiry, and nQuire for personal inquiry learning, (Mulholland et al., 2012; Reiser et al., 2001; White & Frederiksen, 1998). Those tools are aligned with the capability of providing scaffolding to support scientific practice and can be inherent in science classroom practices. Such tools embedded Technology Enhanced Learning in Science (TELS) and able to provide a platform where rich investigation can occur, allowing both access to data and strong analytical tools (Kali, Linn, & Roseman, 2008; Reiser et al., 2001). However, those TELS provide computer and web-based technology only and somehow show limitation to allow context for learning to be expanded beyond the traditional classroom. Consequently, new technology is expected to overcome this constraint.

Mobile learning is a promising new technology which enables some affordances that other technologies might not offer. Moreover, as this new kind of technology emerged, there is an opportunity to have learning science conveniently with mobile technology. Because of its ubiquity, mobile learning could facilitate learning beyond the classroom context and benefit students' inquiry skills so they could then be able to apply knowledge in real-life context throughout their lives. Some studies have been conducted in emerging mobile technology applications in science education. For instance, Miller & Doering (2014) report an investigation involving outdoor mobile application, namely Project Noah, which aims to collect large-scale, ecological data through users encounters with nature. Joiner et al., (2004) offer fascinating insights into the extent that Savannah as mobile gaming, might be employed to create a compelling and engaging learning experience. Another discipline such as in social science, Shih, Chuang, & Hwang, (2010) apply mobile learning via PDA (Personal Data Assistant) that employs inquiry-based learning strategies to facilitate students' field learning.

Those mobile learning apps may fit for other purposes of science education curricula, as for inquiry-based learning, it requires different instructional strategies (Shih et al., 2010). Accordingly, the need to design novel instructional strategies which could promote inquiry skills through mobile learning are eventually become more evident. This study focuses on designing an innovative science mobile learning scenario to promote learners' inquiry skills. The learning scenario employs inquiry-based learning and situated learning activity where students do a meaning-making activity to construct their understanding.

Regarding specific content where the design will be implemented, according to research by (Basson, 2002) students mostly experience difficulties with physics not only due to the complexities of the subject but also due to incapability with their skills and knowledge of mathematics. Moreover, most of these students did not learn physics properly secondary level. Science curricula currently are based on a notion of 'structure of science' and its 'mode of inquiry' (National Research Council, 1996). To accommodate the aforementioned issue, the topic of acceleration from physics will be used to implement the design of the learning scenario.

Inquiry-based learning

Inquiry-based learning is a learning strategy in which students follow some methods as scientists to construct knowledge (D. Kuhn et al., 2017). This strategy emphasises in active participation for a learner to discover knowledge on their own responsibility (De Jong & Van Joolingen, 1998) and many quantitative studies have proven the effectiveness of inquiry teaching as an instructional approach (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). In terms of inquiry phases, Pedaste et al. (2015) analysed in the identification of five general inquiry phases and synthesised framework to describe inquiry cycle in which inquiry phases and sub-phases would be present. The five general inquiry phases include orientation, conceptualisation, investigation, conclusion and discussion and reflection.

Other inquiry phases with a different approach are presented in Mulholland et al. (2012) in which inquiry phases encompass practical eight phases. They developed *nQuire*, a web-based software to support personal inquiry and use the term 'script' as a dynamic lesson plan that guides how students should interact collaboratively in following an inquiry. This research emphasis on personal inquiry to assist students see science as personally meaningful and relevant to their daily lives. The important part of personal inquiry is taking *ownership* of the inquiry process (Anastopoulou et al., 2012) and encompass familiar contexts such as the home, local neighbourhood and school. Each inquiry is about “myself”, “my environment” or “my community”, thus the motivation for this focus is to develop inquiries where students engage in investigating their bodies and local surroundings (Sharples et al., 2015a). This argument is also supported by National Research Council (2000) that reports the importance of students’ taking ownership of a task could engage students in identifying or sharpening questions for inquiry.

