Maximizing Test Success: Identifying the Most Effective Note-Taking Strategies for High School Chemistry

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1. Literature Review

1.1 Note-taking Efficiency

With advanced high school classes containing lengthy and difficult tests at the end of each unit, sufficient notes are practically required to score well. Not only is the ability to take sufficient notes necessary to survive in a challenging course, but the ease with which students can take these notes and be able to go back and review them is also vital. Studying is required to succeed in school, and this is why it is frustrating to have students leave class without retaining anything that was just taught. Rob Wieman, a math teacher, has his class “founded on the assumption that students would use their notes as a primary resource” (2011). Teachers often attempt to set up their classes where note-taking is rewarded and encouraged, but this is often easier said than done. Teachers across America have noticed their students failing to take effective notes, leading to underperforming test scores and student comprehension. Cathy G. Sakta, an Associate Professor of Education at Texas A&M, established in her research article that students often struggle with taking accurate lecture notes (1992). Not only are students struggling, often feeling lost, intimidated, and overwhelmed when tasked with taking notes, teachers also suffer consequences since their students are not comprehending essential information nor performing well on exams.

One common sentiment agreed upon by almost all teachers and education researchers is that most students generally don’t know how to take sufficient notes. In turn, teachers should try to actively teach students how to take notes while also having them effectively grasp the current unit material. Kayla Hess and Caitlin Fournier describe the jump from elementary school, where note-taking was limited and somewhat absent, to middle school, where teachers assumed students had the skills and abilities to prepare for tests by themselves, as going from “a bike with training wheels to a motorcycle on the highway, with no inbetween” (2014). Essentially, there is a gap where students go from a point where they aren’t taught note-taking to an environment where note-taking is expected. Hess and Fournier go on to suggest a system where, in 4th and 5th grades, students are taught note-taking and study skills, and then in middle school, teachers refine and go over the specifics of studying (2014). However, this proposal doesn’t solve the current problem of high school teachers teaching their students without them being able to grasp important information because of an inability to take effective notes. Researcher William G. Holliday claims that most students need guidance when it comes to taking notes in the science classroom. Although labs help, note-taking targets understanding concepts and problem-solving skills. The earlier students learn to take effective notes, the earlier they will realize what kind of note-taker they are. Holliday suggests that science teachers should begin by refining students’ current notes and their levels of grasping key concepts. The more students practice taking notes, the better the chance that their scientific literacy and academic prowess increase (1999).

1.2 Note-taking Styles

Fortunately, students can take many different routes when it comes to the style of their notes. In Hess and Fournier’s research article, they express their gratitude to their 11th grade chemistry teacher because of the note-taking “code” she taught her students. One of the parts of her note-taking philosophy is that note-taking should vary from subject to subject (2014). This is because different subjects call for different types of note-taking. It may not be useful to draw a picture for your math notes or have 30 practice problems for your psychology notes. Teachers should consider this when advising students on how to take notes for each class. Cheska Robinson, a National Science Teacher Association (NSTA) science teacher, lists several note-taking styles and strategies that are used by teachers all over the United States, especially in the science classroom. Robinson's note-taking style in her classroom involves giving students tools, such as graphic organizers, to have them focus on the important elements of the material, which she called "structured note-taking". Concept maps and notebook foldables are characterized as sufficient structured note-taking methods. Robinson also mentions the timeless note-taking system known as Cornell notes, where students divide their paper into two columns to organize the information. Cornell notes target active learning, by which students are directly involved in the learning process, and allow students to easily review their notes in the future. The final type of note-taking detailed was visual note-taking/sketch-noting, where students use creative drawings to capture major concepts. An NSTA middle school teacher wrote to Robinson claiming that their students love sketchnoting and that they will continue teaching this note-taking style in the future. Although these are all different methods that might be useful for specific lessons or units, Robinson suggests that combining old methods with more modern ones would likely create the best student learning experience. She claims that there is no “one-size-fits-all” note-taking style and that it is important to accommodate your specific class by interacting and collaborating with them (2018).

