

# Using Digital Science Notebooks to Support Elementary Student Learning: Lessons and Perspectives From a Fifth-Grade Science Classroom

[Angelina Constantine](#)  
*University of Minnesota*

[Karl G. Jung](#)  
*University of South Florida*

The exploratory case study described in this paper examined the experiences of an elementary science teacher as he integrated iPads into his teaching. With the intent of finding a purposeful use for the district's 1:1 iPad initiative in his science classroom, he adopted digital science notebooks for the first time. During planning sessions alongside an instructional coach, this teacher worked to harness the maximum potential of the digital notebooks' capabilities to support his students' science learning. Data collected from coaching conversations, observations, student notebooks, and a stimulated recall interview uncovered the ways the teacher planned for digital science notebooks and how he could use them to support student science learning. Findings show that structured page templates for students' notebooks modified from previous work helped this teacher successfully incorporate the digital notebooks to enhance his students' learning beyond what a traditional composition notebook can provide. Furthermore, the teacher's perceptions of his experience with digital notebooks was overwhelmingly positive. He considered the value of digital notebooks to be superior to traditional notebooks and shared recommendations for other teachers who may also be considering using digital science notebooks for the first time.

Science notebooks have long existed as an accepted and advocated feature in elementary science teaching (Aschbacher & Alonzo, 2006), providing students space to track and maintain information about classroom investigations, while also serving as thinking spaces in which students can write and draw while making sense of the content they are exploring (Gilbert & Kotelman, 2005). Additionally, the use of science notebooks has been advocated to support collaboration among teachers, develop student literacy, and provide students with space to share their understandings (Gilbert & Kotelman, 2005; Shepardson & Britsch, 2000).

Beyond these uses, science notebooks provide teachers with an effective assessment tool by opening a window into student thinking and understanding of science concepts (Ruiz-Primo, Li, Ayala & Shavelson, 2004). Through our experiences working in elementary classrooms, we have seen science notebooks take many forms, varying from collections of specific worksheets to spiral bound notebooks where students capture their activities and learning during lessons in their own manner.

Technology continues its rapid and dramatic advance in complexity and accessibility. With this advancement, technology in schools has been increasingly ubiquitous, as districts across the country adopt 1:1 tablet initiatives (Richardson et al., 2013). As such, science teachers and science teacher educators must learn to integrate these new technologies purposefully to align with their curricular goals (Hughes, 2005) and support meaningful science learning.

Yet, while technology becomes ever-present in classrooms, research in science, technology, education, and mathematics (STEM) education suggests STEM teachers struggle with understanding how best to integrate technology (Constantine, Rozowa, Szostkowski, Ellis, & Roehrig, 2017; Herschbach, D.R., 2011; Wang, Moore, Roehrig, & Park, 2011). This question, how best to integrate technology, serves as the basis for the current study.

As 1:1 tablet initiatives increase, teachers may find an answer to that question by transitioning from using paper notebooks to engaging their students in digitally produced notebooks (Fulton, Paek, & Taoka, 2017). A burgeoning body of research examining the use of digital science notebooks exists, and this study seeks to expand this research by examining a single elementary science teacher's intentional planning for digital notebooks during science units and how those plans manifested when implemented.

Additionally, because this elementary teacher implemented digital notebooks in his classroom for the first time, we examined his perceived value and effectiveness of the digital science notebooks within his fifth-grade classroom. His perception likely influenced his implementation of digital notebooks with future classes of students. These insights could be particularly valuable and relevant with new research emerging about preservice teachers' use of digital notebooks in science methods courses (Kreps Frisch, 2019), to help inform instructors' modeling based on in-service teacher experience.

## **Review of the Literature**

### **Science Notebooks**

Science notebooks provide students a space to record the ideas and information they produce during a science lesson (Fulton, 2017). Within a notebook, students may include items such as “problems they are trying to solve, the procedures they use, observations they make, conclusions they arrive at, and their reflections” (Ruiz-Primo et al., 2004, p. 1477), and they generally serve as a written description of what students did and learned in a lesson. The utilization of science notebooks within elementary classrooms has been a frequently advocated strategy in many schools, districts, and teacher education programs for many years (Aschbacher & Alonzo, 2006).

Advocates offer a wide range of benefits and uses for notebooks in support of science learning. For example, Gilbert and Kotelman (2005) saw notebooks as not only benefitting student learning, but also supporting the work of teachers. They identified five reasons to use science notebooks in elementary classrooms:

1. Notebooks are thinking tools.
2. Notebooks guide teacher instruction.
3. Notebooks enhance literacy skills.
4. Notebooks support differentiated learning.
5. Notebooks foster teacher collaboration.

Similarly, Fulwiler (2007) advocated for notebooks as a space to provide meaningful writing instruction, scaffolding, and practice for students, while centering this writing “on notebook entries that help develop conceptual understanding and critical thinking within the context of their investigations” (p. 5). Notebooks also afford students the opportunity to use drawings, along with their writing, as they construct their understandings of the content they are studying (Shepardson & Britsch, 2000).

Another significant advantage notebooks present is the window they open into students’ thinking, and the assessment of student learning this window allows (Shepardson & Britsch, 2000). Science notebooks can guide teachers to see student understandings and serve as a “diagnostic tool for informing practice” (p. 29) through the use of notebook entries as a formative assessment. Ruiz-Primo et al. (2004) examined the effectiveness of science notebooks as an assessment tool for examining student learning and opportunities to learn by analyzing the implementation of curricular activities, student performance, and teacher feedback in science notebooks. They determined that science notebooks can be reliably scored and can provide data on student performance that is consistent with other performance assessment scores, indicating notebooks provide a means to assess student understanding of science concepts (Ruiz-Primo et al., 2004).

## **Digital Science Notebooks**

One response to the question of how to incorporate technology into science and STEM classrooms is utilizing digital science notebooks in lieu of traditional paper notebooks (Fulton et al., 2017; Miller & Martin, 2016; Paek & Fulton, 2016; Rappolt-Schlichtmann et al., 2013). Numerous technologies could be implemented to accomplish these digital notebooks, but perhaps the most appropriate would be tablets, such as iPads (Fulton et al., 2017).

Tablets provide many of the same benefits as a traditional notebook (i.e., mobility, ability for students to write and draw, and unstructured space for students to create and capture their thinking), while also including capabilities that go beyond traditional notebooks (i.e., video and audio recording, photography, dictation, typing tools, and data collection capabilities; Fulton et al., 2017; Miller & Martin, 2016). These additional capabilities can create enhanced opportunities for students to communicate their thinking and demonstrate their understanding through multiple mediums, with “new outlets for expression that static paper and pencil [do] not afford students” (Miller & Martin, 2016 [NEED P. #]). Additionally, digital notebooks provide a means by which students can access rich prior knowledge by archiving videos, images, and audio recordings of previous learning experiences.

An emerging body of literature has explored the use of digital science notebooks (Fulton et al., 2017; Miller, Krockover, & Doughty, 2013; Miller & Martin, 2016; Paek & Fulton, 2016; Rappolt-Schlichtmann et al., 2013), which has highlighted the benefits and advantages of using digital science notebooks. Included in these benefits are increased student understanding, motivation, and engagement (Miller et al., 2013; Rappolt-Schlichtmann et al., 2013) as well as greater student independence during inquiry investigations (Miller et al., 2013). These benefits result from the fact that digital notebooks are “valuable tools for

providing multiple modes of communication, assessment, and differentiation for diverse students in the classroom” (p. 89). Fulton, Paek, and Taoka (2017) shared a similar position, arguing that the capabilities of a digital notebook allow students “to learn *with* technology rather than *from* technology” (p. 55).

The majority of existing studies on digital science notebooks are descriptive in nature and explore how digital notebooks are used by students during science or STEM units (Fulton et al., 2017; Miller & Martin, 2016; Paek & Fulton, 2016). Current studies cover the capabilities of digital notebooks, rules and routines, and examples of implementations.