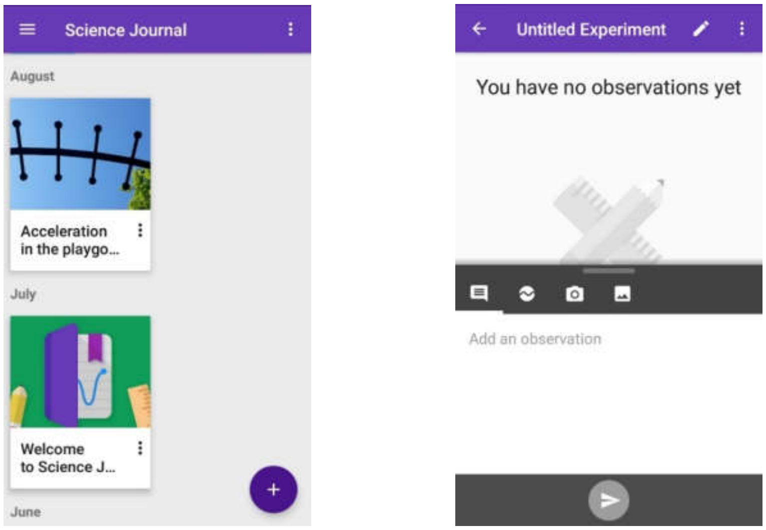
Mobile Learning

Kukulska-hulme (2013) outlines that mobile learning is more than just about *connecting* context; it is about exploiting or *creating* context. Mobile learning connects learners with the place where mobile learning occurs thus provides more flexibility in terms of time, place and resources. Mobile device now has become more powerful and affordable, making the ownership reaches ubiquity, thus, in many countries the possibilities for engaging learning experiences are becoming boundless (Alexander et al., 2019). However, for optimal design, it is required to know the best strategies for making the most of mobile learning.

Mobile learning has the potential in supporting the development of learning communities of offering experiential learning and in encouraging the development of meta-level thinking skills (Joiner et al., 2004). According to a report by UNESCO (2013), mobile devices can support personalised learning to maximise understanding. Because people carry mobile devices with them most of the time, this flexibility allows them to study anytime and anywhere. It supports situated learning where a number of applications guide users in providing information or allow them to learn about particular object in their natural settings. Mobile device then can give literal meaning to ‘the world is a classroom’. The emergent of mobile device in learning is also aligned with the current term of ‘digital native’ which attached to the young generation. As Prensky (2001) points out, digital natives are used to the instantaneity, they receive information really fast, including from their cell phones.

Previous research has shown that some software has developed in addressing the need to improve better in science. As Quintana, et.al (2004) point out, software can help in inquiry learning by scaffolding learners and inform their progress and next steps, providing hints and reminders, and encouraging them to encapsulate and reflect on their progress. One of the mobile software that provides mentioned features is Arduino Science Journal App by Google (ASJA). This app gives students access to conduct a robust observation by collecting data with sensor built-in in the smartphone (Cowen, 2018). The built-in sensor can collect various data including light, sounds, pitch, acceleration, compass and magnet. Moreover, it is a digital form of science journal to document and record investigations through notes, photos and phone's built-in sensors. The app is available for both iOS and Android.

The first interface of ASJA consist of thumbnails of saved projects (Figure 1) and can be continued some time in the future. This feature enables students to revisit and reflect the previous observation. As student create an experiment, the interface will change to split screen mode: the experiment feed and the observation user is making. In the middle of the split screen, the observation tools are seen and allow student to add note, use a sensor, take a photo and attach an image.



You have no observations yet

Figure 1. Interface of Science Journal App

Sensors in ASJA comprises light sensor, sound, pitch, compass, magnet and four types of accelerometers. This study will focus on accelerometer to match with acceleration as the chosen content. Unlike the light sensor and sound, which each just record one value, the accelerometer records acceleration in three different directions, or 'axes' (orientation in space), known as X, Y, Z and additional linear accelerometer. The X, Y and Z axes correspond to a physical direction relative to user's body (Cowen, 2018). Students record the acceleration according to which orientation suitable for the experiment. To record, students need to tap on the red button to begin the recording. The graphic will generate as soon as the recording is on and snapshots can be taken along with minimum, maximum and average acceleration (Figure 2). The ability of the app to share the result in form of .csv file allows students to review and collaborate with other students.

