A Comparative Analysis in Evaluating 'ThinknLearn' from Science Educators and High School Students Perspectives

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Abstract. The current use of mobile technology in the classroom has attracted many educators and researchers to develop mobile web based learning tools for educational purposes. In school science education, deductive or inductive forms of inquiry are used, while the use of abductive form of inquiry has been sparsely explored. 'ThinknLearn', an abductive enquiry tool, was developed and evaluated with students in earlier work. However, this paper addresses the use of such learning practice from the educators' perspective and compares this with previous evaluations in which students were involved. This may help to investigate the longer term impact of this learning practice in classrooms as students and educators are the main stakeholders of this learning practice. Content analyses of data indicated that both educators and students support the use of abductive forms of inquiry-based learning activities with mobile devices in the classroom.

Keywords: Mobile Learning, Abductive Science Inquiry, ThinknLearn, Science Education.

1 Introduction

The rapid development towards mobile device deployment in classroom environments may offer students new opportunities for increasing engagement, motivation and learning [1]. Mobile devices not only revolutionize school education but also transform the traditional classroom into an interactive form of learning for students [2]. These devices provide computing power and wireless capability, which can make learning expedient, immediate, authentic, accessible, efficient and convenient [3]. Hence, these devices may increasingly become a convincing choice of technology in classroom environments [4].

There have been great strides in the affordances of these mobile devices, attracting many educators and researchers to use them in classroom environments for various domains, specifically in science education [5]. Various studies in the literature show

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that the use of these mobile technologies provides enjoyable learning experiences for students, increasing motivation towards science learning and enhances their reasoning skills and learning performance, to some extent [6].

Generally, deductive or inductive forms of inquiry can be supported by classroom learning activities using a number of applications, where students develop meaningful explanation through their pre-defined hypotheses or observational data [7]. Among these, BioKids Sequence [8], WHIRL [9] and nQuire [10] are few prominent science projects in which deductive or inductive forms of inquiry are used. In contrast, abductive science inquiry mainly generates meaningful explanations through the combination of both inquiries: deductive and inductive, in which students can comprehend the given topic by using generated hypotheses from the observed phenomena [6].

Oh's abductive Inquiry model (AIM) [11] consists of the following phases: exploration, examination, selection and explanation. In the exploration phase, students explore the given scientific phenomena by collecting data and find ways to explain it scientifically. The examination phase then follows in which students find out scientific theories or facts to develop scientific hypotheses. During the selection phase, students examine all the previously inferred or possible hypotheses and choose those that provide the most plausible explanation of the observed phenomena. At this phase, if students find any problem then they may revert back to the previous steps for any modifications required. In the last phase of this model, explanation is used for the development of more sophisticated explanations of the observed phenomena where students recommend complete explanations of the given phenomena using the rules and hypotheses chosen in the earlier phases.

The mobile web-based learning tool 'ThinknLearn' [12] was designed on the principles of Oh's AIM model [11] in which students have to perform a real time science experiment in the classroom (laboratory). In one particular example, they have to compare how three tins with different surface colors radiate heat energy. The tool helps students to explain the observed phenomena by involving in all the phases discussed in the AIM's model [11]. This tool was previously evaluated with students in their classrooms with couple of experiments using the M3 evaluation framework [13]. However, the inputs from the educators and their comparison with previous evaluations about this tool were not discussed in earlier articles.

Educators are the main driving force for nourishing high performing and talented students in their society. Hence, their opinions about the established or new forms of learning practice can play a vital role in what may become an established practice for school science education if appropriately implemented [1]. For this purpose, 'ThinknLearn' [12] was evaluated with school science educators in order to comprehend their perspectives in comparison with their students' evaluations. Thus, this paper discusses the semi-structured interview data collected from the educators while evaluating 'ThinknLearn'.

The remainder of this paper is structured as follows. In section 2, related work about the topic is discussed. Section 3 presents the methodology for conducting experiments while section 4 explains the content analyses of the data collected from the educators and students. In addition, the comparisons between educators and students' responses are described in this section. Finally, the last section contains concluding remarks and discusses some advancement in this research.

