Planning and Implementation of Group Activities for Science Teaching in Sri Lanka: Based on Experiential Learning with the Affordances of Mobile Phones

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INTRODUCTION

Teaching science means more than enabling students to acquire scientific knowledge. It is necessary to foster comprehension of a combination of content, processes, and characteristic attitudes related to the science topic being studied. Content includes abstract concepts, laws, and theories whereas processes include observation, classification, measurement, inference, prediction, and communication. The characteristic attitudes involve being curious and imaginative, being enthusiastic about asking questions and solving problems, and respecting for methods and values of science. Therefore, science teachers aim to focus on the development of these three dimensions among their students.

According to Alsop (2005), science teaching is complex, as the processes involved in teaching and learning science cannot be reduced to a series of algorithms applicable to all educational settings. While referring to the content of science, Tabre (2005) claims that science is not an archive of facts but a complex set of theories, laws, and so forth that we use to model the world. Furthermore, Wellington (2004) states that science involves abstractions, difficult ideas, and theoretical entities that cannot be seen or handled. Considering both content and processes, Barton (2004) says that the key elements involved in science education deal with abstract ideas and concepts, pattern finding (that is looking for the relationship between variables), the mathematical processing of data, an introduction to a large and constantly changing body of knowledge, and the visualization of dynamic processes.

To aid students in understanding the difficult concepts associated with science, over many years, Dewey's (1938) 'learning by doing' and Kolb's (1983) Experiential Learning Theory (ELT) have been considered for science teaching. A paper Gorghiu & Santi, (2016) states that in the activities that involve learning by experience, the teacher's role is different as the teacher has to select the experiences that can be used, offer resources to students, create conditions of physical and emotional safety, and facilitate the learning process. An experiential learning-based curriculum model is applied in China, in which real-world problems or situations are used as the comprehensive focus and framework for students to learn science (Zhang & Campbell, 2012). This paper concludes that experiential learning is promising to improve the quality of teaching.

Valk, Ahmed, & Elder (2010) argue that for effective learning and teaching the use the experiential learning approach; the clear delineation and definition of the required skills; observation; well-intentioned, detailed, and descriptive feedback; reviews using video or audio recording; practice and rehearsal of the required skills; and active learning in a small-group or one-to-one are critical. The support of technology for experiential learning especially looking from the perspective of students is also discussed in the literature.

Zacharia et al., (2016) report a study that combines the inquiry-based, experiential learning approach with the use of mobile phones and tablets, especially their data recording affordances, to investigate whether the above approach enhances fourth-grade learning about flowers, their parts, and their functions. Moreover, conducting experiential learning activities conducted on two fifth-grade classes at an elementary school, one class using personal digital assistants (PDAs) and the other working without them, indicated that mobile technologies were effective in improving knowledge creation during experiential learning (Lai, Yang, Chen, HoC, & Chan, 2007). Facer et al., (2004) also reported an experiential learning study, based on a mobile game that was created to improve the students' conceptual understanding of animal behavior. This study concludes that mobile gaming might be a good tool for supporting experiential learning activities. Further, reporting an experimental study to explore the support of PDA for experiential learning Lai et al. (2007) state that PDAs were effective in improving knowledge creation during experiential learning where the group who used PDAs for the learning activity scored higher than that of the group who did not use PDAs for the same activity.

The above discussion demonstrates the potential of experiential learning aided by different technologies for students to obtain a variety of experiences during their science learning activities thus enhancing their understanding of scientific concepts and processes.

Even though the potential of experiential learning that uses different technological tools is well recognized, the use of this is in its infancy in Sri Lanka. The aim of this study is to educate teachers about the potential of experiential learning through some sample lessons where mobile phones were integrated.

Due to the high penetration of mobile phones in Sri Lanka and as teachers and students are well acquainted with the functions of the mobile phone, it is decided to use mobile phones as a technological tool to support experiential learning activities designed in this study. As lessons based on experiential learning with the help of mobile phones are new to teachers in Sri Lanka, a theoretical framework of experiential learning was followed in the lesson planning and implementation stages.