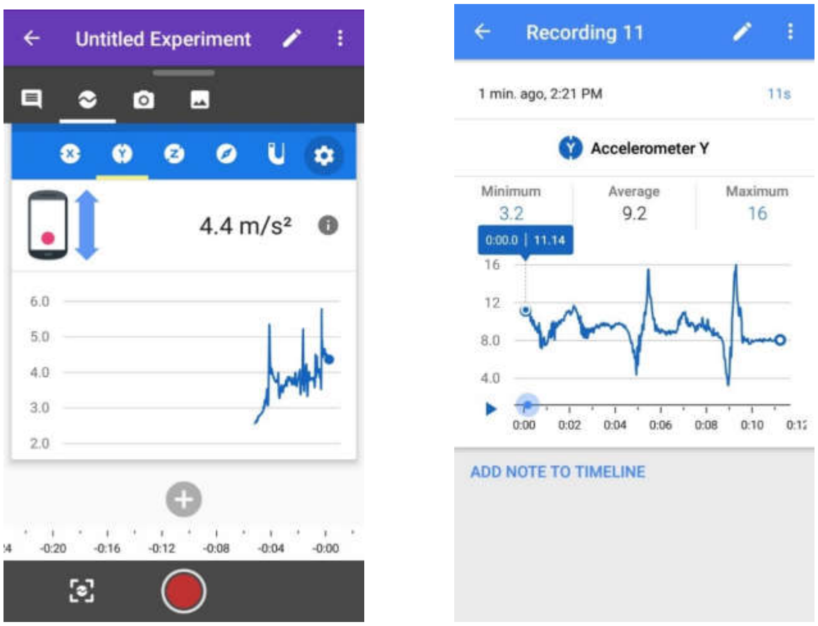


Figure 2. Graphic of acceleration created by SJA

ASJA is utilised as the mobile app in this study because of its several affordances. Firstly, ASJA allows real-time data collection, which is important in inquiry phases as investigation is a central point in inquiry-based learning. The data in the form of acceleration (m/s^2) will then make it easier to proceed to the next phase, which is data analysis. Feature of the app enables repetition as well so that it fosters data accuracy. Secondly, ability to share the data in the form of .csv file making it possible to maintain seamless learning. The learning process could continue across situations (formal and informal contexts) and scenarios (individual learning, small groups, online communities, etc) mediated by technology (Wong, 2012). The third reason is of its interface and usability. The app is quite easy to access and operate, thus, students might not need a long time to master. Accordingly, these descriptions give ASJA plausible reason as to why the researcher involves this app in the study.

Implementation of Inquiry phases

Inquiry-based learning has been chosen in many countries as one approach recommended to teach Science. Similarly in Indonesia, Ministry of Education emphasis the curriculum, especially science subject, to strengthen implementation of inquiry-based learning with scientific learning approach (Indonesian Ministry of Education and Culture, 2018).

Inquiry phases executed in this study are integrated from Pedaste et al., (2015) and Eight-phase inquiry model by Mulholland et al., (2012). These two inquiry models are considered to be employed as they aligned with personal inquiry and supporting mobility during inquiry.

The research conducted by Pedaste et al., (2015) developed a robust inquiry framework from various research. An analysis from a total of 32 articles describing inquiry phases was reviewed, resulting in the identification of five distinct general inquiry phases. Besides, these two inquiry phases represent five essential features of classroom inquiry that apply across all grade levels according to Inquiry and the National Science Education Standard (National Research Council, 2000). Thus, researcher attempts to combine these two inquiry phases to be implemented in this study. The figure below is inquiry model derived from aforementioned studies.

Figure 3. Inquiry model derived from Pedaste et al., (2015) and Mulholland et al., (2012)

The following clarifies what each phase comprise and the flow of what students carry out in the lesson:

Orientation: Find my topic

In this phase, students stimulate curiosity about a topic and finding out a learning challenge based on learning materials introduced by the teacher.

Conceptualisation: Decide my question or hypothesis
Plan my method

This phase is the process of stating the questions or hypothesis based on theory. Then they decide on what approach they will undergo to answer the question or prove the hypothesis.

Investigation: Collect my data
Analyse my data

In this phase, students implement the method and start collecting data and analyse them. They conduct the experiment to test the hypotheses. Then students will interpret data and synthesising new knowledge.

Decide my conclusions

The process of generating conclusions from the data. Students compare inferences made based on data with research questions and hypotheses.

Share and reflect on my progress

The process of communication, presenting the outcomes of the experiment conducted, describing them, critiquing and evaluating the whole inquiry cycle.