2 Related Work

Inquiry based learning (IBL) is an educational activity that allows students to learn science by doing science, offers resources to provide hypothesis generation and explanation of the observed phenomena [14]. In the literature related to school sciences, the importance of using mobile devices in the classroom is discussed a number of times such as in Huang et al. [15] and Shih et al. [16]. They stated that students can perform better if they are equipped with mobile devices while doing scientific inquiries. They further elaborated that these devices may improve students' knowledge and reasoning skills compared with those who do not use them in the classroom. Similarly, a few studies [17-18] also highlighted the use of mobile devices for generating correct explanations or hypotheses if appropriate tools are provided to the students.

Most of these studies follow deductive or inductive form of inquiries in which students either use pre-defined hypotheses or observational data for developing meaningful explanations. In contrast, the abductive form of scientific inquiry is based on the theory of abduction that was proposed as a form of reasoning by C.S.Pierce (cited in [19]). In this type of reasoning, students are required to develop meaningful explanations using both hypotheses and observational data [19]. The example can be seen in our earlier research paper [13] that shows the differences between these forms of scientific inquiries; deductive, inductive and abductive.

According to that given example, it can be observed that in abduction, the Rule (Condition) and the Result (Observation) are involved together to identify a Case (Hypothesis). On the other hand, deduction and induction can be processed with either a Rule or a Result to generate the other component. Thus, abduction is well-suited to scientific inquiries in which students are challenged to formulate scientific hypotheses and explain the observed phenomena [11]. It also provides us with an opportunity to identify the educators' perspectives on this abductive form of scientific inquiry.

3 Methodology

In mobile learning tools, evaluation plays a vital role in examining the effectiveness of the tool to enable learning opportunities with the support of new technology [6]. For evaluation purposes, the M3 evaluation framework [6] was applied to verify the effectiveness of the tool 'ThinknLearn' [12]. The M3 evaluation framework consists of three levels; Micro, Meso and Macro [6]. However, only the Micro level evaluation comparison between students and educators is discussed in this paper.

3.1 Experimental Design

The underlying principle of this experimental design is to evaluate 'ThinknLearn' in educators' perspectives, which may assess whether such abductive science inquiry tool can be used for high school science students [12].

Usability serves as a means to provide a successful learning tool. If in case, a learning tool is not usable enough then it may obstruct learning and students may spend more time in understanding how to use such tool instead of learning the provided contents [20]. In addition, usability also enables a platform to identify opinions of the users about such given tools [21]. For that reason, qualitative data were gathered from the science educators in order to evaluate their opinions about 'ThinknLearn'.

3.2 Participants

A meeting was conducted with a group of eight science educators of diverse background (Chemistry, Physics, Biology) from a local high school in Auckland, New Zealand. In the beginning, information was disseminated about how abductive science inquiry can work in general and how 'ThinknLearn' works in particular. After describing this information to educators, mobile devices were provided to each of the participants to evaluate the given tool in terms of its usability [21] and mobile quality aspects [22]. Further, qualitative data were also collected in a group discussion held during the meeting. Previously, 86 students in 25 groups from three classes had participated in a group discussion [13], which is used for comparison in this paper.

4 Content Analysis and Discussion

Qualitative data were collected in semi-structured group discussions between eight school educators and 86 students from three classes. Five questions in the discussions were asked of the educators for evaluating the given tool while only three questions were posed to students as the last two questions were related to educators (see Table 1). For analysing responses from the participants, qualitative content analysis was used, which is a research method that can be used to define the characteristics of language as communication describing the contextual meaning of textual data [23]. In that method, a large amount of data can be divided into a small amount of content categories or codes [24]. There are three forms for developing codes in a content analysis [25]; conventional, direct and summative. In this experiment, direct content analysis was used in which categories are derived during the group discussion and few key categories were used beforehand. In other forms of content analysis, categories are identified either prior to the experiment or after conducting the experiment.

4.1 Content Analysis

In group discussion with science educators, the researchers used some prior knowledge about the topic to identify some key categories such as 'Easy to understand', 'Enjoyable experience' and 'Helpful'. As analysis proceeds, additional categories emerged during the group discussion. For instance, 'Difficulty in use', 'Confusion in hypothesis' and 'Uneasiness' highlight the negative aspects of the tool while 'New or innovative' and 'Interactive' are the positive aspects regarding the given tool, as depicted in Table 1.

