International Journal for Educational Media and Technology
2016, Vol.10, No. 2, pp. 44-51

Writing in Digital Science Notebooks: What Features Do Elementary Students use?

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This study investigates the potential of a tablet-based note-taking application (TbNA) to act as a digital science notebook for elementary students. Eighteen fourth and fifth grade students used a TbNA during a six-week intensive summer course. During the program, students used TbNAs as personal digital science notebooks in their science-related lessons. Students' notebook entries and survey responses regarding their experience were collected. The study discusses how students made use of various features within the TbNA, particularly in terms of their writing.

Keywords: Elementary, Science Practices, Technology Implementation, Science Notebook

Introduction

Science notebooks, traditionally in the form of paper-based notebooks, are commonly used in elementary classrooms to promote students' scientific practices, such as constructing explanations and obtaining, evaluating, and communicating information. Building on this strong foundation, we are interested in exploring the potential of *digital* science notebooks, and the benefits, if any, they might bring to the elementary classroom. As part of this exploration, we examined how fourth and fifth graders used a tablet-based note taking application (TbNA) as a science notebook. Particular attention was paid to how students used the functional tools within the TbNA, such as voice recording and picture taking, in their science-related writing.

Background of Study

It is well known that professional scientists view reading, writing and speaking as foundational tools of their profession (Yore, Florence, Pearson, & Weaver, 2006). Because actual scientists rely so heavily on these skills, many educators believe that literacy practices should be a central component of science education. Writing, in all its forms, has been emphasized as an integral part of doing and learning inquiry-based science (Baker et al., 2008; Pearson, Moje, & Greenleaf, 2010; Yore, et al., 2006). Evidence of this can be seen in *A Framework for K–12 Science Education* (NRC, 2012), which asserts that "from the very start of their education, students should be asked to engage in the communication of science [and] should write accounts of their work, using journals to record observations, thoughts, ideas, and models" (p.76). Similarly, the American Association for the Advancement of Science (1993) specified communicating and defending a scientific argument as one of the fundamental abilities of science inquiry. Bybee (2000) elaborated on this idea by emphasizing the need for students to practice accurate and effective communication in science including, "writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments" (p. 34).

Writing in Science

Science notebooks have been leveraged as a way to encourage students at the elementary level to write within science (Baxter, Bass, & Glasser, 2001; Fulton & Campbell, 2014; Fulwiler, 2007; Rivard, 1994). Science notebooks serve as a place where students describe and document their experiments as well as their interpretation of the results (Butler & Nesbit, 2008). As a result of using science notebooks in this way, students are being exposed to the structured type of writing that accompanies the scientific method and the use of science process skills (Nesbit, Hargrove, Harrelson, and Maxey, 2004). Research has shown that when students incorporate the communicationrelated aspects of science, such as the development of explanations within their science notebooks, there is a strong, positive correlation between their performance and their understanding of the content (Aschbacher & Alonzo, 2006; Fulton, 2012; Ruiz-Primo, Li, Tsai, & Schneider, 2010).

Writing in this way can be a challenging undertaking for primary-aged students. As most budding scientists would agree—writing about scientific practice is not an easy task; it requires a set of skills that are learned and refined over time. Of course this difficulty has implications for educators who must work hard to scaffold their instruction (Ruiz-Primo et al., 2010). Some effective ways teachers can scaffold instruction include providing writing frames that support students' use of scientific language (Choi, Notebaert, Diaz, & Hand, 2010; Ruiz-Primo et al., 2010) and by delivering explicit instruction (Baxter, et al., 2001; Ruiz-Primo et al., 2010; Tucknott & Yore, 1999).

Information Communication Technology

While explicit instruction and other scaffolding mechanisms may support students in developing their scientific writing, other studies suggest that Information Communication Technologies (ICT) are another avenue educators should consider for their students' development. Some documented benefits of ICT, in relation to science education, include increased encouragement regarding communication, collaboration in science research activities, collection of scientific information, and interaction with multimedia resources (see Bingimlas, 2009). Recent studies, for example, discuss the potential of digital notebooks in various formats, such as web-based digital science notebooks (Rappolt-Schlichtmann, Daley, Lim, Lapinski, Robinson, & Johnson, 2013), virtual science notebooks (Wu & Pedersen, 2011), electronic laboratory notebooks (Myers, Mendoza, & Hoopes, 2001), and e-notebooks (Miller & Martin, 2016).

Building on previous studies examining ICT in relation to science practices, this particular project introduced a tablet-based note-taking application (TbNA) to an elementary science classroom. It examined how using the application as a digital science notebook impacted students' scientific writing. In this paper we focus on how various features of the TbNA such as handwriting, voice recording, and picture taking, enhanced or hindered students as they completed common science-related tasks. The rationale for the study was the belief that a well-designed TbNA should allow students to engage in the same writing practices they would use in a paper-based notebook but with additional technology-supported tools (e.g., camera, microphone) that might support and even enhance students' scientific writing.