Kaitlyn McGlynn and Janey Kelly, in their article, claim that language arts must have a place inside of the science classroom. They claim that good writing is practically essential for efficient learning in science class since reading, writing, and speaking skills are required to communicate at an advanced level; however, writing instruction often gets lost in the science classroom. McGlynn and Kelly suggest giving students frequent opportunities to write about the content of their lesson plans, such as a quick bellringer or even a large lab report. They also recommend using positive writing models to break projects into manageable chunks that can be reviewed separately to not overwhelm students and have them picture what they are working toward. Similar to other sources, McGlynn and Kelly also suggest using graphic organizers in class to have students visualize the information. Effectively incorporating writing into the science classroom would improve students' notes as well as their performance in class (2019).

In another one of Robinson’s articles, she employs the term “interactive notebooks” (INBs), an organizational style of notes where students can process the information that they learn in class. INBs allow students to creatively record information through sketch-noting, or even a more basic style, such as Cornell notes. To effectively incorporate INBs into the science classroom, Robinson suggests the following methods: using INBs every day of class, incorporating labs, providing space for students to draw sketches, implementing STEM projects, encouraging students to build on their INBs outside of class, and allowing students to use INBs during open-note assessments. Another style introduced in the article was “digital notebooks”, which are essentially interactive notebooks but on a student’s electronic device. Robinson claims that digital notes can be as effective as hand-written notes when done correctly. The effectiveness of digital notebooks is derived when students don't copy and paste notes and instead diligently take notes by typing while also allowing students to use the wide range of tools available to them online (2018).

1.3 Digital Age

It’s no secret that the world is actively digitizing, and technology is not only playing a bigger role in our day-to-day lives but is also seeping into our long-standing traditions, such as schooling. Although most high schools nowadays require students to have a computer and teachers to record grades digitally, the choice is mostly up to the teacher on how much they choose to incorporate technology into their lesson plans. Some teachers can have a student never pull out their computer in class, and some teachers have all of their assignments online exclusively. With this being noted, can digital note-taking be incorporated effectively into teachers' lesson plans? Digital notes provide lots of advantages that paper notes don't provide. One such advantage is easy accessibility, where a student can take notes on their laptop and later pull them up on their phone since their devices are interconnected. Another advantage is that students can record more information during classes, with most students being able to type faster than they can handwrite. Lastly, digital platforms provide a multitude of tools and resources to allow students to customize their notes to their note-taking experience preferences. With this being said, it should be a clear decision to have teachers transition from teaching students how to take hand-written notes to online notes. However, a known sentiment amongst most educators and researchers is that the pen is mightier than the keyboard, or in other words, digital notes simply aren't as effective as hand-written notes when it comes to student comprehension and information retention. Mueller and Oppenheimer, who experimented to compare hand-written notes to digital notes, claimed "Participants who took longhand notes and were able to study them performed significantly better than participants in any of the other conditions (digital note-taking) " (2014). This is primarily due to the mind subconsciously comprehending information better while writing it on paper. This often leads teachers to ban digital notes or strongly encourage hand-written notes, which is understandable; however, because of the plethora of benefits online notes can provide, digital note-taking should at least be attempted to be incorporated into teachers' lesson plans.

1.4 The Gap

After reviewing the note-taking styles that teachers across the country use, as well as techniques, strategies, and methods that researchers suggested to increase student note-taking efficiency, can a new note-taking style that incorporates all of these methods be implemented into a science classroom? Can interactive notebooks, which already include graphic organizers, engaging notes, and tactics that reward effective note-taking and going back and studying them, be combined with digital notebooks to attempt to get the best of both worlds? In the science classroom, it's important to balance labs, notes, diagrams, and other diverse lessons to have students sufficiently comprehend the fast-paced units and differing concepts week-to-week. Thus, the question arises: can "digital interactive notebooks" emerge as the best note-taking strategy for students in high school chemistry classes to score the best on tests?