Table 1. Questions asked to educators during semi-structured group discussion

Q.No.	Questions	Categories	Frequencies	Code No.
1	What type of difficulty do you find in using this tool?	Easy to use	3	I
		Easy to understand	3	II
		Difficulty in use	2	III
2	How do you feel after using this tool?	Enjoyable experience	6	IV
		Different experience	2	V
3	What do you think about the adaptive suggestions given in the tool?	Relevant suggestions	6	VI
4	What do you think about this abductive form of inquiry used in the classroom?	New or Innovative	4	VII
		Confusion in hypothesis	3	VIII
5	How do you feel the use of mobile devices in the classroom?	Uneasiness	2	IX
		Interactive	3	X
		Helpful	3	XI

After the identification of key categories from the group discussion and their frequencies, some codes were defined. These categories can be further used to organize and group into themes [26]. For this paper, the identified categories of the Table 1 were combined into themes according to the nature of the responses as shown in Table 2. For instance, 'Helpful' and 'Interactive' categories were formed into 'Useful' (see Table 2). In addition, the total frequencies of each of these themes were also calculated by adding the frequencies of the combined codes as presented in Table 2.

During the analysis of the group discussions conducted with the students, the identified key categories are added in response of question 1 such as 'Help in understanding a topic', 'Difficulty in understanding questions' and 'Confusion in hypothesis', as depicted in Table 3. Similarly in question 3, students group discussions also found some more categories including 'Provide guidance in generating hypothesis, 'Correct answers straightaway' and 'Less explanations as suggestions' (see Table 3). In addition, only those frequencies are considered in this analysis, which are at least greater than 10 in number (11.6 % of total frequencies).

Table 2. Categories, themes and total frequencies during educators' group discussions

Q.No.	Combined Codes	Categories	Themes	Total Frequencies (Out of 8)
1	I, II	Easy to use Easy to understand	Usable	6 (75%)
	III	Difficulty in use	Difficult	2 (25%)
2	IV	Enjoyable experience	Engaging	6 (75%)
	V	Different experience	Unpleasant	2 (25%)
3	VI	Relevant suggestions	Relevance	6 (75%)
4	VII	New or Innovative	Innovative	4 (50%)
	VIII	Confusion in hypothesis	Confusing	3(37.5%)
5	IX	Uneasiness	Uneasiness	2 (25%)
	X, XI	Interactive Helpful	Useful	6 (75%)

Table 3. Categories, themes and total frequencies during students' group discussion

Q.No.	Combined Codes	Categories	Themes	Total Frequencies (Out of 86)
1	I, II, III	Easy to use Easy to understand Help in understanding a topic	Usable	53 (61.6%)
	IV, V	Difficulty in under-standing questions Confusion in hypothe-sis generation	Difficult	16 (18.6%)
2	VI	Enjoyable experience	Engaging	64 (74.4%)
	VII	Different experience	Unpleas-ant	10 (11.6%)
3	VIII, IX	Relevant suggestions Provide guidance in hypothesis generation	Relevance	46 (53.4%)
	X, XI	Correct answers straightaway Less explanations as suggestions	Irrelevant	17 (19.7%)

4.2 Discussion

According to the responses, question 1 revealed that most of the science educators consider this tool as usable enough to guide students and encourage them to think about the topic as shown in Table 2. One of the educators said "*…this application is very easy to use and the navigation is very straightforward*". However, there were two educators in discussion who found this tool a bit difficult to understand. One educator responded how "*…It may confuse students because they may not understand the purpose behind the use of the given adaptive suggestions in the application"*.

As far as the students' responses are concerned (see Table 3), they responded well in saying that 'ThinknLearn' is a usable application there but not enough understanding of what was expected by their educators. One of the students' groups highlighted that "*... questions were difficult and the given suggestions were not easy to understand*". It could be argued that they did not relate suggestions to understand the given topic. However, the concepts covered in 'ThinknLearn' had already been discussed in their theory classes earlier. In another instance, one participant of the other group described how "*it was not difficult but confusing on some occasions"*. Those participants who considered the application a bit confusing and difficult did not understand the deliberate purpose of this application to exploit students' higher level skills of critical thinking in such inquiries.

Responses to question 2 were very straightforward as most of the educators (6 out of 8) considered that this tool may lead to an interesting and engaging tool for high school students. In a similar fashion, students responded positively towards question 2 as more than 70% of them were positive about their learning experiences. For instance, one of the student group participants stated that "*I really enjoyed using it. This application was pretty good and engaging, it helped you to learn about your course (science)*". The other group participants gave an interesting comment about it during the discussions as *"this type of application keeps you on focus and requires better attention but it was an interesting and enjoyable experience*".