While these studies are useful in describing an approach to integrating these notebooks across science classrooms, studies are needed that capture how a teacher can intentionally plan to leverage the additional capabilities so students can learn with technology. Without capturing this essential part of the teaching process, it can be argued that any advantages of digital notebooks are incidental in nature and ambiguous to replicate for successful implementation – merely a result of integrating technology for the sake of presence rather than with specific curricular and instructional goals in mind.

For the benefits of digital notebooks to be replicable for other first-time users the ways teachers plan for the use of the digital notebooks to align with curricular goals and instructional methods must be understood, and what they found successful. This study sought to expand on that body of work by exploring how one teacher planned for the use of the notebooks and why he made decisions to support and inform future technology integration efforts for first-time users of digital notebooks.

## **Conceptual Framework**

The Replacement, Amplification, and Transformation Framework (RAT; Hughes, Thomas, & Scharber, 2006) was utilized in conceptualizing this study of digital science notebooks. The RAT framework is described as one that can be used for critical decision-making regarding technology integration. A better understanding is needed as to the decisions teachers make regarding the integration of digital science notebooks and what purpose the digital notebooks serve in relation to the teaching and learning of science.

The RAT framework, thus, lends itself well to examining the decision-making process and the resulting manifestation in the classroom. This framework considers three dimensions of teaching and learning (instructional methods, student learning processes, and curriculum goals) and represents technology integration in the classroom in one of three ways: (a) replacement, (b) amplification, and (c) transformation (Hughes et al., 2006). Technology integration that falls within the replacement category are instances when the technology is merely a substitution in the medium but is used to accomplish the same purpose within the lesson.

An example of technology as replacement would be students utilizing a stylus with a paper application on a tablet to write a story. Without implementing any additional features, the medium has simply changed and students are still performing the same activity.

Technology integration moves into the amplification category when the technology is used to make lesson activities more efficient or effective, but without changing the tasks and goals of the lesson. As an example, students using a word processor application to type a story, instead of handwriting it in a notebook, would increase the efficiency with which students would be able to edit and revise as they continued working on their story. The overall task or goals have not changed, however.

In order for technology integration to move into the final category, transformation, the technology must serve as a change agent that reorganizes instructional methods, student learning processes, or curricular goals and drives students to engage in learning in completely different ways (Hughes et al., 2006). Building on the example of writing a story, if students were to use an iPad application to develop an animated movie to present the story they wrote, this would transform not only what the students were producing, but also the learning and curricular goals.

Technology integration practices in STEM have been previously examined with the RAT framework (Hughes, Ko, & Boklage, 2017), and it was investigated at the high school level to explore iPad integration by teachers of various STEM classes. Findings from this study showed that the high school teachers primarily integrated the technology through amplification, creating more streamlined and efficient general pedagogical activities, with fewer integrations being transformational or focused on content. The authors of this study noted that curriculum in high school settings appeared to be more standardized and that elementary classrooms may provide space for more innovations.

We sought to build on this literature by exploring an elementary classroom context, to understand foundational experiences to technology integration that a teacher facilitated for his students, and to examine the impact that nuances of instructional design and implementation decisions made in terms of replacing, amplifying, and transforming student experiences as they learned with digital notebooks.

As the use of digital notebooks revolves around how teachers facilitate the technology use for their students, particularly in this study, which examines a teacher's planning process and implementation of digital notebooks, the PIC-RAT model (Kimmons, 2016) became a useful extension to our conceptual framework. The PIC-RAT model develops the RAT model further by addressing the relationship students have to the technology being implemented in the classroom, examining if the students are using the technology in a *passive, interactive, or creative* manner.

Students' relationship to technology is a key factor to consider when examining the plans a teacher develops for technology integration and by considering the students' relationship to technology, the types of technology integration experiences a teacher designed and facilitated for his students can be examined through a richer and more layered lens.

The following research questions guided this study:

1. In what ways does an elementary science teacher plan to use digital science notebooks for the first time in a fifth-grade classroom?
2. How do those initial plans evolve as the teacher implements the digital notebook pages with multiple sections of fifth-grade students?
3. After implementing digital science notebooks for the first time, what are the teacher's perceptions of their use and how the digital notebooks supported student science learning?

## Research Design

This qualitative study was conducted using a single case study approach (Yin, 2014), with the unit of analysis being the teacher, Mr. Martin (pseudonym). It was bounded by the fifth-grade classroom with which Mr. Martin used the digital science notebooks. Descriptive in nature, this study sought to provide a rich description of Mr. Martin's planning for, and perspectives of, digital science notebooks in elementary science.

## **Participant and School Context**

This study was situated in a fifth-grade elementary classroom with 25 students during the 2016-2017 school year. During the 2014-2015 school year, the district adopted a 1:1 iPad initiative, and teachers were expected to begin developing means to integrate the iPads into their instruction. Mr. Martin taught at an urban public prekindergarten to fifth-grade school in a large Midwestern city. Following is an overview of the demographics of Mr. Martin's school (Source: State Department of Education):

54% - Asian/Pacific Islander  
25% - Black or African American  
12% - Hispanic  
8% - White  
1% - Native American  
57% - English Learners  
94% - Free and Reduced Priced Lunch

Mr. Martin was the school's only science teacher, responsible for teaching science to all students in Grades K-5. Mr. Martin taught each unit to a group of fifth-grade students for 50 minutes each day for 1 week, followed by a different group of fifth-grade students the following week. In total, there were four groups of fifth-grade students, which meant that Mr. Martin taught each group of students approximately once a month. The classroom that was the focus of this study was the last group of students that Mr. Martin taught in each rotation.

Mr. Martin was selected for this study for numerous reasons. First, his approach to teaching was grounded in hands-on, inquiry-based science learning. This environment was conducive to the implementation of science notebooks, as students were frequently engaging in lessons that required them to conduct experiments and design projects, thus, exhibiting the need to track their learning in these individual and collaborative spaces.

Additionally, Mr. Martin was using the district provided iPads as digital notebooks for students in his science class. He spent the 2016-2017 school year working with the second author in an instructional coaching partnership to establish the use of digital science notebooks with his fifth-grade students. This study examines his use of the notebooks during the second half of that school year, once the use of the iPads was established in his classroom as a routine for the fifth-grade students.

## **Classroom Context**

The students in Mr. Martin's class used the app Notability and the learning management system Schoology to track their experiences and learning in the form of digital science notebooks during the week-long science units. Notability is an application that allows students to take notes on a continuous page, combining a number of technical features, including but not limited to handwriting, typing, photos, audio recording, and the insertion of figures and shapes. Schoology is a learning management system that Mr. Martin used to post PDF documents for his students to access. The students were able to import these into Notability for the lesson from Schoology, and then resubmit to Schoology as an assignment at the conclusion of the lesson/unit.

After resubmission, Mr. Martin could view, assess, and grade student work within Schoology. As this format of digital science notebooks was becoming an established routine for the students in Mr. Martin's class, his classroom made for an interesting context in

which to examine how he intentionally planned for use of the digital notebooks across each unit and within the embedded lessons.

This case study focuses on Mr. Martin's planning for and use of digital notebooks during two units of instruction. The first of these units engaged students in an engineering design activity in which the students were designing a mining tool that could be taken to an alien planet. The students participated in activities in which they learned about renewable and nonrenewable resources before designing a tool that would extract one specific resource: Sand and gravel, trees, or iron ore. The students then built, tested, redesigned, and retested their mining tools before providing a justification for why their tool should be chosen for use on the alien planet.

The second unit provided students with the opportunity to review the idea of how to design scientific experiments, in order to prepare them for the upcoming state-mandated science assessment. During this unit, Mr. Martin began by reintroducing his students to concept of variables and engaged students in an experiment in which they soaked a piece of gummy bears candy in different liquids.