Physics is chosen as the subject in this study due to its characteristics. The research of questionnaires study by Angell et al., (2004) shows that upper secondary students perceived physics as difficult and with a high workload, but also interesting. In that research, it is known that such a higher workload demands more conceptual understanding. As for laws and rules, one of the examples are theory of Newton's laws of motion and rules for adding or subtracting vectors (force or velocity vectors).

2 METHODOLOGY

The study was an exposure of learning scenario designed by the researcher to the participants in which they review and try some of the activities). The participants are experienced science teachers that have been teaching for more than four years. The activities in the learning scenario include some experimental procedures embedded with inquiry process. Participants examined the learning scenarios and its relevance to improve learner's inquiry skills and then write some views. After writing some commentary, participants had semi-structured interviews. Inquiry phases in this study were integrated from Pedaste et al (2014) and Eight-phase inquiry model by Mulholland et al (2012).

Table 1. Description of activities undertaken by participants

Activities	Time
Pre-activity: Familiarise Science Journal App, watching an introduction video Familiarise with phases of inquiry process by Pedaste et al (2015) and Eight-phase inquiry model by Mulholland et al (2012). Review the learning scenario, and try some of the activities	30 mins
Examine the learning scenario, how it meets the criteria based on participants' teaching needs and curriculum	30 mins
Interview	30 mins

Following the approach, data from the interview and some written commentary were collected to support the study. Since the study implements a learning scenario to be examined by teachers, the primary data were teachers interview asking them as informants and experts towards the pertinence of learning scenario if applied in a real classroom setting. The interviews conducted were semi-structured interviews which interviewer hold an open-ended interview guide that has a list of topics to be addressed and a default wording. However, the interviewer the wording and order are subject to change following the interviewee to develop ideas on the issues raised by the researcher (Denscombe, 2017; Robson & McCartan, 2016).

Interviews were chosen because the research wants to explore phenomena and understand them in-depth for a detailed understanding of how things work and speak with key players who can give valuable insights based on their experience and position (Denscombe, 2017) thus, 'providing rich and highly illuminating material' (Robson & McCartan, 2016 p.286).

In this study, qualitative data from the interviews were analysed using thematic coding analysis. The analysis following Flick, (2014) Braun & Clarke, (2006) and Robson & McCartan, (2016) thematic coding analysis which comprises five phases. Thematic analysis was chosen as it can usefully summarise key features and highlight similarities and differences across the data set (Braun & Clarke, 2006).

3 FINDINGS AND DISCUSSION

The findings gathered from six interviews and some written commentary by the participants. This research aims to figure ‘How is science mobile learning scenario best be designed to promote students’ inquiry skills?’. The result will be presented in some themes developed from the interviews.

3.1 Implementation of Inquiry Phases

The interviews revealed that participants considered the learning scenario is suitable with their curriculum and teaching needs. In accordance with the present results, previous studies have demonstrated that lesson plan – in this case, learning scenario is what links the curriculum to the specifics of instructions, it offers for more productive instructions and advances the potential of effective teaching (Clark & Dunn, 1991; Freiberg & Driscoll, 2000). In regard to this result, National Science Education Standards also mentioned that teachers who plan an inquiry-based science program for their students need to select science content and curricula to meet the interest, knowledge and experiences of the students. This standard accounts for a clear call for inquiry-based science instruction and illuminates such features in teaching practice (Jacobs, Martin, & Otieno, 2008; National Research Council, 1996).

As one of the participants mentioned that the learning scenario is suitable in terms of Indonesian curriculum, this finding is consistent with that of Indonesian Ministry of Education and Culture, (2018) who asserts in the current curriculum to reinforce scientific inquiry approach. Furthermore, in another standard, like in National Research Council, (2000) also describes inquiry encompasses grade K-12, namely content standard for science as inquiry. It can therefore be assumed that the inquiry has emerged in most curricula.

Participants also commented that the implemented inquiry phases did demonstrate that each of inquiry phases is enacted in the design. They considered that inquiry phases are important for students to excel in science as it makes students think critically. This statement may be emerged due to some probing questions are given, thus lead students to employ their expert thinking in finding the answers. This result is in line with those of previous studies. Goodrum, Hackling and Goodrum, Hackling and Rennie (2001) point out inquiry means that students combine all scientific process as they develop reasoning and think critically about the evidence found and give an explanation to build their understanding. The previous researcher argues that critical thinking is the elaborated agenda of science education along with inquiry method (Rutherford, 1964). According to National Research Council (2000) students do not merely undertake inquiry by only learning words like "hypothesis" and "inference" or by some procedures stated as "the steps of scientific method". Therefore, students need to experience inquiry themselves to perceive a deep understanding of its characteristics. Hence, experience and knowledge could not be separated. In the design, the learning activities focus on students' enacting the experiment and experiencing acceleration by doing simple activity and exploring the playground rides.

