New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION

Using Apps as Digital Scaffolds for Science Learning in the Primary School

Professor Garry Falloon[1]

Abstract

Recent technological developments have seen increasing numbers of mobile digital devices being used in schools, and the advent of these has opened new possibilities for supporting science learning. This paper reports outcomes from primary students' use of apps as digital scaffolds for self-regulated learning, in a 'Forms of Energy' inquiry. Results identified design features of the apps that were effective in supporting students' organisation and procedural knowledge, but found limitations to how well they could support conceptual understanding. Outcomes highlight the importance of human factors in optimising learning benefits from using apps in science, and underpin the importance of teachers' conceptual knowledge to students' science learning. Keywords: apps, iPads, self-regulated learning, science, digital, scaffold.

1. Technology in Science Teaching and Learning

There exists a long history of research into using technology to support science teaching and learning, dating back to the 1980s and 90s [1]. Many early studies focused on the efficacy of technology for teaching science concepts using simulations [1] [2], while others investigated their value for helping students master science content and process skills [3]. Recent work has included studies into computer-assisted instruction (CAI) for supporting student engagement and retention [4], enhancing achievement in secondary school biology [5], and for personalising learning in elementary school science inquiries [6]. Most early quasi-experimental studies took place in laboratory-like settings using desktop computers and specifically-developed software packages, while more recent work has focused on the interaction between students, teachers and technology "in dynamic classroom settings" [7 p.412]. This changed focus has been supported by technological developments including multimedia-capable, portable devices such as laptops, Chromebooks and tablets. This means teachers now have access to sufficient technology to support different science learning models, including more individualised, inquiry-oriented approaches. Software developers have also provided teachers with thousands of free or very low cost applications (apps) covering all curriculum topics, that can be loaded onto devices either brought from home (via Bring Your Own Device or BYOD), or purchased and used on school-owned, mobile-device 'pods'. The combination of portability and affordability means teachers and researchers are no longer tied to laboratory settings or quasi experimental designs for exploring technology's role in supporting science learning. The change to mobile devices and apps has shifted the focus of research towards how technology might function as scaffolds *alongside* students, as they complete practical investigations in the field or classroom. There is emerging evidence that device tools such as cameras, wifi, data access, sharing and broadcast services, location-aware functionality, data logging capabilities and specialty apps, are providing new opportunities for teachers to better engage students in science learning [8]. New approaches to use and research are also emerging that more accurately reflect technology's contribution in regular classrooms, supported by innovative data capture tools that allow researchers to gain unique insights into how students use it during normal classroom activities [9].

2. Background and Research Context

This article details the use of Okiwibook Science apps in an inquiry-based 'Energy' topic involving two teachers and 64 nine and ten year old students (34 girls and 30 boys) in a New Zealand primary school. The teachers and students worked collaboratively in a large, BYOD innovative learning environment (Figure 1). Data were gathered over three weeks as the students completed a range of self-directed, workshop-based learning experiences using the apps as digital scaffolds along with various functions of their iPads, to record and communicate their work.

[1] The University of Waikato, New Zealand

Figure 1. Student workstations in the ILE

The research question was:
How were device and app scaffolds used by students during their self-directed science inquiry?

2.1 The Apps

The Okiwibook Science apps comprise three main components. These are an optional science quiz, a scrolling page containing information about equipment and basic procedural steps, a short textual explanation of the science behind the experiments, and a silent video with numbered stages illustrating how each experiment is set up, and its results.

3. Data Collection

IPad display and audio data were collected using a unique data capture tool developed at the researcher's university. The tool was installed on a set of university-supplied iPads, due to issues with installing it on student-owned devices. Full details of the tool's operation can be found elsewhere [10], but briefly it records as video (with audio) all interactions students make with the device's display, the apps, and each other, as they complete their work. After each workshop, recorded files were transferred from the iPads to the researcher's laptop, for later analysis. Using this system meant data could be gathered from all groups at the same time, irrespective of their location in the classroom or other space.