Following this activity, the students were introduced to the science phenomenon where a piece of paper covers a glass of water and is flipped over, and the paper and water do not fall from the cup. After the introduction, the whole class tested to see if the size of the cup influenced how this phenomenon worked, followed by groups of students testing one of three additional variables: type of paper, type of liquid, or amount of liquid. The Notability files for the notebook pages for each of these units have been included in the online supplemental materials.

### **Data Collection**

A number of data sources were collected to examine the use of digital science notebooks in Mr. Martin's classroom. These sources included the following: audio recordings of instructional coaching conversations in which digital notebook pages were generated and discussed, video recordings of classroom instruction, completed student notebook pages, and a stimulated recall interview (as defined by Calderhead, 1981) with Mr. Martin after the school year had concluded.

The stimulated recall interview, conducted by the second author, provided Mr. Martin the opportunity to examine and reflect on the digital notebook pages, their use in the classroom, and the ways in which his students engaged with the notebooks. This interview served primarily to answer the second research question, by allowing Mr. Martin to discuss his perspectives and thinking around the digital notebook pages and their usefulness in supporting his students' science learning.

### **Data Analysis**

Data sources for this study were subjected to a number of analytical steps to examine Mr. Martin's planning for digital science notebooks, the evolution in his planning, and his perspectives on their use. Following completion of the coaching partnership, all coaching conversations related to the two selected units, as well as the stimulated recall interview, were transcribed. Following transcription, all data sources were subjected to a two-step coding process.

The data were first inductively coded using descriptive and in-vivo codes (Saldaña, 2015). Next, a secondary coding process, focus coding, was used to further examine the data set.

During the focus coding process, we sorted the codes that were developed through the initial coding to develop focus codes for further analysis (as recommended in Saldaña, 2015). These focus codes were utilized to reexamine the data set and deepen the analysis. After the completion of focus coding, codes were categorized by research question, and examined to develop themes. Following is an example set of initial codes, their resultant focus code, and the associated theme that was developed through the analysis:

Initial codes: Lesson sequence, Sounding board, Uses coaching feedback, More space to draw, Make it simple.

Focus code: Influences on editing choices.

Theme: Designing custom templates for student use. e full codebook, including focus codes and themes, is included in [Appendix A](#). The themes developed through this analysis served as the basis for the following findings.

## Findings

### Planning for Digital Science Notebooks

Our analysis of the ways in which Mr. Martin planned to use digital science notebooks in his classroom focused on Mr. Martin's process and the actions he took to develop ways to use digital notebooks with his students. The following sections present the two themes that were developed through our analysis: (a) Designing custom templates for student use, and (b) enhancing previous lessons and learning activities.

***Designing specific templates for student use.*** When planning for the use of digital notebooks within the classroom, Mr. Martin primarily did so by generating specific notebook page templates for the students to use during the lessons. These templates, essentially graphic organizers or worksheets, were designed to provide students with the structures necessary to capture successfully the information expected within each lesson and unit.

Mr. Martin felt providing this type of structure was important for supporting the students and that his students might not have been as successful in organizing their thinking and information on simply a blank Notability page. Mr. Martin reflected on the importance of developing the templates in this way during the stimulated recall interview:

[People need to] Really put in a lot of effort ahead of time to get the notebook pages set up and don't just give them up. The only reason it worked is because we formatted those pages ahead of time and made those templates. I can see people taking it easy and going, "Oh, no. They can handle making their own." It's not the same as a paper notebook in that way. (Stimulated Recall Interview, 06/22/17)

Developed through the coaching partnership with the second author, Mr. Martin was influenced by a variety of factors while planning for digital notebook templates, considering aspects such as the unit or lesson sequence, the resources and features available, and how he intended his students to use the notebooks. The templates, created in Google Docs, exported as PDFs, and placed in Schoology for students to access during the lessons, proved to be a vital component of the experience that allowed the students to learn *with* technology and support their learning. Examples of all templates produced by Mr. Martin for use in his classroom are included in [Appendices B-D](#). The following Notability files can be downloaded for use with the Notability app:



[Mining Tool Design Sheet Notability file - Download](#)  
[Gummy Bear Soak Experiment Notability file - Download](#)  
[Paper and Water Cup Activity Notability file - Download](#)

**Features of the template to support student use.** In developing the templates, Mr. Martin included a number of specific features to support student use. One of the major features that Mr. Martin included was boxes in which his students could place their text when providing written responses to questions.

As he explored the features of Notability, Mr. Martin discovered that if the students wished to use the typing feature, which many of his students did as opposed to writing with the pen tool, the app responded better when inserting a text box if there was a box already on the page where the text was to go. Mr. Martin created such boxes across the templates he generated for his students. He frequently included sentence starters to support his students' language use as well. Figure 1 provides an example of such a template.

(While you are building) 2

Describe any design changes you make while building your mining tool.

I made these changes \_\_\_\_\_ because \_\_\_\_\_.

We added \_\_\_\_\_ because \_\_\_\_\_.

We added \_\_\_\_\_ to help \_\_\_\_\_.

We discovered that we needed \_\_\_\_\_ because \_\_\_\_\_.

**Figure 1.** Example of box to support student use of templates.

As he developed the notebook pages, Mr. Martin came to the realization that it was no longer important for him attend to formatting the notebook pages so they appeared on a single sheet of paper, as he did when developing traditional notebooks pages, "Because it's not paper now, we don't have to worry about formatting so much and trying to get it on one or two pages" (Coaching Conversation, 01/24/17). However, this freedom also created concern for Mr. Martin that his students would not know where to start and stop during each successive lesson when working multiple days within one set of digital notebook pages.

Once PDF documents were imported into Notability, they were converted into a single long page, removing the clear indications of one page ending and another beginning. Mr. Martin

recognized this as potentially problematic: “When you put this in Notability, you're not going to see a space like that” (Coaching conversation, 01/30/17).

To preempt this possible challenge, Mr. Martin had the idea to place a black bar in the document between lesson activities to signal for the students where each “page” ended in the digital notebook: “I think we could put one [activity] on top and then put a black bar across the page break and be, like, ‘We're in this section. Don't go beyond the bar...We're on page one or something,’ you know?” (Coaching Conversation, 01/30/17).

In addition, Mr. Martin placed a page number to provide further support. Figure 1 (above) includes the black bar and page number to signal the page break for the students to avoid confusion about which activities were being completed in a given lesson.

***Enhancing previous lessons and learning activities.*** As Mr. Martin developed the digital notebooks for his students to use in his classroom, he did so by drawing on the learning activities he had completed with previous year’s students. He identified ways in which he could enhance them through the digital notebooks by modifying and editing work that he had already created in previous years.

It was important to Mr. Martin that the digital science notebooks extended beyond his student simply filling out a worksheet electronically, and he felt strongly that the digital notebooks needed to be more than an electronic reproduction of the paper notebooks he typically used, noting during the stimulated recall interview,