Another important finding was that participants believe that inquiry can construct students' understanding. This view may be explained by the fact that learning best occurs when students are engaged in finding answers to real-world problems. In other words, students are required to struggle with ill-defined problems (Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005). Additionally, another literature also supports this view, National Research Council (2000) reports that inquiry abilities require students to link the process with scientific knowledge as they apply scientific reasoning and critical thinking to build their science understanding. In building new knowledge, students have prior conceptions about natural phenomena. When new knowledge is accepted by scientific community, this prior knowledge forms a strong base to build deeper understanding. Also, effective learning will happen when students take control of their own learning.

Investigation phase requires learners to collect valid data and making a prediction. As stated by the participants, opportunity to carry out experiment is evident in the learning scenario. The result indicates that teachers perceived making prediction and hypotheses are essential in inquiry learning and thus students should experience these steps to accomplish the whole phases. Learners prioritise evidence, which allows them to build and evaluate explanations that address scientifically oriented questions (National Research Council, 2000).

The next inquiry phase mentioned by the participants is compare and review. These stages are included in investigation: analysing my data. In the learning scenario, compare and review will take place after a learner record acceleration and the graphic has released. A learner is supposed to take notes of the results using the app and then compare the results with friends. As the study from the National Research Council notes that learners 'formulate explanations from evidence to address scientifically oriented questions' (p.26). This phase oriented on the path from evidence to develop robust explanations. Scientific explanations are based on reason and respect on evidence, therefore explanations relating what is observed to what is already known. In other words, it means building new ideas upon their current understandings.

In respect to making inferences, it is stated in the learning scenario as post activity, where students analyse the data by reflecting on the questions they chose earlier and review the data. Moreover, the probing questions also provided to help students in analysing the data. In consonance with this, NRC noted that evaluation of the explanations has occurred in search of alternative explanations. One can ask questions like, 'does my evidence support the proposed explanation? Does my explanation sufficient enough to answer the questions? The point of this stage is that students can link their results with their scientific knowledge appropriate in their level (p.27).

3.2 Mobile application and acceleration topic

Generally, the participants responded that the Arduino Science Journal App (ASJA) is helpful and exciting. Mobile application such as ASJA is helpful as it helps teacher and students to record experiment data conveniently. In the learning scenario, ASJA is the main application for supporting the experiment, hence it is necessary for teacher and learners to install it in their mobile device.

ASJA is perceived as an innovative mobile application by participants as it is novel and interesting, therefore it might be easy for the teacher to grab students' attention. Moreover, students nowadays are digital native (Prensky, 2009) they exposed to digital enhancements, causing them at ease in interacting with new technology like ASJA. ASJA itself has many affordances in supporting the learning activity. Data recording, immediate result and enable taking snapshots and notes are some features that some participants mentioned. ASJA utilise sensors in mobile phone to record phenomena in real-world situation and students can use the app to collect real-time data as part of their science investigations (Cowen, 2018). In the learning scenario, motion sensors are used, measuring acceleration using a 3-axis coordinate system with accelerometers (accelerometer X, Y, Z and linear accelerometer). Besides four motion sensors, this app also contains five other sensors, namely light sensor (brightness), compass, magnetometer, pitch and sound intensity. These features offer limitless possibility for observations which are the core of ASJA. The observation tools comprise add a note, use a sensor, take a photo and attach an image. By making observations, users record data and notes about experiment, just like the way they usually keep notes and record data in paper-based journal, besides, ASJA enables everything stored digitally (Cowen, 2018). As participants tried to install the app and operate it, initial insights from the evaluation of the ASJA reveal that participants like the fact that they can use their phones to do science and unlocks their phone potential.