Methods

The research was conducted at a university-sponsored summer program in the Pacific region. Twenty-five students in Grades 4 and 5 participated in the six-week course. Twelve tablet computers (i.e., iPads) were available to students and each tablet had the TbNA, called *Notability* installed. During class time, all students collaborated with a peer to document their work within the TbNA.

On the first day of class, the teacher introduced the TbNA as a digital science notebook and demonstrated how to use it. After a brief introduction to the TbNA, the teacher allowed students to explore the application and play with its various tools. Although the teacher stated that students became familiar with most of the tools quickly, she also provided direct instruction on how to use specific tools. This was an effort to ensure students were aware of the tools and knew how to access them within the TbNA.

Beginning on the third day, students were free to use the TbNA as their daily science notebook. At the end of the six-week course, students' notebook entries were collected. Students also responded to a survey (described below) about their use of the TbNA. In total, 18 students out of 25 completed the survey.

Accordingly, the responses from those 18 students and their notebook entries were analyzed for this paper. For students' survey responses, descriptive data analysis was conducted to examine the use of specific tools available in the TbNA. In addition, students' entries from the TbNA were analyzed using a content analysis similar to that used by Ruiz-Primo and Li (2004). The surveys and notebooks were analyzed to determine which technology-supported tools students used as they wrote in their science notebooks.

Results

TbNA Use – Survey Results

The survey included seven questions. One question was multiple-choice and the six remaining questions were open-ended. The multiple-choice question asked students to identify the tools available in the TbNA that they used while recording their work. The question listed all of the available tools and students were asked to simply check the ones they had used. Table 1 presents the frequency of students' responses.

As shown in Table 1, more than 70% of the students reported taking a photo, drawing/coloring, erasing, using handwriting, typing, cutting/pasting, highlighting, and zooming. On the other hand, only a few students reported inserting figures and web clips. Similarly, only a few students added stickies or used audio recording. Interestingly, none of the students reported using the palm rest, which suggests that the 16 students who reported using the handwriting tool, might not have been able to do so in a natural way as they would in a paper-based notebook, since this is really dependent on the palm rest feature.

Table 1.
Tools Used by Students

Tool	Number of Responses	% of Responses
Taking a photo	17	89%
Drawing/Coloring	17	89%
Erasing	16	84%
Handwriting	16	84%
Typing	15	79%
Cutting/Pasting	15	79%
Highlighting	14	74%
Zooming (Magnifying glass)	14	74%
Changing paper	10	53%
Sharing (Google Drive)	8	42%
Inserting Web clip	4	21%
Inserting figures	3	16%
Adding stickies	3	16%
Recording Audio	2	11%
Palm resting	0	0%

Next, five open-ended questions asked students to identify their favorite, least favorite, most helpful, most used, and the most difficult tools. Students were also asked to explain their answers. Students' responses to those questions are shown in Table 2.

Table 2.
Tools Identified by Students

	Most favorite	Least favorite	Most helpful*	Most used*	Most difficult
Drawing/Coloring	7	3		3	8
Typing	6		16	15	
Erasing	2	6			2
Taking a photo	2		2		1
Magnifying		3			1
Recording Audio		1	1		1
Cutting		2			
Highlighting				1	2
Inserting Figures	1				
Other		3	1		3

* Some students listed more than one tool.

As shown in Table 2, students favored the tools of drawing/coloring and typing. Seven students chose the drawing tool as their favorite. Statements provided by students as to why they chose the tool included, "It let me write and draw with the same icon," "Because you can write and draw with it," and "Because I can show people my work and more diagrams." Six other students chose the typing tool as their favorite. These students noted that they liked the typing functionality because it was "fast" and "the keys are easy to press." One student noted that he or she preferred to "type instead of write."

The students' least favorite tool was the eraser, as six students chose this. One student explained that the eraser tool "erased to[sic] much at once." Other students noted that the eraser "sometimes…erases everything" and can accidentally "erase the things that you don't want." While the drawing/coloring tool was a favorite for many, three students selected it as their least favorite. Reasons given included "because its slow," "It was hard to write" and "It is hard to control."

Interestingly, the drawing/coloring tool was also identified as the most difficult to use. Students' reasons for this were similar the ones specified for the least favorite tool. In addition, 16 out of 18 students chose the typing tool as the most helpful tool for data recording, and 15 identified it as the most used tool. This suggests that the pen/pencil tool may not have been intuitive for students, therefore, most students used the typing tool as their main writing method rather than the handwriting tool.
A final question asked students which notebook they liked better: a traditional composition notebook or a digital notebook. Thirteen students chose the digital notebook over the traditional; three students chose the composition notebook; and two students did not respond. The three students who chose the composition notebook stated that they liked it better because it was easier to write and draw. In contrast, students who chose the digital notebook felt the technology-enabled device was easier and faster to use. Additionally, some students mentioned that the digital notebook had more tools to use and was more fun to work with.