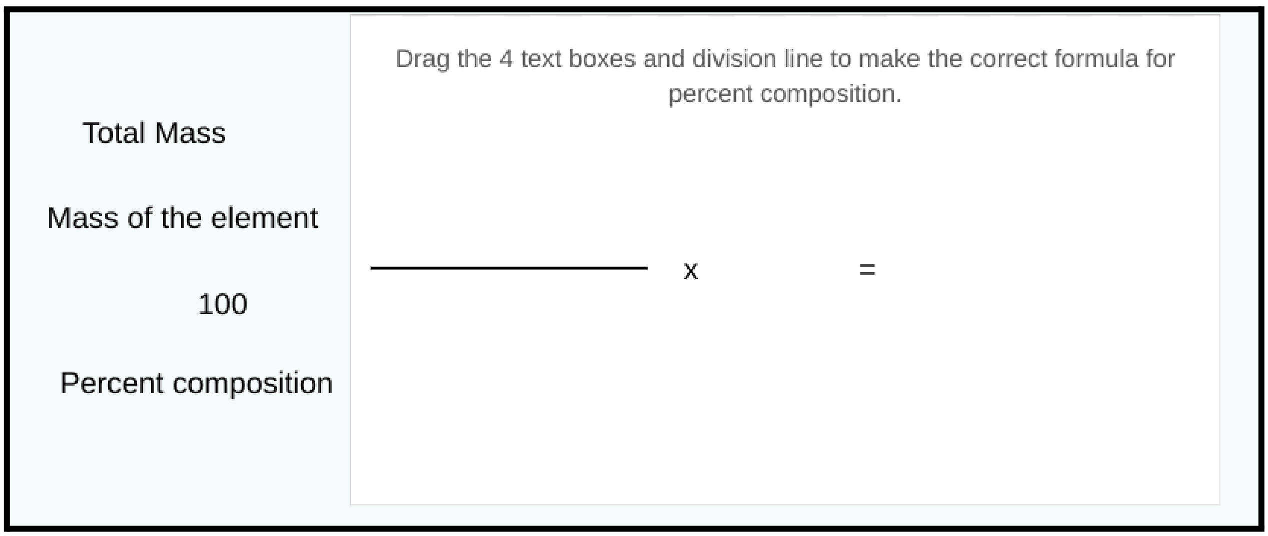
2. Methods

This experiment was designed to effectively test the efficiency of a new note-taking system, combining elements of both interactive notebooks and online, typed notes. The note-taking system was intended to increase accessibility, increase efficiency, and allow for personal customization from student to student while remaining engaging enough for content to be fully comprehended.

Collaborating with a public high school advanced chemistry teacher, one of their classes was selected as an experimental group to receive the new note-taking instruction. This class will be referred to as B3, the third-period class on B days at school. Chemistry, a subject students often struggle with, was selected because of its style of learning, with students often relying on note-taking to understand concepts. The teacher who assisted with the experiment gave the researcher access to change the note-taking style for one of their three chemistry classes during the stoichiometry unit. The two other advanced chemistry classes were assigned to the control group, in which they received the same lesson plan that the teacher had done in years past and would've ordinarily done. This ensured the only difference was the use of enforced online note-taking. These control group classes will be referred to as B1 and B2, and their results were combined when analyzing results to compare strictly the experimental class and the control classes. Students in the experimental class were asked to do nothing more than normal classroom procedures inside of chemistry, and the period of experimentation was restricted to just the time allotted for chemistry class— 90 minutes every other day.

Before each week of class, a digital interactive notebook was designed and created on Google Slides. The current lesson notes, which the teacher already had on Lumio, an online learning tool for the stoichiometry unit, were transcribed onto the Slides. Intentional blanks were left for students to fill in definitions, terms, or answers to questions. When appropriate, certain elements of the lesson plans were changed to better fit an online format and to encourage the use of digital-specific tools. An example of how this was approached was using a drag-and-drop style to approach a conversion problem. This was an attempt to increase interaction for better comprehension.

Before:



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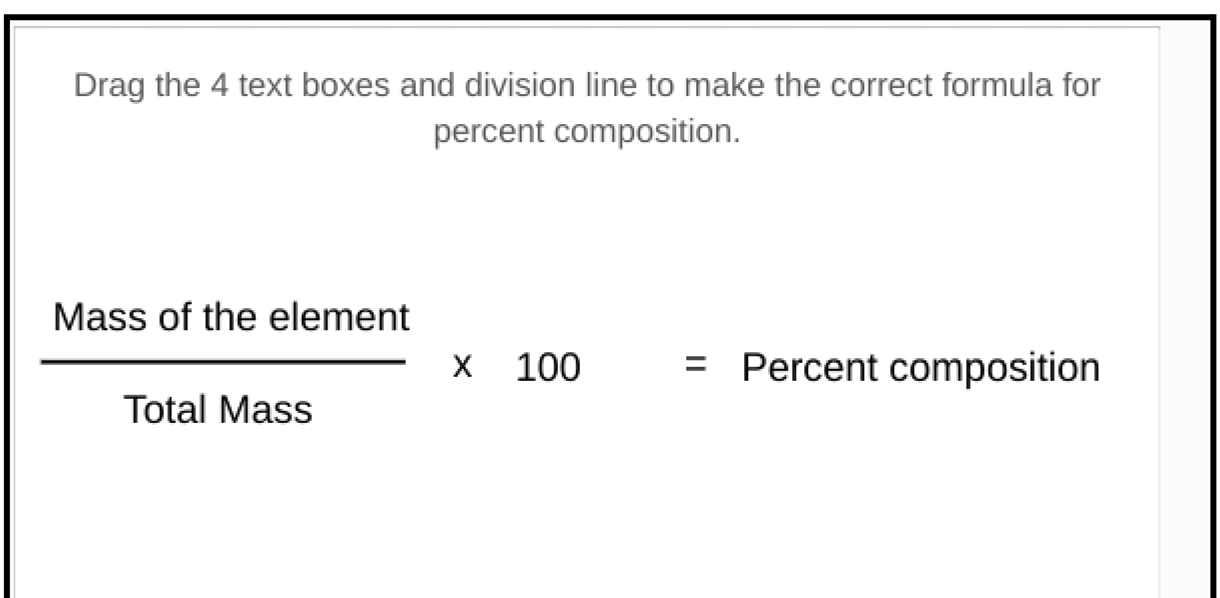

Then, the teacher would download and provide copies to students during class on the learning management system, Schoology, weekly. Students were instructed to take notes during class on their new digital interactive notebook for each week of the unit. The teacher presented all of the information on Lumio at the same pace that students were navigating each slide, allowing students to type important information quickly along with the teacher. This, in turn, allowed more information to be presented in one class. Additionally, most students in the school have experience working on Google Slides, so they were able to customize each slide to their preference or add new information to tailor the slides to their comfort.

After multiple weeks of using the digital interactive notebooks, all students were given in-class quizzes, on paper, to test their knowledge of stoichiometry. Before each test was given out however, the experimental group, B3, was instructed to take a pre-test survey, which consisted of questions asking if they preferred the new note-taking method, which benefits they received from the digital notes, what was missing from the digital interactive notebooks that could've made learning better, and more. Student input is an important part of maximizing the efficiency of notes. If students don't enjoy taking notes, they're unlikely to put maximum effort into it. Student input was collected to identify any flaws that could be fixed and incorporated into future experiments.

After taking the in-class assessment and receiving their scores, students were given a post-test survey, consisting of the same questions as the pre-test survey, but adding the question, "Do you believe using the digital interactive-book helped you understand the concept better, and is your response reflected in your test score?" This question was included to see if their satisfaction with their score after using their notes affected their attitude towards digital interactive notes.

3. Results

3.1 Data

After the tests were taken and graded, 62 scores were obtained for the Mole Concept test, with 19 of these results coming from the experimental group, B3. The average score for B3 was 69.579%, and the average score for B1/B2, the control groups, was 74.727%, as seen in Figure 1.