THEORETICAL BACKGROUND

Experiential learning

Experiential learning shifts the learning design from being teacher-centered, to an approach that is semi-structured and requires students to cooperate and learn from one another through various direct experiences that are tied to real-world problems (Kolb & Kolb, 2009). According to Wright & Vice (2015), experiential learning is not a set of tools and techniques to provide students with a range of experiences. However, it is a method of instruction that considers learning as a continuous process in which students bring their own knowledge, ideas, beliefs, and practices to their understanding and interpretation of new information. Thus, to support students' learning, the learning environment should be comprised of resources to facilitate the above processes. According to Marlow & Mclain, (2010), the experience needs to be structured in a way that the learner to take initiative, make decisions, and to be accountable for the results.

Supporting this, Boud, David, Cohen, Ruth, Walker, (1993), emphasize that discussing learning is meaningless in isolation from experience, which is the consideration of all learning. Furthermore, the value of actions while learning is also emphasized by Dewey's (1938) 'learning by doing' theory. Supporting this Kolb (1983) by introducing the Experiential Learning Theory (ELT), which focuses on experience as the chief contributor to the learning process and states that 'learning is the process whereby knowledge is created through the transformation of experience'.

ELT learning consists of four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. That is learning starts with an active involvement of a learner in getting experience by doing something individually or as a team; then the learner takes time out from 'doing' and stepping back from the activity and reviewing what has been experienced and done. The above stages are followed by the process of making sense of what has happened and involves interpreting the events and understanding the relationships between them drawing upon theory from textbooks for framing and explaining events, models they are familiar with, ideas from colleagues, previous observations, or any other knowledge that they have developed. Finally, the learner considers how they are going to put what they have learned into practice.

Affordances of mobile phones

Mobile phones provide a range of affordances due to their functions such as Short Messaging Service (SMS), Multimedia Messaging Service (MMS), video, camera, the internet, voice recording, and Bluetooth, and attributes such as their personal, informal, contextual, portable and ubiquitous nature (Hartnell-Young & Heym, 2008), (Kukulska-Hulme, 2005).

Furthermore, mobile phones open the door for a new kind of learning and performance support in the field and provide anytime and anywhere access to information, processes, and communication thus supporting learner to perform authentic activities in the context of their learning (Martin & Ertzberger, 2013). According to Godwin-jones (2011), the availability of responsive touch screen, relatively large virtual keyboard, the capability of editing captured images and videos enhances the potential use of them for education. Furthermore, Arrigo & Ciprì (2010) state that mobile phones provide new educational opportunities due to the fact that they are personal, portable and permit new forms of interactions among all involved in the learning process and their respective surrounding environment. Mobile phone can be beneficial to instructors since they can access and interact with students while on the move.

Even though, not strictly follow experiential learning approaches, many studies reported in the literature emphasize the support of affordances of mobile phones for science learning through various experiences (Ekanayake, T. M.SSKY & Wishart, 2014); (Naismith, Lonsdale, Vavoula, & Sharples, 2004); (Hartnell-Young & Heym, 2008) (Woodgate, Fraser, Crellin, & Gower, 2008).

For example, Hartnell-Young & Heym, (2008) report a study on a series of secondary-level science lessons in three schools in the UK, where the students engaged in science experiments through the use of their own mobile phones. In one school according to the teacher's instructions students had used mobile phone cameras on a regular basis to capture evidence of experiments into plant growth. According to the authors, the affordance provided by the image capture function of mobile phones helped students to accurately record physical observations and thus enabled them to ensure the 'scientific validity' of students' collected data. This also enabled teachers to encourage students to review their material and to reflect on the evidence over time. Furthermore, Ekanayake & Samarakoon (2016) report the support of mobile phones for students' science group activities, outside the classroom. In this activity, students engaged in the activity on grafting as small groups in the school premises. They received audio-visual instructions as small video clips to their mobile phones which were sent by teachers using a unique system consisting of mobile phones, laptop computers, and a router. Followed by a teacher demonstration on grafting in the classroom, students had to go to the school garden and as small groups engaged in the activity. As the instructions were provided with teacher's own voice and also the possibility of going back and forth, and revisiting the instructions made the student activity more comfortable. At some stages, according to the instructions they received they had to send images and text as evidence of their engagement to the teacher and get the teacher's feedback to do further steps of the activity. Woodgate et al. (2008) also report another field based study that emphasises the potential of having GPS on mobile phones. Students (age 13-15) working in small groups were loaned mobile sensors to collect scientific data in their local area. They collected data on parameters such as carbon monoxide, sound and temperature, and GPS data to record the location of their findings. On their return to the classroom, their data were downloaded to a personal computer. These data were then visualized in