4. Analysis

Data were analysed using Studiocode video analysis software. Due to the time-consuming nature of coding video data, a representative sample (teacher-selected) was identified for final analysis (10½ hours). Main and sub codes were developed following double-blind evaluation of 3 hours of the sample data, and built into a Studiocode template that was used to code events onto timelines (Figure 2). Table 1 summarises the main and sub-codes, with a brief description of their meanings.

5. Results

Results for each group were exported from Studiocode into an Excel spreadsheet for analysis. These results were duplicated and combined into a single table to support analysis across all groups. The data export included total event counts and total and average time per event. To enable charting of percentages of actual runtime (ie., time 'on the task'), total and average times were converted to percentages of a whole day (ie., 24 hours). These data were then used to plot charts for each main and sub code category. The chart below (Figure 3) illustrates data for *planning and preparation.* Due to space limitations, other data will be reported in the Discussion.

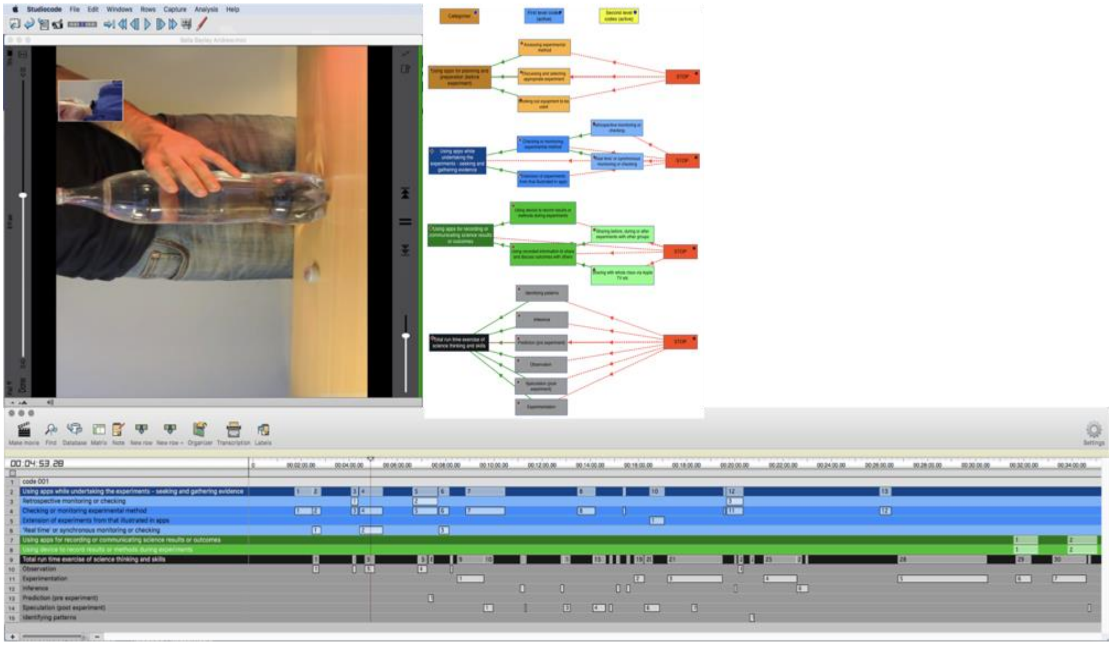

Figure 2. Studiocode timeline showing Okiwibook video scaffold (top left), the coding template (top right) and the code timeline (bottom).

Table 1:
Summary of main and sub-codes with description

Main code	Sub-code/s	Description
Using apps for planning and preparation	Accessing experimental method	Students reviewed experiments from the range of options, deciding which was viable given resources and time available.
	Discussing and selecting appropriate (viable) option	Checking and discussing the experimental method, organising and arranging equipment
	Working out needed equipment	
Using apps during experiments – gathering evidence, seeking explanations	Checking or monitoring method	Students accessed textual and video scaffolds for various reasons during the experiments. These included mirroring, comparing outcomes with the video, 'step checking' methods, seeking science explanations, identifying variables for testing
	Extending or modifying experiment (manipulating variables)	
Using apps for sharing, recording or communicating science results or outcomes	Results or outcomes during experiments	Using iPad video and camera functions to capture stages and outcomes from their experiment. Sharing image data via Apple TV in class plenaries. Capturing image data for Facebook and Edmodo.
	Using recorded information to share and discuss outcomes with others	Making notes using Pages app.