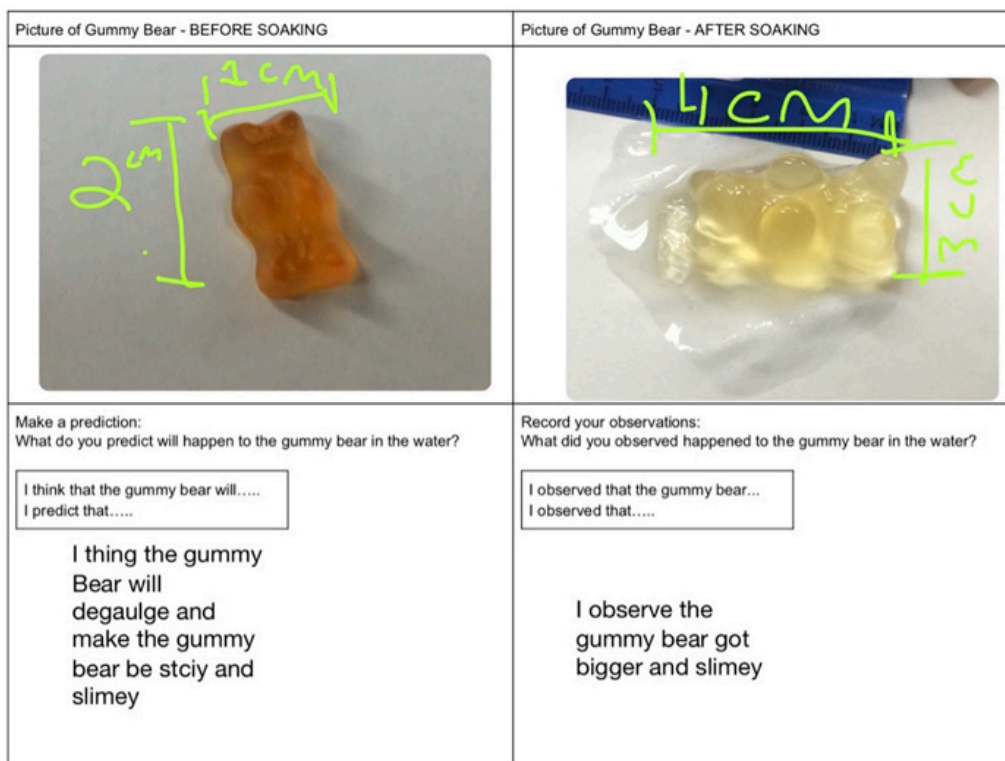
Don’t just use them as a worksheet generator. Don’t just use them as a digital version of a paper notebook, either. Incorporate the pictures. Incorporate the things that make it worthwhile, because if we had just done strictly writing, that would have been boring, but in the fact that they got to take pictures and import videos...that kind of made it interesting for [the students] using [the notebooks], and different from writing in a paper notebook. (Simulated Recall Interview, 06/22/18)

He wanted to harness the capabilities of the iPad to amplify or transform the experiences students have with traditional notebooks. Simply incorporating the various tools available on a digital science notebook was not sufficient for Mr. Martin. The tools had to serve a specific purpose that aligned with the science learning taking place.

One of the tools that Mr. Martin utilized within the digital notebooks to enhance the work his students had done in previous years with traditional notebooks was the camera tool and the ability for students to annotate images. In planning for the experiment with the gummy bears, Mr. Martin enhanced his previous activities by incorporating the camera and annotation capabilities. In previous years when Mr. Martin implemented this unit, before and after placing the gummy bears in the various liquids, they were required to make written observations in their science notebooks.

Transitioning to the digital science notebooks, Mr. Martin built on this activity by adding a section into the notebook page that required students to take a picture of their gummy bears before and after they were soaked in the various liquids and then annotate the images with the measured dimensions of the gummy bears to determine how their size had changed as a result of the soaking. This enhancement allowed students to collect additional information in the experiment, and maintain an additional piece of evidence for how the gummy bears had changed as a result of soaking in the various liquids. Figure 2 provides

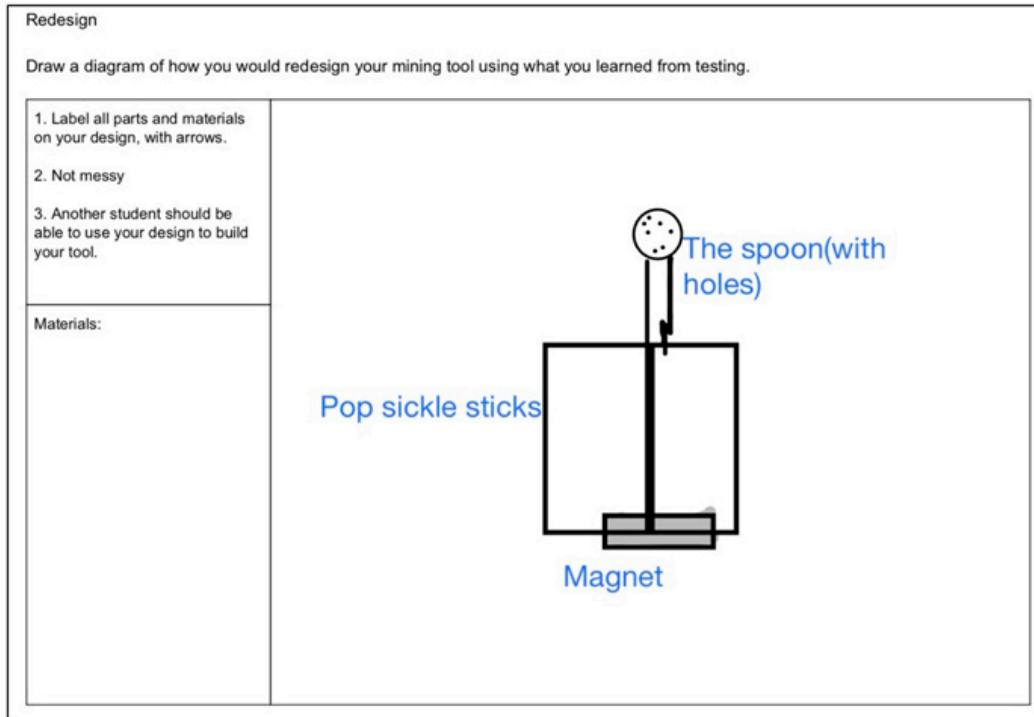
an example of one student's use of the camera and annotation feature of the digital notebooks, as well as the accompanying written observations.



**Figure 2.** Example of student use of camera and annotation capabilities of the digital science notebooks.

Another tool that Mr. Martin made use of was the capability within Notability for students to create a figure. This tool allowed students to create an image, utilizing both ready-made shapes and lines as well as freehand drawing tools. This image could then be resized to fit within specific sections of the notebook page without losing proportions or distorting the image. Mr. Martin incorporated this tool into the mining tools engineering design unit, utilizing it to support the students in drawing designs of their mining tools during the design and redesign portions of the unit.

Students in previous years also drew images of their mining tool designs, but the capability of the digital notebooks to produce readymade shapes and lines supported students in creating clearer and more accurate drawings of how they intended their designs to look. Figure 3 provides an example of one student's use of these drawing tools in support of their drawing of their redesigned mining tool.



**Figure 3.** Student drawing of redesign completed using Notability drawing tools.

### Evolution of Digital Science Notebook Plans

In addition to looking at what and how Mr. Martin planned for the digital notebooks, we were also interested in seeing how his plans evolved over the course of his implementation and the coaching partnership. Teachers' plans frequently change over time as they reflect on the implementation of classroom activities and students' engagement with those activities. Therefore, it was important to understand how Mr. Martin's plans changed and the factors that influenced those changes. In examining this evolution, two themes were developed: (a) Adjusting plans in response to student input, and (b) identifying revisions for future iterations of the digital notebooks

**Adjusting plans in response to student input.** Due to the structure of elementary science in Mr. Martin's school and the rotation of fifth-grade classes, each rotation served as a source of insight to inform his templates and plans for the next rotation. Mr. Martin reflected on the experience of implementing the digital science notebooks as "a good beta test" (Stimulated Recall Interview, 06/22/17).

Through his work with each fifth-grade class, Mr. Martin was responsive to the ways students used the digital notebooks, the ideas they shared as they worked, and areas of struggle requiring modification. An example was demonstrated in the mining tools unit. After designing and building their mining tool, one page of their notebook required the students to describe how their mining tool worked. This task was initially designed to have the students write a description of how the design worked, with the students being provided a series of lines to write this description.

Mr. Martin anticipated that the students would write this description through a series of numbered steps. However, Mr. Martin's students had other ideas, and through the input of the students, this task was changed from a written description to a how-to video demonstrating and explaining how the mining tool worked. When reflecting on why he made that change in the digital science notebooks, Mr. Martin said,

I think it was just the kids saying, "Why can't we just shoot a video of it?" It happened in the previous week.... I think I know which student came up with the idea, and I remember going, "That's great!" It was more tech integration, obviously, but it's also like, sometimes they're better at speaking than writing. Sometimes it's the opposite. I realize that, but so that's why I changed. I think it ended up working really well. (Stimulated Recall Interview, 06/22/17)

Mr. Martin's responsiveness to the students' input as the units were in progress allowed him to incorporate their feedback into how the digital science notebooks were used going forward and created opportunities for the students to utilize more capabilities of the digital notebooks and in ways that they would not have been able with a traditional science notebook.