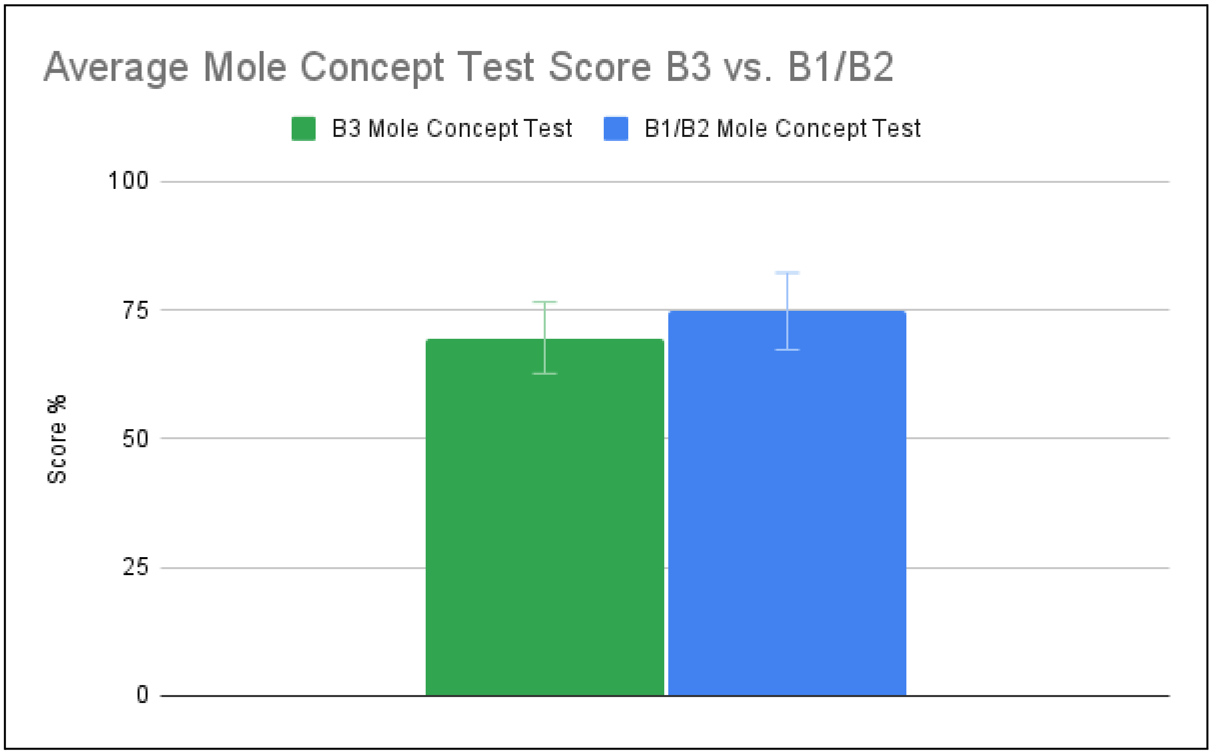

Figure 1: Average Mole Concept Test Score B3 vs. B1/B2

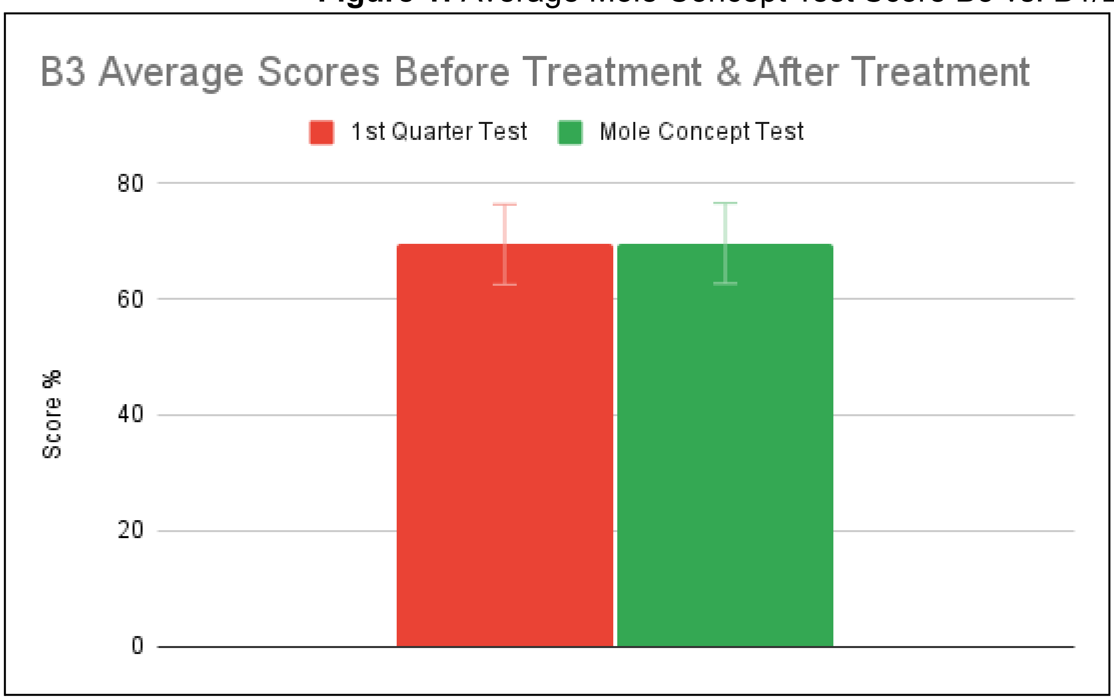

Figure 2: B3 Average Scores Before vs. After Treatment

20 responses were received from the pre-test survey, showing students' opinions on the digital interactive notebooks.