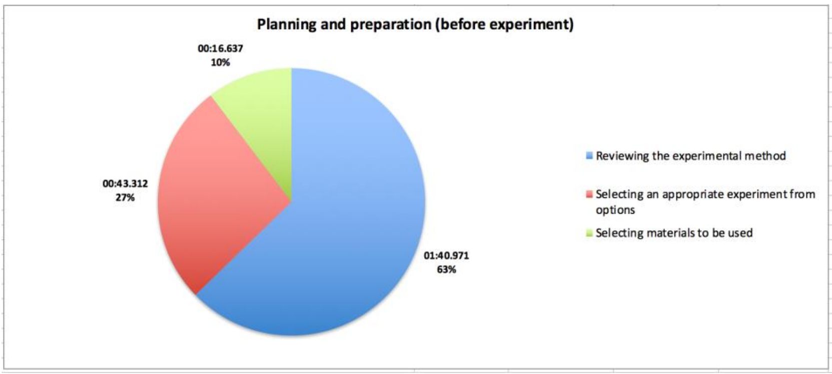

Figure 3. Charted data for *planning and preparation*

6. Discussion

Results demonstrate the seamless way these students integrated device functions and app scaffolds with their practical work, at different times and for different purposes. Most frequently accessed scaffolds related to understanding experimental methods - either for selection and planning (63% in *planning and preparation*) or after the experiment had been selected but before practical work commenced (24% in *understanding and accessing*). Data linked to the first of these indicated students initially reviewed textual scaffolds relating to equipment (10%) and methods (63%) to gauge the viability of the experiment, before making a final selection (*selecting* was 27% in *planning and preparation*).Audio suggested students did this to evaluate the type and level of resourcing needed, and whether the experiment was within their capabilities and could be completed in the allocated time. After selection, students reviewed the method again (24% in *understanding and accessing*), but this time they generally used the video rather than reading the text scaffold. Audio of their discussions highlighted the video's value for helping clarify and understand the steps needed to complete the experiment, before they started. Students also frequently accessed the video during experiments (20% in *understanding and accessing*), using it as a 'visual check' to evaluate progress or assess the accuracy of their methods. It was particularly useful for helping analyse problems if the experiment did not produce the expected outcome, as students could visually compare their procedures with those in the video, to determine variables possibly affecting the results. An interesting feature of the video was the absence of audio. Whether this was a deliberate design decision or not is unknown, but data suggested there may have been learning advantages from doing this. The absence of audio meant students needed to interpret and closely analyse the videos *by and for themselves*, both for initial guidance, and later as a reflective tool against which to compare their procedures and results. Doing this triggered much interaction between students as they debated and evaluated the video's content in relation to their own procedures and results. There was substantial evidence of higher order thinking (analysis, evaluation, critical) in many discussions, as students used a range of strategies linking information in the video with their practical work. Some groups 'mirrored' the stages shown in the videos using their own equipment - pausing and replaying it as they copied step-by-step, what it displayed. Others completed their experiment, before going back to the video to check that their results were like those recorded there. If results differed, students frequently replayed the videos discussing variables that might have influenced their outcome, before repeating the experiment. Device features such as the camera and video recorder were used extensively to capture different aspects of students' practical work (57% in *sharing, recording*). Some groups allocated a person to video the experiment from set up to completion, while others took this role at different times during the practical work. The recordings were an important resource both during the workshops and at their conclusion. During the workshops, recordings were shared between groups either electronically using Wi-Fi or Bluetooth, or through physical interaction (groups meeting and sharing, 22% in *sharing and recording*). These exchanges were formative, allowing groups to benefit from the work of others by helping identify mistakes in methods or other variables that may have contributed to unexpected outcomes. Being able to do this *while working* benefited the students as they learnt from others' mistakes and they could compare methods, speculating on the effect these had on results. The recordings were also valuable during class plenaries where teachers got students to discuss their methods and results. Students broadcast their recordings via Apple TV (Figure 4), using them as visual aids to explain what they did and their developing science understandings. The plenaries were an important opportunity for teachers to ensure students were constructing accurate science knowledge. They used them to clear up misconceptions and discuss, in 'child-friendly' language, scientific explanations of experiment results. However, this required the teachers to thoroughly research the concepts themselves, in preparing for this topic. Interestingly, while the apps contained textual scaffolds summarising the main science concepts, very few students read these. Data suggested this was due to the complexity of language used, and the length of the explanations. As one student commented, "maybe they could've had an option on the video... you could press a button and they could explain what's going on while you're watching it..." (student A, 1.33:45). Feedback like this indicates app developers should be cognisant of how accessible scaffolds are to their target groups.