TbNA Use - Students' Notebook Entries

Along with the students' self-reports, their notebook entries from the 12 tablet computers were collected and analyzed. How did students use the various tools of the TbNA in their writing? As a whole, students' notebook entries varied in terms of their format and content. For example, entries on catapult design varied from 1 to 6 pages in length. Despite these differences in length, the tools that students used throughout their entries were similar. That is, most students used typing, picture taking, drawing/diagraming, and handwriting while composing their notebook entries. Examining the students' notes also revealed that students used different color pens, graphic organizers such as tables and charts, and highlights as they worked to document and communicate their ideas scientifically. As an example, Table 3 shows how many TbNAs used each tool for documenting the catapult design describes the usage of tools within the entries on catapult design. These results reflect students' responses about their own tool use.

Table 3.
Evidence of Specific Tool Type within Entries on Catapult Design (n=12)

Photos	Typing	Handwriting	Colored Pens	Tables/Charts
12 (100%)	12 (100%)	10 (83%)	8 (67%)	7 (58%)

While both handwriting and typing were frequently used tools, students' notes show that the typing tool was the main method for writing rather than the handwriting tool. In fact, students used the typing tool to document their observations and thoughts and used the handwriting tool to label photos, record data, and sketch ideas (see Figure 1).

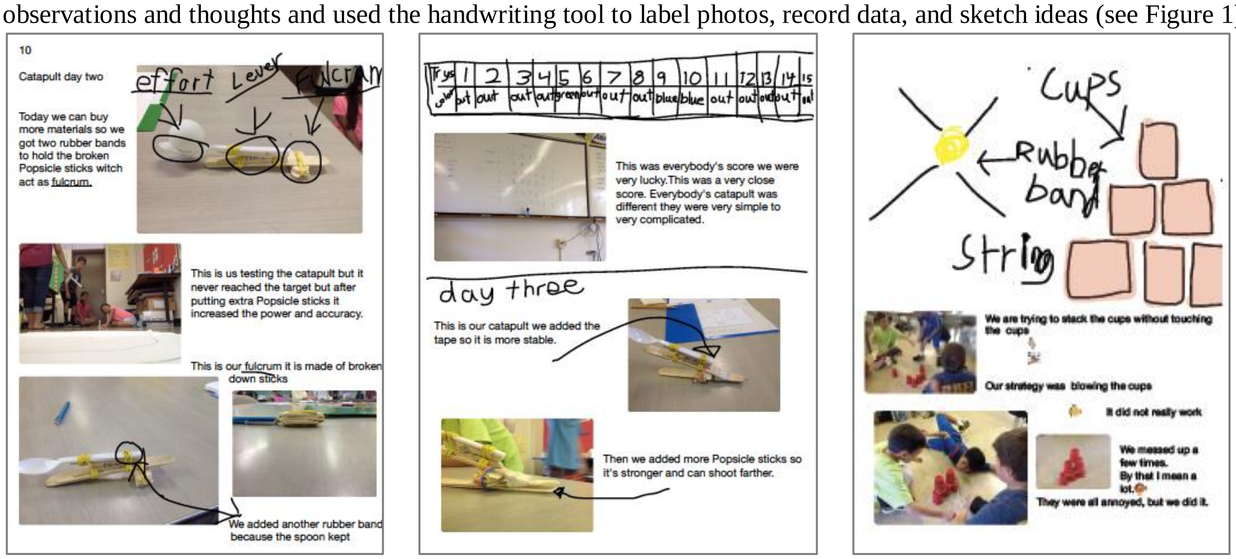

Figure 1. Samples of students' science-related writing in a tablet-based note-taking application.

Similarly, it was noted that students frequently took pictures to document their work rather than drawing it out. However, in several cases, students created drawings as part of their planning (see Figure 2) but then documented the building process and final product using photos.