The primary influences on Mr. Martin's editing choices were ensuring the templates continually evolved to match the lesson plans, learning goals, and lesson sequence and how he could best simplify and scaffold the templates for his students. An example of Mr. Martin adjusting the digital notebook pages to better support his students comes from the planning that took place for the gummy bear unit. Prior to this planning, Mr. Martin had recognized that the students were not using sections of his digital pages as he intended, specifically when he provided the students sentence starters to support their language use.

I'm noticing that they are wanting to fill in the blanks on the example sentences as opposed to writing in the box.... All the kids were, like, tapping on there, like, they're trying to put their text tool on the little tiny little blank lines that we had left on the example sentences. (Coaching Conversation, 03/02/17)

As a result of this behavior, Mr. Martin and the second author modified the digital notebook page to include the sentence starters with a box around them, to signal to the students that they were to type their own sentences and not simply complete the sentence starters that were provided (Figure 4).

<p>Make a prediction: What do you predict will happen to the gummy bear in the water?</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"><p>I think that the gummy bear will..... I predict that.....</p></div>	<p>Record your observations: What did you observed happened to the gummy bear in the water?</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"><p>I observed that the gummy bear... I observed that.....</p></div>
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**Figure 4.** Modification made to sentence starters to support student use of digital notebook pages.

An inherent influence amongst all of Mr. Martin's planning was the ongoing coaching relationship with the second author, in which the second author acted as a sounding board for Mr. Martin's ideas and process. The coaching partnership provided Mr. Martin with a dedicated time and space to focus on developing his digital notebook plans, as well as support in working through ideas, issues, and challenges when constructing the pages.

A representative example can be seen from the coaching conversation that occurred on 01/25/17, in which Mr. Martin wondered whether the design sheet for the mining tools should include a place for students to include additions to their design. When he asked the second author whether they should include this space, they discussed the concepts of design and redesign within engineering education. This discussion ultimately led to the following suggestion for the template from the second author:

Coach: Or you could have a space. I don't know, it might add time and stuff, but if you had [time], if you let them make those additions and then you add a space where they say, "Here's what we added and here's why we added it."  
Mr. Martin: Yeah, I like that. Instead of top view, side view...I would rather have that. (Coaching Conversation, 1/27/17)

These plans were incorporated into the digital notebook pages that were developed for the mining tools unit, and can be seen in Figure 1.

**Identifying revisions for future iterations of the digital notebooks.** Throughout his template development process and reflections with his instructional coach, Mr. Martin consistently generated ideas of what he would improve for next time or general ideas of things that could be added or enhanced. Similar to his original plans for the templates and the associated influences on his editing choices, Mr. Martin used his current experiences as an opportunity to reflect and brainstorm for future plans. While some of these plans were simple edits to the design and layout of the templates, other plans were generated to deepen student learning.

Simple plans for the future that Mr. Martin considered consisted of additions to the templates or reformatting. During the stimulated recall interview, he reflected on the adjustment that allowed students to make minor changes with justifications during the build process and felt a picture of their final mining tool would be a good addition to the templates.

For Mr. Martin, the picture was something essential to include in future use of the digital notebooks because the notebooks tracked the students original design plans, as well as their changes and justifications, but there was no record of the students' final product. Another simple edit he envisioned for future iterations was the spacing and size of the digital notebook:

Maybe we can section it off smaller, because it just seems to be too much for them to do. When you look at them, I remember...when you look at them completed, they don't look like there's a lot of information because it's spread all over these giant pages. Maybe that's the way to do it. You have to be aware to the fact that they did do the work because it doesn't look like it – because they're sparsely filled out across the whole thing. (Stimulated Recall Interview, 06/22/17)

When reflecting on the possibilities to deepen student learning with the digital notebooks, he envisioned the use of memos or a tracking bar to help make the engineering process in the unit explicit. For Mr. Martin this was important because, while the students certainly

were engaging in the engineering design process during the mining tools unit, it was never explicit to students what the engineering design process was and where they were in the process.

When I did this at the first unit, I used to do memos. At the top of the memo, there was a line with circles on it. Every circle was designated like what this resource is, how to find resources, how do I get resources, how do I find resources. Then every day when we change to that topic, the circle would get filled in on the top of their memos. They could see they were progressing through the process. Something like that, some sort of visual cue like, “Now you’re in the design phase. Now you’re in the create phase.” I think that alone could help by drawing attention to it and front loading them about it and everything. I think that alone, a little engineering design process component on the notebook page, would be more beneficial. I don’t think it really hits the engineering design process at all. (Stimulated Recall Interview, 06/22/17)

### Perceptions of Digital Science Notebooks and Student Learning

When teachers see value in using a technology in the classroom they are more likely to implement that technology as part of their classroom practice (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Zhao, Pugh, Sheldon, & Byers, 2002). As this was Mr. Martin’s first time implementing digital science notebooks in his classroom, we felt it was important to understand his perceptions of the digital notebooks and their utility in supporting student engagement in science and science learning.

Through our examination of his perspectives, two themes were developed: (a) Implementing the digital notebooks was a positive experience, and (b) offering words of wisdom to others interested in implementing digital notebooks.

**Positive experience.** Throughout the use of digital notebooks, Mr. Martin’s experiences were overwhelmingly positive. During the stimulated recall interview, he reflected on how he saw value in the use of digital notebooks, as they were able to meet his expectations and work “so much better” than traditional notebooks. He found that by using digital notebooks, it made the notebook experience easier for everyone involved and that the affordances greatly enhanced the use of science notebooks. When asked whether he considered it worthwhile to do science notebooks digitally, he said,

Yeah, I think it was worth doing digitally as far as when I was doing their grades toward the end of the year. After something like having Schoology in front of me, and just like clicking through their work and being able to determine the grade in Schoology. Being able to give a grade right there, I mean, that is great instead of going, “Alright. More folders [of student notebook pages].” It’s a huge time saver to begin with for me, but I feel like it just, as cheesy as it sounds, has got that cool factor to it for the kids, “Oh I’m designing something on my iPad.” I mean, yeah, we could have done it on paper. I just think it worked better on the iPads. (Stimulated Recall Interview, 06/22/17)

While his experience was overall positive, it was not without a few minor issues. At times he encountered some technology hurdles to overcome when designing templates, such as formatting issues or certain features needing a lot of effort to navigate to.

He also noted that while the students did well with the digital notebooks, a couple of students required more support in navigating Schoology, Notability, and the features of the

digital notebook pages. With many of these issues, he typically had solutions in mind that mitigated the difficulties, such as carving out time to explicitly teach iPad use to help students overcome the learning curve involved with digital notebooks.

The digital science notebooks were used in both engineering- and science-focused lessons. When considering whether the digital science notebooks helped the students with their understanding of engineering and its associated design process during engineering-focused lessons, Mr. Martin saw room for improvement. As seen in his plans for future iterations, Mr. Martin had generated ideas for making the engineering design process learning more explicit to support his students in developing an understanding of what engineering is and the engineering design process.

During both science- and engineering-focused lessons, Mr. Martin introduced his class to tools available on the digital science notebooks that amplified their experiences beyond what traditional paper notebooks afford. Mr. Martin saw value in the digital tools to enhance the students' science learning by providing them more evidence to support their claims.