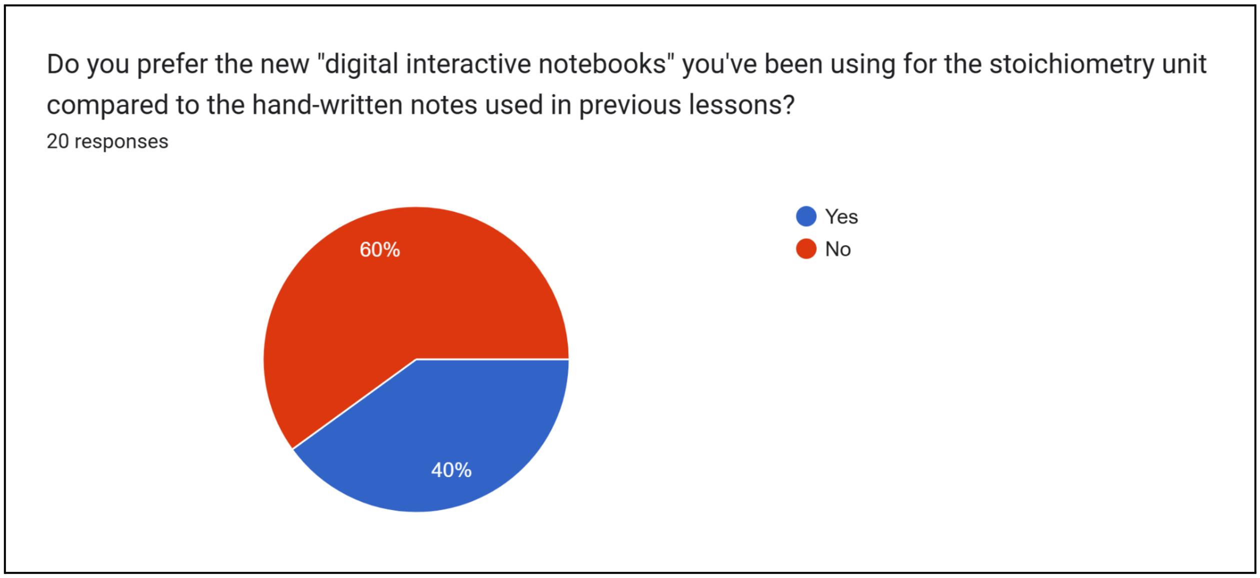

Figure 3: Digital Interactive Notebook Preferability

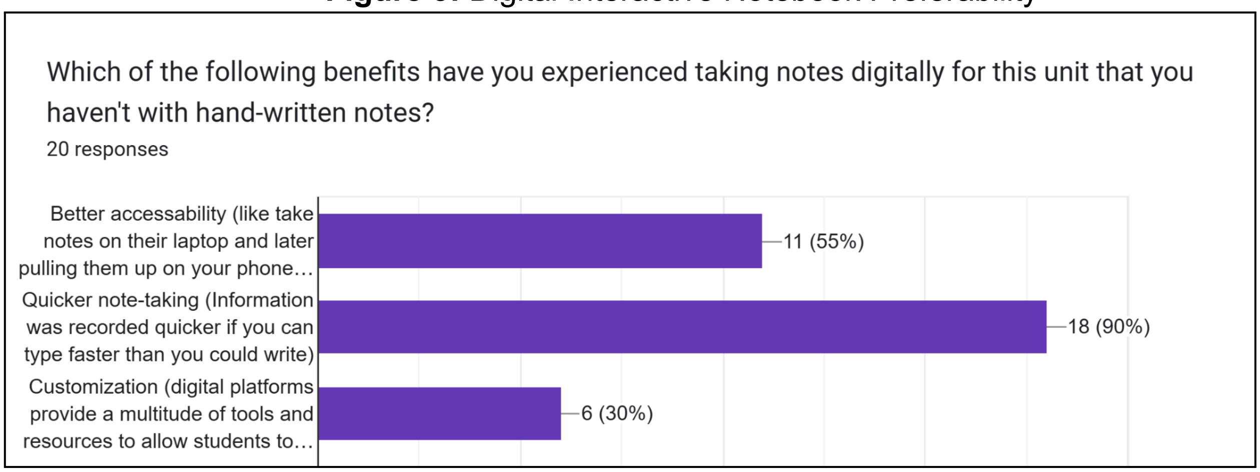

Figure 4: Digital Note-taking Benefits

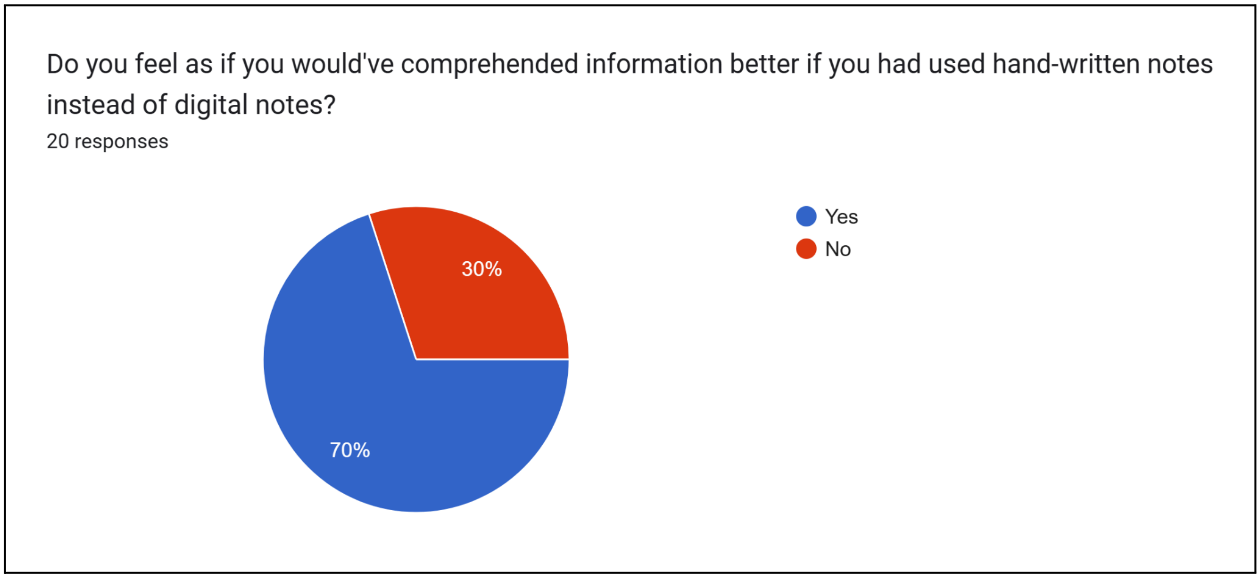

Figure 5: Content Comprehension

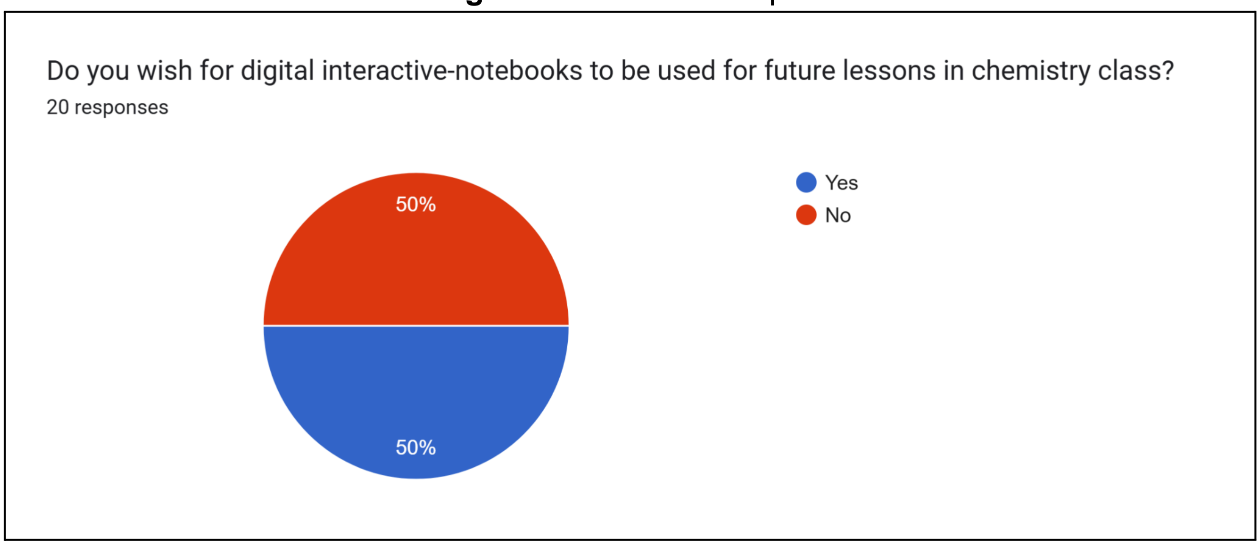

Figure 6: Digital Interactive Notebook Future Preferences

Qualitative data was also received in the survey, with students being able to express their opinion on the digital interactive notebook in open-response questions. When asked, "What elements were digital-interactive notebooks missing that could've helped with better comprehension, engagement, or quality of notes?" Seven students responded, saying that no elements were missing. However, other students responded differently, with four asking for more pictures and diagrams. Another four students responded, claiming that the lack of writing made comprehension more difficult. Some notable individual responses asked for clearer formatting on the slides and more repetition for core concepts.

In the post-test survey, additional responses were received from the question "Do you believe using the digital interactive notebook helped you understand the concept better, and is your response reflected in your test score?" These responses did not follow any particular trend, with