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Google Earth or Google Maps and uploaded to a dedicated website along with associated material created by the students to share the findings with students and teachers in another project school. Thus, in this study, different affordances of mobile phones enabled students to engage with the activity and to collect, visualize, reflect, and discuss their own scientific data more effectively.

The above studies demonstrate how different affordances of mobile phones support some stages of the experiential learning cycle. Therefore, in this study, teachers considered how the affordances of mobile phones could be utilized during the planning and implementation stage of lessons that were designed based on ELT.

Research Objectives

The objective of this study is to plan and implement group activities based on experiential learning and the affordances of mobile phones to help students understand abstract concepts like resistance to current flow, and the influence of insulators, conductors, and semiconductors on current flow.

METHODOLOGY

Sample

This paper is based on implementation of three science lessons, which were developed in a professional development workshop conducted to explore the possibilities of integrating mobile phones into science lessons in supporting students' experiential learning. For this workshop, 12 science teachers (seven female teachers and five male teachers) from Sri Lanka who were co-researches in a previous mobile learning project (Ekanayake & Wishart, 2014) were purposively selected. Among seven female teachers, three were from schools having science stream spanning up to G.C.E (A/L) examination or up to Grade 12 (in Sri Lanka these schools are categorized as 1AB schools) and others were from schools having science stream spanning up to G.C.E (O/L) examination or up to Grade 10 (categorized as 1C schools). Three male teachers out of five were from 1AB schools and others were from 1C schools.

Materials and procedure

During a workshop, teachers created two lesson plans after selecting suitable lessons from the Grade 6-11 National Science curriculum, where experiential learning with the affordances of the mobile phones could be integrated. The two lessons developed were: 'How resistance affects the current' and 'Current electricity'. These lessons provided concepts such as conductors and insulators; resistors and equivalent resistance and semiconductors. As these are difficult concept to understand a number of different experiential learning activities were carefully designed while considering each stage of ELT. The image capture and video functions of the mobile phone were utilised in each lesson to enable reflective observation and abstract conceptualisation of the experience that students gained by different activities assigned to them.

One of the teacher participants (as a volunteer) implemented the designed lessons in her/his own school. Prior to conduct each lesson in school setting, the students were given a hands-on session in a free period on how the video and image functions of mobile phones can be used. This was to make the students familiar with the model and make of the mobile phone that were used during the lessons. In these sessions, first teacher demonstrated image capture and video capture functions of mobile phone and the students were given time to practice under the teacher's supervision.

In the lesson on 'how resistance affects the current', the students were asked to use a mobile phone image capture function to read the resistor code as a colour image and to take pictures to show the brightness of the bulb under different resistance to current flow. After the student activity teacher used a photostory created

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using images captured by students for the abstract conceptualization of the lesson.

The lesson on 'current electricity' was based on two sessions. In the first session, the students were asked to use mobile phone image capture and video functions to capture the current flow through insulators, conductors, and semiconductors. After the first session, the teacher revisited the captured observations by each student group (as diagrams, video, and audio clips) and selected appropriate ones to prepare a PowerPoint presentation. During the second session while showing students' captured observations that were embedded into the PowerPoint presentation teacher conducted the lesson. The teacher conducted this session by asking students reflections, and questions based on their existing knowledge, and also referring to the theories in the textbook and discussing them.