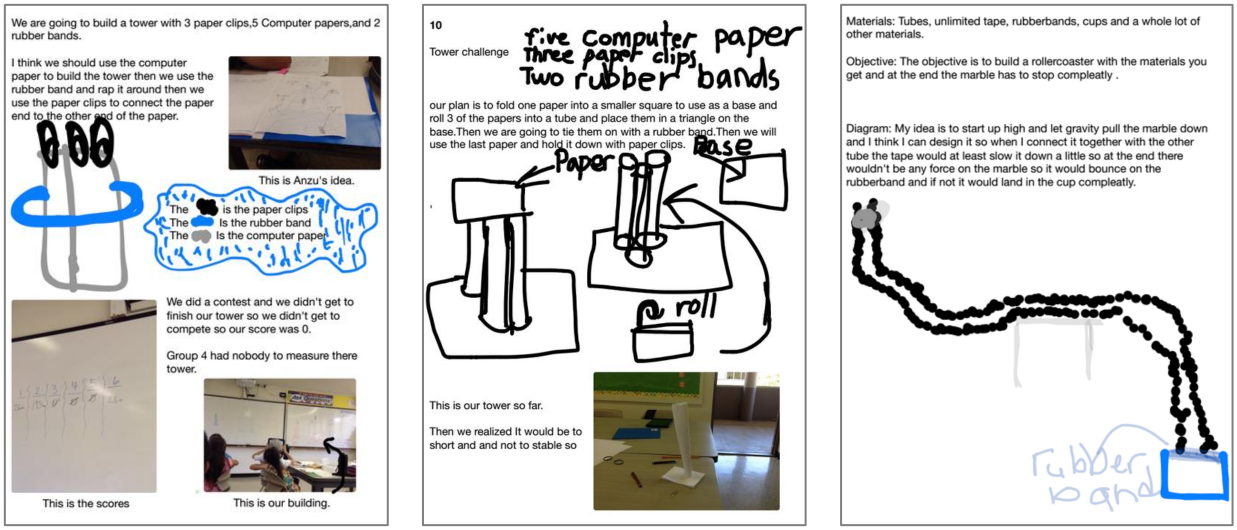

Figure 2. Students drawing for planning and designing

These examples illustrate that even though some tools (i.e. handwriting, drawing) might have been used less than others (i.e. typing, photos), they were still useful for different purposes. In other words, it seems there were times when drawing was necessary rather than taking pictures, and handwriting was more convenient than typing with a keyboard, for some tasks. Importantly, students were able to choose those tools within the TbNA and seemed conformable switching as needed.

What was not evident in students' entries was the use of audio recording. Even though two students responded that they used the audio recording tool, we did not see how this tool was used. This does not mean that students never used the audio recording tool, however, it did catch our attention since students mentioned this tool in the survey. In addition, one student chose audio recording as his or her favorite tool, explaining, "It was easier myself talking [sic] or typing my review." Another student chose audio recording as a tool that was hard to use, and stated, "It's always recording the wrong thing." Because this feature did not appear in students' notes and was not mentioned frequently in the students' survey responses, further investigation on the use of this tool to promote writing in science is needed.

Discussion

This study aimed to investigate how a tablet-based note-taking application might facilitate students' writing in science, by examining how students used various tools within a TbNA. The results suggest that most students used a variety of tools without much difficulty. Students' self-reports combined with the actual notebook entries showed that most students used the tools for typing, drawing, taking and inserting photos, and highlighting text. While there were some tools (i.e. typing and taking a photo) that were used more than others, students seemed to choose tools for different purposes. Importantly, the TbNA provided an environment in which students could maintain practices they typically used in paper-based notebooks (i.e. handwriting and drawing), but could choose from additional tools that could further support their writing as well. Studies have shown that there is a close relationship between students' learning and having choice or control about *what* is to be learned and *how* to learn it (Collentine, 2011; Kraiger & Jerden, 2007). Hence, it is believed that having choices in the form of TbNA tools could enhance students' scientific practices by facilitating their writing and increasing their motivation and engagement with tasks. This presents a benefit of digital science notebooks over paper-based notebooks.

In addition, the TbNA has tools for audio recording and file sharing. It was anticipated that these tools would support students' writing in ways not possible with paper-based notebooks. For example, recording audio could serve as a means to rehearse ideas. Fulton (2012) found students recorded and listened to their ideas, modified their thinking, and repeated the process until satisfied with their answer, which helped students assess their understandings. The lack of evidence suggests that the audio recording tool may need to be introduced explicitly for students to understand how it can be used and to incorporate it within their entries.

Studies also have shown the importance of formative assessment in guiding students toward learning and academic achievement (Hwang & Chang, 2011). We believed the cloud-based features could facilitate formative assessment by making communication between teacher and learners, and among learners easier. In this study, however, we were not able to examine how formative assessment was conducted using the TbNA.

Thus, future studies are needed to investigate what students know about these tools and how they use these tools. Why are particular tools less popular than others? Are tools easy or difficult to use? In which ways can these tools enhance or hinder students' scientific practices?

Conclusion

Taken together, the results reported here are encouraging in that they show how easy it is for elementary-aged children to use a TbNA in the context of their science lessons. It is promising that the majority of students seemed to recognize some value associated with the digital science notebook over the more traditional composition notebook. Furthermore, the results demonstrate the potential of TbNAs to be used as digital science notebooks in applied settings. Future investigation is needed to examine how students use TbNA's in various scientific practices including organizing, analyzing, and interpreting data, as well as constructing explanations and engaging in evidence-based arguments.

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