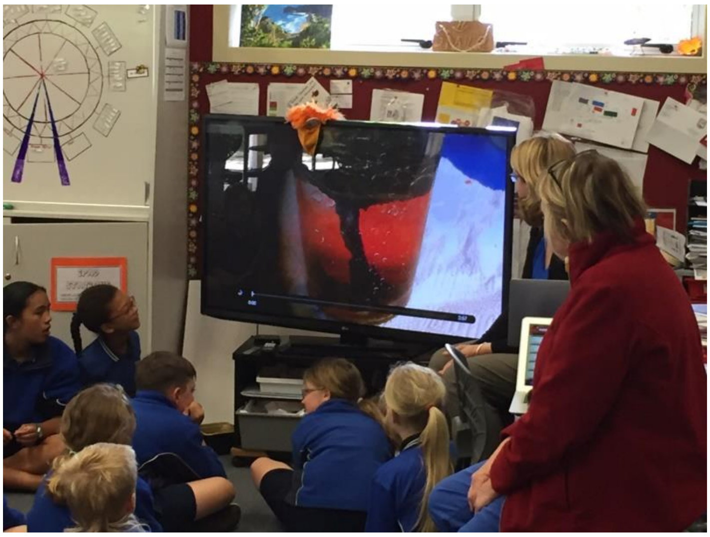

Figure 4. Students used Apple TV to share recordings during class plenaries

7. Conclusion

In this study, integrating apps with 'hands-on' science supported aspects of students' learning, and was compatible with teachers' curriculum and competency goals. However, while useful for supporting students' organisation and procedural knowledge, these apps were limited in their ability to scaffold conceptual development. If teachers plan to use apps like these as scaffolds alongside practical work they need to be mindful of these limitations, and support students' conceptual learning by upskilling themselves and combining a range of teaching approaches.

8. References

[1] De Jong, T. (1991). Learning and instruction with computer simulations. Education & Computing 6, 217–229.
[2] Lewis, E., Stern. J. & Linn. M. (1993) The effect of computer simulations on introductory thermodynamics understanding. Educational Technology, 33, 45–58.
[3] Brophy, A. (1999). Is computer-assisted instruction effective in the science classroom? M.S Thesis, California State University: Dominguez Hills.
[4] Kara, I. (2008). The effect on retention of computer-assisted instruction in science education. Journal of Instructional Technology, 35(4), 357-364.
[5] Osman, K. & Vebrianto, R. (2013). Fostering science process skills and improving achievement through the use of multiple media. Journal of Baltic Science Education, 12(2), 191-204.
[6] Song, Y., Wong, L. & Looi, C. (2012). Fostering personalised learning in science inquiry supported by mobile technologies. Educational Technology Research and Development, 60, 679-701.

[7] Kim, M. & Hannafin, M. (2011).Scaffolding 6th graders' problem solving in technology-enhanced science classrooms: A qualitative case study. Instructional Science, 39, 255-282.
[8] Looi, C., Sun, D. & Xie, W. (2015). Exploring students' progression in an inquiry science curriculum enabled by mobile learning. IEEE Transactions of Learning Technologies, (8)1, 43-54.
[9] Falloon, G.W. (2016). Researching students across spaces and places: Capturing digital data 'on the go'. International Journal of Research and Method in Education. Retrieved from http://dx.doi.org/10.1080/1743727X.2016.1219983