According to the literature, physics is at best an oversimplification of how scientists operate. Scientific method – is a game plan that is frequently modified when the actions start. It starts with *observation* of the phenomenon, continues with forming *hypothesis* and soon the scientist performs an *experiment* that will test this hypothesis. Then, the outcome of this experiment often raises more questions that lead to *modification*. Another literature supports this claim is that children may not realise they are learning while playing. The swings – for example, allow children to physically experience a wide range of physics concepts, such as velocity, gravitational energy acceleration or angular acceleration. Practical experience enables learning in more than just the mind; it develops skills. Out-of-classroom experiences are also opportunities where scientific method is continuously applicable. Schools that has limited laboratories can benefit by perceiving the world as one big laboratory where enable science engagement with the real world (Mavhunga, 2018). These findings then further support the idea of how physics characteristic match well with the mobile app.

3.3 Redesigning learning scenario

Reflecting on the above findings, recommendations for the improvement and implementation of the design of the learning scenario emerge including the need of (i) comprehensive classroom management (ii) revisit previous lesson (iii) the need to include experiment and; (iv) additional deeper learning for more meaningful physics lesson

3.3.1 Comprehensive classroom management

Classroom management is revealed as one of the issues arising from participants. This pedagogical skill includes supervising, time scheduling, safety, rules and risk, technical issue and grouping. Classroom management is one of the roles associated with effective teaching, alongside with instructional strategies and classroom curriculum design and has been recognized as a pivotal element in effective teaching (Marzano et al., 2003).

The implication of this recommendation is that the learning scenario and its implementation should value how to manage the class both in formal settings (inside the classroom) and informal settings (outside the classroom, e.g. school playground)

3.3.2 Revisit previous lesson

Before entering new subtopic while teaching science, it is suggested by the participants to revisit the previous theme, as it will bridge the known information with the new knowledge. This finding is in accord with what suggested by Johnson (2000) to apply ‘input’ in the lesson study/learning scenario.

3.3.3 The need to include experiment

When asked about the previous experience in teaching some related content, the participants were unanimous in the view that ‘experiment’ is always involved and attached to most of physics content. The scientific method – or scientific inquiry is important, specifically in day by day process in filling the detail of a phenomenon. Some great discoveries in physics were done by traditional physicist working in the labs, implementing ‘scientific method’ (Ostdiek & Bord, 2013). This finding supports evidence from previous study (J. Kuhn & Vogt, 2013), in addition to the use of SJA as experimental tools, the cognitive and motivational learning of the learner is greater when a physical phenomenon, like acceleration is explored with experimental tools. This claims thus support views that experiment and the use of experimental tools are quite vital in physics teaching.

3.3.4 additional deeper learning for more meaningful physics lesson

Involving students to learn physics in a more meaningful way seems essential to support the understanding of science. One of the participants gave valuable insights to sharpen deeper learning in physics by increasing the level of acceleration itself. Comparing the result of highest acceleration among students might lead them to realise and finally acknowledge factors that influence acceleration. Students could later generate with the 2nd Newton’s Law that different mass will cause different result of acceleration. Therefore, it can be assumed that this addition could increase students reasoning and benefit their learning.

4 CONCLUSION

The study aimed at finding out how effective science mobile learning scenario best be designed to promote learner’s inquiry skills in Acceleration topic in Middle School Science. A design-based research study was conducted to query teachers’s view about the designed learning scenario.

The utilisation of Arduino Science Journal App is beneficial as it will help students to record experiment data conveniently as well as generating immediate result to continue to the next phase which is data analysis. ASJA utilise sensors in a mobile phone to record phenomena in a real-world situation and students can use the app to collect real-time data as part of their science investigations (Cowen, 2018). Collecting data is central in doing scientific investigation, therefore these findings then further support the idea of how physics characteristic match well with the mobile app.

Taken together, these findings suggest a role for effective learning scenario in promoting inquiry skill. Reflecting on the above findings, recommendations for the future improvement and implementation of the design of the learning scenario for the subsequent iteration are identified. The recommendations mainly focus on pedagogical factors, including (i) comprehensive classroom management; (ii) revisit the previous lesson; (iii) the need to include experiment and; (iv) additional deeper learning for a more meaningful physics lesson. These recommendations are based on the first iteration of a DBR study. Therefore, it is recommended that further research in emerging mobile learning and inquiry-based learning be conducted to broaden our understanding of potential relationship of mobile learning and inquiry learning. Through future iterations this work will quest to contribute to this development.

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