In the gummy bears unit, students were experimenting with variables. Gummy bears were soaked in different liquids to see the effect. One task in the digital notebooks was to include before and after photos of the gummy bears, annotated with measurements, followed by predictions, observations, and claims. Mr. Martin felt this experience was important for the students' science learning:

Well obviously, before and after – the change is a huge part of science. I wanted to be able to, because they're kids, seeing it is going to have a huge impact, seeing it ... if you had that picture there instead of just, "Describe it to me" [which] gets old after a while. If you can take a picture of it and then it's right in front of you, nobody has to remember it if it's right there. You have this great tool, so why not just take a picture of it? I think this was better because you have this record of what happened. They're supposed to be making claims and evidence. Great, it got bigger. Perfect. Look at the picture, look at the measurements. Oh, great, there's more evidence for their science. (Stimulated Recall Interview, 06/22/17)

**Words of wisdom.** Mr. Martin's reflections on his experiences provide insight for other educators considering digital notebooks. He maintained realistic expectations about the use of digital notebooks, stating how important it is to prepare ahead of time, doing it yourself, and anticipate the time involved and frustrations that can occur.

Mr. Martin was forthcoming about the amount of time incorporating digital science notebooks into a classroom can take. When asked to share advice for other educators planning to incorporate digital notebooks, he immediately responded with the amount of time involved with digital notebooks.

Plan for the time it takes. To set up, get the infrastructure going. Plan for the time it takes within the lesson, that you're going to have kids that just naturally move more slowly through the process of using the iPad. That's fine. You've just got to be ready for it. (Stimulated Recall Interview, 06/22/17)

This time factor was evident in his own experiences. In both the gummy bears and mining tools units, there were instances when Mr. Martin had to demonstrate the function of new tools in Notability, such as how to annotate images.



Beyond the time in class to show students how to navigate the applications, there is also a lot of time that goes into planning and developing the templates. Yet, Mr. Martin believed the time investment did not detract from the value of doing the science notebooks digitally. He emphasized this belief during a coaching conversation when he spoke about how useful it was to have the templates developed in advance.

But once you have it, you have it. You save it in your own personal thing. I just need to, you know, spend some time this summer doing that ahead of time. It's ready to go and then you can just make small changes, but I can see the value. I just need to make sure I backup everything we use. (Coaching Conversation, 03/08/17)

He described the setup of digital notebooks as "really slick." Grading became more efficient by having the notebooks available to him on Schoology. While the notebooks became more efficient in the end when it came to grading and once templates were already developed, Mr. Martin noted at various points in the year that digital notebooks were very different from traditional.

It's funny how there's no learning curve for them to use an iPad but there's such a steep learning curve for them to use an iPad. You know what I mean? They know how to use an iPad, they use it all the time. But like, to do specifically what you want, because there isn't like a.... Doing a digital notebook on an iPad isn't like something that they just go out and do for fun, you know? (Coaching Conversation, 03/08/17)

This line of thought reemerged during the stimulated recall interview. He reflected on how essential the templates were to the successful implementation of digital notebooks. This experience is why he believed it was necessary to factor in the time it takes to develop templates. The templates worked as a great scaffold to help him walk the students through the learning curve of digital notebooks in a more guided way.

Kids don't always know how to write in a notebook. You need to have those templates for them. That's a huge part of it. It's necessary, at this level anyway. Older kids maybe could do it on their own. (Stimulated Recall Interview, 06/22/17)

He was adamant that, while the units could have been done with paper notebooks, it worked much better digitally. He also considered the digital notebooks to be an excellent way of preparing students for the next stage of their education, as iPads are used much more frequently in middle and high school. Mr. Martin believed that the digital science notebooks were a more natural and useful way to bring technology into the science classroom. He pushed back against the assumption of automatically including technology simply because it is science class. For him, the technology had to serve a purpose and the usefulness of digital science notebooks captured that purpose.

## **Discussion**

As educators are faced with purposefully integrating technologies that align with their curricular goals (Hughes, 2005), studying cases of teachers undertaking this task becomes imperative. By exploring the experiences of a teacher who intentionally planned for first-time iPad use that supported students' science learning, our study expanded on the existing body of research that showcases how to set up digital science notebooks and student use.

As the findings indicate, Mr. Martin had an overall positive and successful experience implementing digital science notebooks for the first time. We know that when teachers

perceive value in specific technology, it leads to a greater likelihood of that technology being integrated into their practice (Ottenbreit-Leftwich et al., 2010; Zhao et al., 2002). Mr. Martin's successes, particularly when articulated through his perceptions of the experience, can provide insights to science teacher educators on different approaches to try with teacher candidates and affordances to highlight to help preservice teachers find value in digital notebooks.

Mr. Martin set aside dedicated time with his instructional coach to design templates and reflect on the experiences across class rotations. Naturally, the development of the notebooks required an investment in planning time. The coaching partnership allowed Mr. Martin to critically and intentionally plan for how the iPads would be used for digital science notebooks. He was able to reflect on the successes and make necessary changes in the use of the digital science notebooks based on his experiences in previous units and in previous iterations of the same unit with different groups. This time allowed him to make templates that harnessed the full capabilities of the iPads in direct alignment with the learning experiences he was facilitating for his students.

As previous studies have indicated, teachers can struggle to translate their vision of technology integration into their science or STEM teaching practices (Constantine et al., 2017; Herschbach, 2011; Wang et al., 2011). This dedicated planning time and coaching partnership was essential to help his vision for the digital notebooks actually manifest in practice. Having the implementation align with what he planned for the digital notebooks ensured that the curricular and instructional goals were enacted, rather than simply integrating technology for technology's sake.

Mr. Martin was emphatic, however, that time was not only a critical component to the development of the digital science notebook templates, but also critical for the implementation of them. He was cognizant of the fact that while some students may be familiar with iPads in general, using them for academic purposes within the context of unfamiliar applications and tools required extra time to learn.

When sharing advice for other teachers considering the use of digital science notebooks in their classrooms, he was quick to emphasize that they need to be prepared for, and they needed to plan for, the extra time in class to experience science notebooks digitally. He framed the experience of learning new digital technologies as akin to students learning math – students move at different paces and teachers need to provide them the time and space to experiment with and adjust to these new digital experiences.

This example strongly illustrates the PIC-RAT framework in action, as Mr. Martin was able to consider not only the type of technology integration happening, but also his students' relationship to technology and how to support their success in engaging with new integration efforts such as digital notebooks (Kimmons, 2016).

With intentional planning, such as with the template development by Mr. Martin, a teacher can facilitate technology use to replace, amplify, or transform learning experiences (Hughes et al., 2006) – which can help ensure alignment with the lesson's purpose and responsiveness to learner needs.

This fact is evident in Mr. Martin's experiences with digital notebooks. Investing in planning time to develop templates allowed Mr. Martin to truly move away from replacement, in which the notebooks could have become merely digital worksheets. Instead, this planning time allowed him to deeply reflect on how he wanted the students to use the notebooks and experiment with different tools and features available to him. His

transition into the amplification portion of the RAT framework can be seen in examples such as the annotated gummy bear photos.

While students certainly could have captured the change in gummy bears with their own drawings, incorporating the annotated photos provided them another rich piece of evidence to support their scientific claims. The annotated photos targeted a similar aspect of students' notebooking experience that drawings would, but took it a step further by making use of tools that simply were not possible to include when using traditional notebooks.

If the digital notebooks had only been a digital version of the traditional notebooks, the entire experience would fall within the passive or interactive replacement portion of the PIC-RAT framework (Kimmons, 2016). While passive and interactive replacement with technology certainly has its place, these additional capabilities of the iPads made the whole experience worthwhile to Mr. Martin. These additional capabilities allowed Mr. Martin to weave in new elements to the notebook templates that amplified and transformed students' experiences with notebooking in science and also incorporated creative aspects.

Mr. Martin's shift into the creative transformative spaces of the PIC-RAT framework (Kimmons, 2016) was evidenced by his inclusion of video recordings with the digital notebooks. By having the students record videos that were sales pitches and demonstrations of their designs, he was able to incorporate a piece of learning and entirely new skill set that traditional notebooks simply are unable to capture.