Compared to question 2 responses, the educators responded to question 3 in a similar fashion. Educators agreed that the suggestions given in the tool were very relevant to the given topic and all these suggestions are adaptive according to the answers given to the multiple choice questions asked in the tool. One of the educators explained the relevancy of the given suggestions in such a way that "*….the given suggestions are like hints, which can guide students for generating hypotheses and their explanations"*. Another one described how "*….these suggestions make them [students] think about the given topic and that is why I like the concept behind this engaging and interactive tool for learning purposes"*.

On the other hand, the student groups considered the critical thinking process as a bit of a burden, but on number of occasions, participants understood it as a challenging activity to learn from. One of the students stated *"…it is a challenging task as we have to think and find out the answers ourselves instead of having straightaway answers but I really enjoyed and learnt the topic from this*". On the other hand, there were 17 students who remarked like that *"…more detail should be provided" and "… relevant but they (suggestions) did not explain much"*. These comments showed that this application presents some challenges to the students to comprehend the given topic and make this application more engaging and interesting. However, they considered it a confusing way to generate hypotheses (see Table 3), compared to their educators. Thus, some way may be needed to convince those students about the challenging nature of this application or perhaps some further evaluation is also required to understand these challenges faced by the students.

The last two questions, as depicted in Table 1, were asked to the educators only because of their nature. With respect to how this abductive form of inquiry was a new or innovative way of learning (in response to question 4), only half of the educators supported this, while the others were confused or totally rejected this way of learning in the classroom. According to those who propose this abductive form of inquiry is an innovative way of learning, "*….this form of learning assists students to comprehend how to develop hypotheses and transform observational data into meaningful explanations*". In contrast, a few of them were against this concept because "*…this way of learning may confuse students because in a traditional way of learning, we first develop hypotheses and then collect the data afterwards but in this form of inquiry, we have to do both concurrently (collecting observational data and generating hypotheses)*".

From their replies, abductive form of inquiry not only helps to confirm both forms of data simultaneously but also guide investigators to understand both phenomena (deductive and inductive). Similarly, if an investigator starts with a hypothesis (deductive) or begins with any observation data (inductive), these are lacking in innovations because in both of inquiries, investigators tried to interpret observational data into meaningful hypotheses or vice versa [27]. These explanations may be further scrutinized with large number of experts, students or users for particular learning activity.

Responses to question 5 were promising as 75% of the educators found that mobile devices are helpful as interactive technology used in the classroom. One of the educators described how '*….mobile devices are the personal assets of our young generation and if they enjoy playing with them why can they not use them as learning tools*". However, one of the proponents of this concept elaborated that "*mobile devices could not be used in the classroom environments due to their small screens, negligence towards studies and expense (bringing their own devices)".*

Overall the responses in semi-structured group discussion were promising. Most of the educators and students both support the concept of abductive form of inquiry in the classroom after being convinced to some extent. However, there were a few suggestions given by those educators to improve 'ThinknLearn' further as "*this tool can be used as teacher-oriented along with student-centered approach*" and "*can be adaptive in such a way so that teachers can assign different inquiry learning activity in a classroom or outside if possible*". These suggestions indicate that educators were very enthusiastic to use such mobile learning tools in the classroom compared to the students. In addition, educators considered the abductive form of science inquiry an innovative and challenging activity that may enhance students' learning and inquiry skills. However, students were reluctant and confused to use this kind of approach as they believed that the hypothesis generation activity with provided suggestions may become a burden in understanding the underlying domain knowledge.

5 Conclusion and Future Work

In this paper, the comparison between educators and students' responses to the use of the mobile abductive inquiry tool 'ThinknLearn' in the classroom has been discussed. According to the data collection and analysis, this form of learning not only guides students in learning science by doing science but also provides a way that students can think in order to generate hypotheses and explanations of the given topic. The educators considered that 'ThinknLearn' has considerable mobile and software quality measures. However, while students considered this tool an interesting and engaging, some of them were not convinced with the challenge provided in terms of the hypothesis generation activity. This may need further development so that students may be comfortable with this new approach for inquiry learning activities in the classrooms.

In the future, 'ThinknLearn' can be further evaluated with other students and educators, which may help us to comprehend the use of such abductive forms of inquiry in the classroom, so that it may become an established learning practice in science education. For this purpose, we are trying to implement this tool for all science subjects at school levels. In addition, an extended version may be designed for educators so that they may assign different tasks or learning activities related to science inquiries within or outside the classroom.

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