Data Collection and Analysis

During the lesson implementations, the data were collected as observational data by gathering students' and teachers' voices and activities as both video and audio data. In addition to this, field notes were taken by the researcher, while acting as participant observers. Informal interviews were conducted with five students selected for the opportunity to probe more deeply about each lesson. After the lessons, teachers' reflections were also collected.

The collected data were analyzed using NVivo 10 software and using the thematic analysis technique. Here the NVivo 10 software was used as it makes the process of transcribing easy.

RESULTS

Dimension 1: Designed lessons provide opportunities for concrete experience and reflective observation

In the lesson on 'how resistance affects the current', the students were given the following opportunities to obtain concrete experience:

- Read the colour code of the given set of resistors and identify the respective value of each resistor.
- Connect the resistors to the given battery and bulb assembly as one resistor, two in parallel and two in series. Then to (i) observe the brightness of the bulb, (ii) take a picture using the mobile phone provided to show the brightness of the bulb under each condition and (iii) send the photo to the teacher's mobile phone using Bluetooth facility.
- Finally, calculate the value of each resistor that they were provided

Students were also given a worksheet and during the practical in the relevant step they filled the worksheet, and they reflected on the observations that they obtained.

In the lesson on 'current electricity', the students were provided the following opportunities to obtain concrete experience:

- Connect different materials provided between a bulb and a battery, and observe whether the bulb is lit or not
- Connect a Nichrome wire between the bulb and the battery and observe the brightness of the bulb. Then increase the length of the wire and observe the brightness of the bulb.
- Connect an LED across the bulb and the battery, and observe whether the LED is lit. Then reverse the direction of the LED and observe the same.

During the above activities class was divided into three groups and observations were taken by different groups either drawing a diagram capturing an image or capturing a video clip. Each group had an opportunity to capture observations using one of these ways by rotating the mode of taking observations for each of the three activities specified above.

Again in this lesson, a worksheet was provided for reflective observations. The discussions of students during the completion of the worksheet after each activity was with full of arguments. Most of the time, they tended to revisit the saved observations and reflect on them so as to complete the worksheet with accurate answers. As reported in the fieldnotes this motivated students to think critically about observation. For example, there were different opinions regarding the observations collected by changing the length of the Nichrome wire. One student said

"We couldn't notice what happened to the brightness of the bulb when we did the experiment. However, when we revisit the video clip, we realised that brightness reduces. Then we argued among ourselves and understood the concept that the resistance increases with the length of the wire."

(Student comment 3)

Based on the observation, it was clear that during both lessons as the teachers assigned learning experiences to students, it opened up a space for them to engage in learning activity rather than passively listen to the teacher. It was also noted that teachers' pedagogical decision to assign learning experiences to students as small groups enhanced student engagement further by providing opportunities to actively participate in this experiential learning activities. According to the data, it was revealed that throughout the lessons as small groups each and every member involved collaboratively, in reading the worksheet, planning the task, managing time and resources, and also completing the assigned task within the given period of time.

According to the data from session 2 of the lesson 'Current electricity', as a consequence of using the mobile phone students could reflect on different observations captured by different groups on the same activity. In this session, as the teacher followed whole group discussion approach this opened up an environment where students could compare and discuss how the observations collected by their colleagues were different from their own. Further, it was observed that with the involvement of teacher in these discussions and her reflections on students' observations created an environment where students could understand the scientific content easily.

In these lessons, students not only obtain the observations but also pay careful attention to get the maximum experience. In both lessons, it was noted that some groups tried to capture the same observation more than once to get a better image as they wanted to send the best one to the teacher. It was also noted that in some groups when they were taking observations, they changed the person who captured the observation. This provided opportunities to get that experience to more than one student and for others to reflect on the observation captured.

Dimension 2: Designed lessons provided opportunities for abstract conceptualization

During the lesson on 'how resistance affects the current', the teacher used students' captured images and the equivalent resistance values that they calculated to reflect on the effect on the current flow with different resistances and the effect of parallel and series connection of resistors.