Though students with traditional notebooks could do class presentations that work as demonstrations and sales pitches, it was not an experience that would be represented in their notebook for them or their teachers to look back on. Mr. Martin's digital notebooks transformed this activity by chronicling their entire experience in a STEM unit more holistically.

The digital notebook's affordances gave Mr. Martin the flexibility to truly manipulate the technology to best fit the needs of the lesson and the students. The ability to design tasks within the notebooks that could not only replace, but also amplify and transform (Hughes, 2005) while engaging students in interactive and creative ways (Kimmons, 2016) was what made the endeavor valuable to Mr. Martin. It promoted a more thoughtful approach to technology integration, rather than integrating technology for the sake of technology. It captured the essence of students learning *with* technology advocated for by Fulton et al. (2017).

While Mr. Martin had an overall positive experience with the digital notebooks, digital notebooks still have limitations within the classroom, however. He discovered that the nature of the relationship between Notability and Schoology presented some limitations. In the Notability application, students were able to record and embed videos. Their sales pitch and demonstration videos could be included directly within their notebooks. Unfortunately, once students uploaded the notebooks to Schoology, the Notability pages were converted to PDF files, meaning the embedded video became a static image that was no longer viewable. As a result, the videos needed to be shared separately.

This situation limited the affordances or, at least, complicated the inclusion of videos once it was time to share a copy with the teacher. Mr. Martin worked around this challenge by having the students Airdrop their videos to his iPad.

This case study provides a springboard for other teachers and teacher educators to work from that allows them to integrate digital science notebooks for the first time in ways that go far beyond only replacing traditional notebooks or engaging students passively with technology. Through structured plans, digital science notebooks can enhance student learning experiences with technology by allowing them the power to become producers, rather than merely consumers.

Given the success of Mr. Martin's first time use of digital science notebooks, future research can explore the continued, or lack thereof, use of digital notebooks and how in-service teachers maintain and replicate the success of their first year of technology integration in the years to come. Additional research that would provide valuable insight as a next step would be to examine how preservice teachers' digital notebook or general technology integration efforts fare with supports similar to Mr. Martin, such as coaching partnerships, technology integration frameworks like the PIC-RAT (Kimmons, 2016), template use versus blank pages, and dedicated digital notebook planning time.

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**Appendix A  
Codebook**

Initial Codes	Focus Code	Theme
Lesson sequence, Sounding board, Uses coaching feedback, More space to draw, Make it simple, Options for students, Work on modifying, Requirements, Creating criteria, Not creating from scratch, Saves time, That's easier	Influences on editing choices	Designing custom templates for student use
Forgot about pages, Needed it today, Missed opportunity, Downloading previous files, Did all this work already, Could have used today, Haven't modified yet, Saved last years, Make new?, Agreement, Good start, Play with that feature	Previous teacher experiences and plans	Enhancing previous lessons and learning activities
Rotations to practice, See how it goes, We can take notes, Anticipating Modifications, After rotations, See how they fill it out, Notice from other sheets, Prevent confusion, Really help, Issues with other sheet, Work out kinks, Make small changes, Kid's idea, Wasn't my idea, Appreciating student ideas	Digital notebook iterations and rotations	Adjusting plans in response to student input
More scaffolding, Simple modifications, More instructions, Use lines, Good beta test, Ideas for next time, Front load, Doesn't hit EDP, Simpler version, Would have loved other units on iPads	Future plans and editing choices	Identifying revisions for future iterations of the digital notebooks

Initial Codes	Focus Code	Theme
<p>Like everything, Good start, Made it really clear, Kids were able to do it, Seemed to work, Worked well, Exactly what I'm looking for, What we intended, Huge part of science, This was better, More evidence for science, Easy system, Easy for student use, Students enjoy it, Students like the affordances, iPads worked better, Plans translated well</p>	<p>Positive experiences</p>	<p>Implementing digital notebooks was a positive experience</p>
<p>Lots of supervision, Works well as support, Not enough as standalone, Figure out value of digital, Have great tools so use them, Have humor, Technical things, Anticipate frustration, Go over the details, Doing it yourself is important, Set rules and expectations, Features can be click heavy, Plan for time, Some things not worth doing, Prepare pages ahead of time, Adjust schedule, Worth doing digitally, Huge time saver for teacher, Blank won't work, Worked because templates, Not just a digital version, Incorporate affordances, Not the same as traditional</p>	<p>Words of wisdom</p>	<p>Offering words of wisdom to others interested in implementing digital notebooks</p>



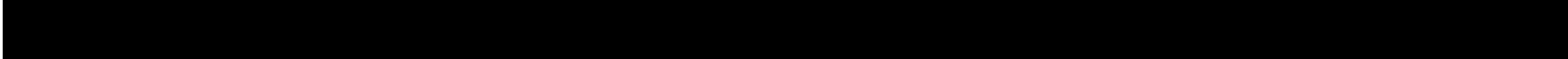
**Appendix B**  
**Mining Tools Notebook Templates**

1

Design Sheet - Design #1

Resource: \_\_\_\_\_

<p>1. Label all parts and materials on your design, with arrows.</p> <p>2. Not messy</p> <p>3. Another student should be able to use your design to build your tool.</p>	
<p>Materials:</p>	



(While you are building)

Describe any design changes you make while building your mining tool.

I made these changes \_\_\_\_\_ because \_\_\_\_\_.

We added \_\_\_\_\_ because \_\_\_\_\_.

We added \_\_\_\_\_ to help \_\_\_\_\_.

We discovered that we needed \_\_\_\_\_ because \_\_\_\_\_.





## Redesign

Draw a diagram of how you would redesign your mining tool using what you learned from testing.

<ol style="list-style-type: none"><li>1. Label all parts and materials on your design, with arrows.</li><li>2. Not messy</li><li>3. Another student should be able to use your design to build your tool</li></ol>	
Materials:	

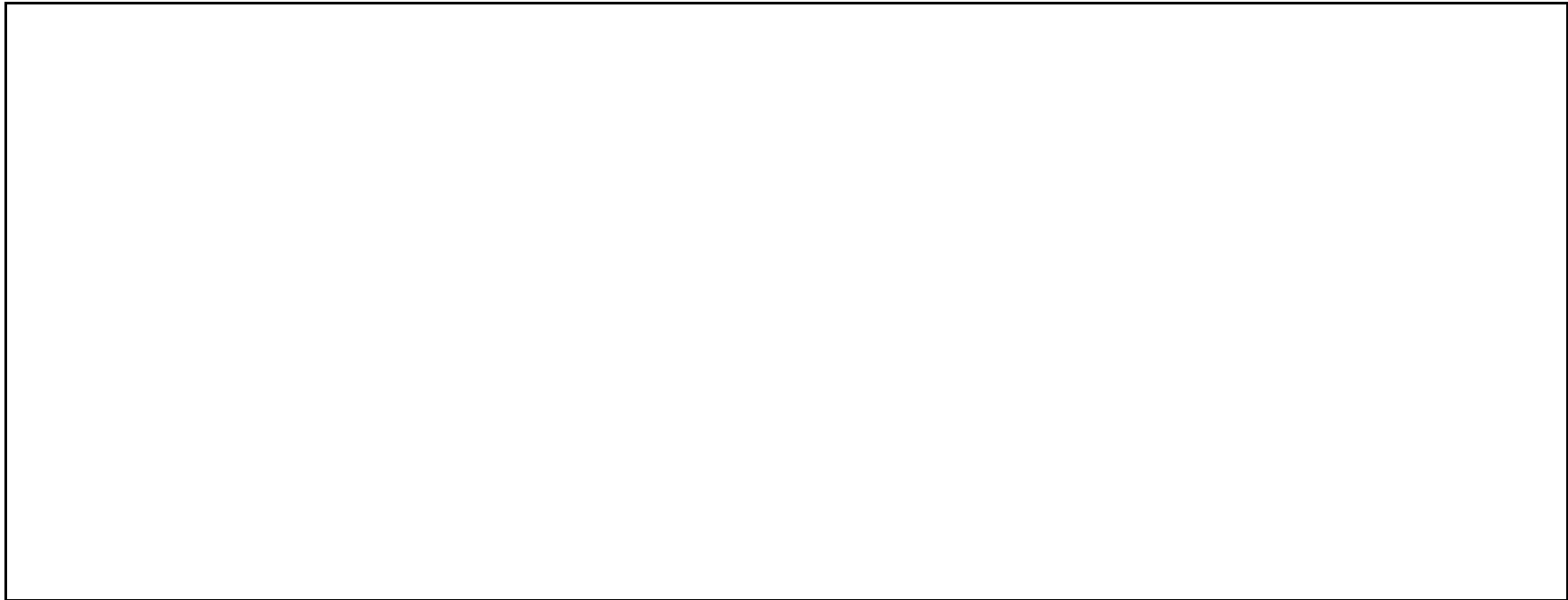
Describe the changes you made to your design and why you think it will work better to get your resource.