Similarly, in the lesson on 'current electricity', the teacher developed a PowerPoint presentation based on the observations students took and used that to conceptualize the abstract concept of current flow in the presence of insulators, conductors, and semiconductors.

According to field notes, the teacher viewed the images taken by the students after each activity as rewarding to plan and discuss the underlying concept of each lesson. During the post-lesson interviews, both teachers mentioned that the use of mobile phones in these lessons supported them in planning lessons with a different approach. For instance, the teacher who conducted the lesson 'current electricity' stated that,

"Due to the possibility of integrating mobile phones into my lesson, I could plan to implement my lesson as two sessions. In the first session by using the small group discussion approach, I planned to provide an environment where students could explore the relevant scientific concepts by involving in the learning activity in a learner-centered manner. Furthermore, as I could use the students' observations as records for the second session I could discuss the underline concepts easily".

(Teacher 2- comment)

Moreover, both teachers emphasized the importance of planning the lesson as per the experiential learning cycle. According to the field notes, it was noted that the integration of experiential learning theory with the affordances of mobile phones allowed teachers to plan the lessons in a more effective way than the usual lessons. For example one of the teachers' views was as follows;

"Today's lesson was different from my usual science lessons. In other lessons, I do theory in the classroom and practical work in the laboratory as separate lessons. Most of the time theory and after that the relevant practical. However, today I could incorporate the observations obtained during the practical class with the theory in the classroom as the students could collect the observations as images and videos. So easily, I could discuss the concepts of current flow".

(Teacher2 comment)

The possibility of connecting the practical class with the theory class was also noted as one of the opportunities provided by the careful planning of the lesson. According to a lesson interview, one teacher said;

"The presentation I used in the discussion class was embedded with students' recorded images and videos. Therefore when I questioning on them getting responses from the students was easier than in the other lessons. So, I could easily connect the observations into what they had already learned in the previous classes and teach them new concepts related to the lesson easily."

(Teacher's comment-3)

Dimension 3: Affordances of mobile phones enhanced experiential learning

According to the collected data, it was observed that during lessons the integration of mobile phones provided more opportunities for students' to gather more experience. In the lesson on 'current electricity' this was highlighted as the mobile phone offered different modes such as capturing images and videoing to collect observations rather than recording observations as diagrams in the notebook as in usual lessons. Further, the lesson provided oppotunities to share the skills, knowledge and attitudes of students as each group had to complete all these tasks within the allocated period of time collaboratively. One student commented on this as follows;

"On the other days, we just draw what we were seeing on our own book. But today, as we had to collect observation using a mobile phone functions we engaged with the activity enthusiastically."

(Student comment 1)

Similarly, during the lesson on 'how resistance affects the current', as the students could collect observations as images, they could reflect on the effect of equivalent resistance on current flow, thus the brightness of the bulb. This is very different to the usual lesson, where students only calculated the equivalent resistance and current flow.

Student admired the fact that videoing was useful to reflect on the observation repeatedly and understand the scientific concept correctly. One student's comment is as follows:

"It was a good experience. Usually, when we do practical, we will not be able to see the observation without doing the experiment repeatedly. However, today mobile phone cameras allow us to video the observation and visit it repeatedly. By doing that we could reflect on the observation and understand the concepts easily."

(Student comment 1)

During the lesson on 'how resistances effect the current', as students captured the observation as images, they could compare the calculate value of the current and the brightness of the bulb (when connecting different resisters in series and parallel). Thus, the potential of revisiting observations, which was added due to the integration of mobile phones provoke discussions related to learning science.

In the lesson on 'how resistances affect the current' students were asked to collect data as sketches, images, and videos. This was to extract the best affordance of mobile phones for each task. It was recorded that collecting observations as video was easier than capturing observations as images. One student commented as follows

"Collecting observation as videos is easy because we can start videoing a little earlier and capture the observation easily. However, collecting observation as an image was bit difficult, as we had to capture it exactly when the event is happening. For instance, if the bulb is lit for a moment we had to capture it. Otherwise, we want to collect the correct observation."

(Student comment 2)

Supporting this, according to the field notes on the second session about 60% of students stated they preferred to collect observations as videos.

However, some students reported that capturing observations as images was much better as the video captured the background noise thus making it difficult to extract real information from a video clip.

I like taking photos when capturing observations. It only captures what we are taking.

(Student comment 2)

Supporting this student another one said

Totally agree! When our teacher was using our group's video as one of the observations on her presentation, we could hear what we were talking about during the activity. It recorded all the background noises. Therefore, it is not very good.

(Student comment 3)

Teachers stated that the integration of mobile phones into science lessons supported them to discuss the relevant scientific concepts during the allocated time period as the teachers could use the students' observations as evidence in explaining the content. Further, they pointed out the students' engagement in the discussions as a fact of teachers' use of their materials during the discussions.

DISCUSSION AND IMPLICATIONS

As illustrated in dimensions 1 and 2, the lessons designed on the ELT offered more opportunities for a learner to construct knowledge, skills, and values directly from an experience within the environment. Further, filling out the given activity sheet after each of activity was also provided good space for students to reflect on what they had collected as observation. Filling the worksheet not only helped with reflection but also it provoke students for the process of sense making or conceptualizing. As the students could revisit the captured images, it supported them to create a discussion and to come to an agreement. As one of the questions on the worksheet asked students' views on the application of the use of electrical conductivity of different materials for day-to-day lives, it guided students to think about how they are going to use what they have learned in practice. This is in line with Kolb (2014) findings as he says the process of learning would be facilitated if the education process begins by bringing out the learner's beliefs and theories, examining and testing them, and then integrating the new, more refined ideas into the person's belief systems.

As discussed in the results section, during these lessons to make the students' science learning meaningful mobile phones support learner as well as the teacher. Rather than marking observation as a diagram, collecting observation as images and videos increased the number of students' active engagement. Furthermore, due to the possibility of capturing more than one observation (as image or video) within a short period of time opened up avenues for capturing observations by more students and selecting the best one to send to the teacher. This is in line with the observations provided in Zacharia (2016); it says authentic data recording affordances through the use of photo and video capturing tools, enhanced students' learning.

According to field notes, mobile phones supported teachers in engaging students throughout the learning activity as well as during the discussions. The post-lesson interviews with teachers revealed many reasons for this observation. They were (a) mobile phones being one of the students' favorite technological tools, (b) the potential of mobile phones to create learning activities while providing more opportunities for students' active engagement, and (c) the potential of mobile phones to record observations in different formats that enable revisiting the observations.

The potential of capturing observations as images and also as videos and saving them within the mobile phone supported teachers to assess students' learning as well as preparing teaching aids while incorporating students' recordings. The teacher could conceptualize the abstract concept easily as the students' active participation was high during the discussions. This was as a result of conducting the whole group discussion while reflecting on students' collected observations that were embedded in teacher's presentation. Especially, the opportunities provided to the teacher in explaining of the scientific concepts while referring them to their preferred modes of observation were also identified as an important aspect in making science lessons more effective.

In the present study as mobile phones provided more options to collect observations it enhanced students' active engagement (this will be discussed in detail later). Furthermore, in completing the worksheet mobile phone provided the opportunity of revisiting the observation. Moreover, the mobile phone supported the teacher in creating a teaching aid (presentation) while opening up avenues to reflect on students' captured observations and the process of making sense of what has happened and involves interpreting the events and understanding the relationships between them.

This study clearly demonstrates that the data capturing affordances of mobile phones as image and videos benefit students' learning when experiential learning activities are considered. Further, teachers could plan and implement the activities effectively as they were planned as per the ELT. That is our findings are aligned with the theoretical background considered for this study.

Moreover, this activity provided confidence in a group of Sri Lankan teachers on designing lessons based on ELT and the affordances provided by the mobile phone to effectively carry out the different stages of the experiential learning cycle described under our theoretical background.

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