We added \_\_\_\_\_ because \_\_\_\_\_.

For my new design we changed \_\_\_\_\_ because \_\_\_\_\_.

This tool will work better because \_\_\_\_\_.

We will get more resources because \_\_\_\_\_.



## Appendix C Gummy Bear Notebook Templates

3/6/17 - Science - Experiments!

Qod: What happens to gummy bears when the soak in different liquids?

Variables we are keeping the same:	Variable we are changing:

Instructions for Experiment:

### BEFORE SOAKING

1. Place gummy bear in the circle on the paper
2. Take a picture in LANDSCAPE of the gummy bear in notability and move the picture to the "BEFORE SOAKING" box.
3. Measure the height and width of the gummy bear with a ruler.
4. Annotate (write on the picture), the dimensions of the gummy bear.
5. Write a prediction about what you think will happen.

### AFTER SOAKING

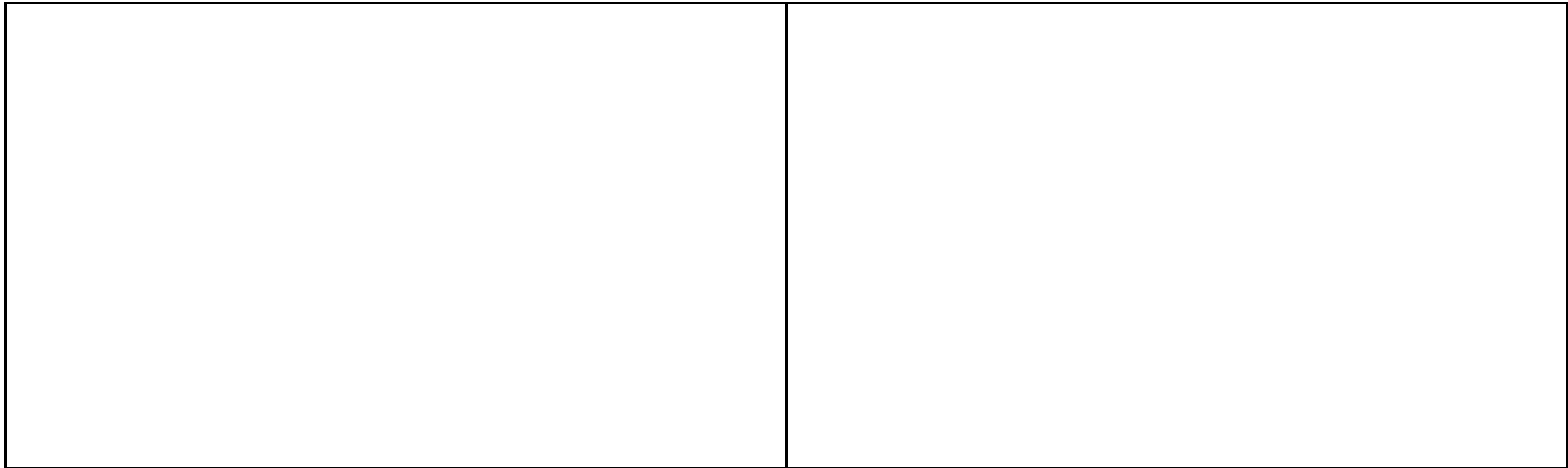
5. Remove your gummy bear from the liquid.
6. Place gummy bear in the circle on the paper.
7. Take a picture in LANDSCAPE of the gummy bear in notability and move the picture to the "BEFORE SOAKING" box.
8. Measure the height and width of the gummy bear with a ruler.
9. Annotate (write on the picture), the dimensions of the gummy bear.

10. Write an observation about how the gummy bear changed (or didn't change).

**Cup 1 - WATER**

Place 40 ml of water in the cup.

Picture of Gummy Bear - BEFORE SOAKING	Picture of Gummy Bear - AFTER SOAKING
<p>Make a prediction: What do you predict will happen to the gummy bear in the water?</p> <div data-bbox="191 1240 705 1349" style="border: 1px solid black; padding: 5px;"><p>I think that the gummy bear will..... I predict that.....</p></div>	<p>Record your observations: What did you observed happened to the gummy bear in the water?</p> <div data-bbox="1064 1273 1579 1382" style="border: 1px solid black; padding: 5px;"><p>I observed that the gummy bear... I observed that.....</p></div>



**Cup 1 - SALTWATER**

Place 40 ml of water in the cup and 1 scoop of salt.



Picture of Gummy Bear - BEFORE SOAKING	Picture of Gummy Bear - AFTER SOAKING



<p>Make a prediction: What do you predict will happen to the gummy bear in the saltwater?</p> <p>I think that the gummy bear will..... I predict that.....</p>	<p>Record your observations: What did you observed happened to the gummy bear in the saltwater?</p> <p>I observed that the gummy bear... I observed that.....</p>

**Cup 1 - VINEGAR**

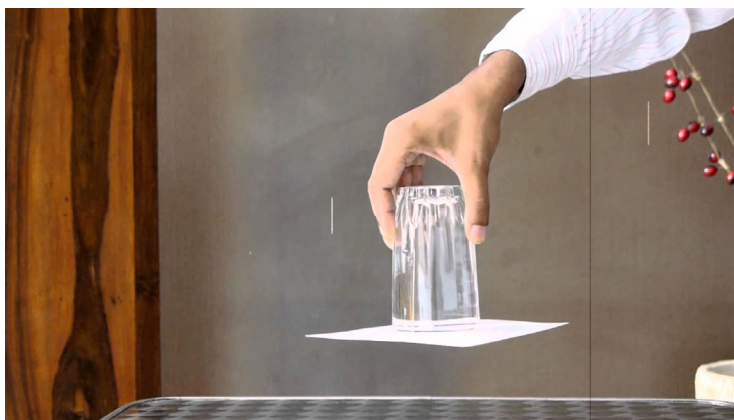
Place 40 ml of vinegar in the cup.

Picture of Gummy Bear - BEFORE SOAKING	Picture of Gummy Bear - AFTER SOAKING
	
<p>Make a prediction: What do you predict will happen to the gummy bear in the vinegar?</p> <div data-bbox="191 1235 705 1344" style="border: 1px solid black; padding: 5px;"><p>I think that the gummy bear will..... I predict that.....</p></div>	<p>Record your observations: What did you observed happened to the gummy bear in the vinegar?</p> <div data-bbox="1064 1235 1579 1344" style="border: 1px solid black; padding: 5px;"><p>I observed that the gummy bear... I observed that.....</p></div>

--	--

Other variables we could change change:

## Appendix D Water Cups Notebook Templates



Variables that are in this experiment:

- Type of Liquid
- Cup size
- Type of Paper
- Amount of Liquid

Today - Cup size

Picture of cup empty	Picture of cup upside down with liquid (if it works)


Today my variable was:

I noticed when we changed the \_\_\_\_\_ the water \_\_\_\_\_



Tomorrow: Each table will be assigned a different variable




Today my variable was:

--

I noticed when we changed the \_\_\_\_\_ the water \_\_\_\_\_

--