most responses simply expressing the student's opinion on the digital interactive notebooks inherently. Notable responses included: "I felt like it helped me understand it better and do better on my homework and other assignments, but it wasn't reflected on my test scores.", "I feel like the interactive notebook was confusing for me, and it wasn't how I would organize my notes in my notebook. But I do think that it is a better way to keep up with my notes.", "No, the digital interactive notebook did not help me understand the concept better. My lack of understanding was reflected in my test score.", and "Yes, it helped me as I understood it much more deeply than I would."

3.2 Data Analysis

Observing Figure 1, the standard error bars were overlapping heavily. This implies that if the experiment were repeated, scores would vary, and trials where B3 scored higher would be observed. To take a closer look, an unpaired T-test was conducted between B3's Mole Concept Test Scores (19 values) and B1/B2's Mole Concept Test Scores (42 values) to see if there was a significant difference in implementing the new note-taking style. The two-tailed P value equaled 0.4897, meaning this difference is not statistically significant, and the intervention did not have an effect on their test scores. Another unpaired T-test was conducted between B3's previous test scores and B1/B2's previous test scores to determine if either B3 was scoring higher or lower on average on tests than B1/B2. The two-tailed P value equals 0.6972, showing there is not a significant difference; this means that classes had similar test performances before experimentation. Figure 2 shows how B3's scores were hardly altered before and after experimentation. A final unpaired T-test was conducted between B3's 1st Quarter Test scores and B3's Mole Concept Test scores to see if the new note-taking style helped B3 students improve. The two-tailed P value equals 0.9742, making this difference not statistically significant and implying that the implementation of the new note-taking style did not have an effect on test scores.

3.3 Discussion

It is no secret that note-taking does not come naturally to a considerable number of students, but if teachers not only teach note-taking inside of the classroom but also try new methods that appeal to modern classes, students will, in turn, perform better in class and on tests. While the new current version of the digital interactive notebook did not yield the expected outcome, there are still valuable takeaways that can improve student learning in the future.

For one, students had mixed opinions about digital note-taking and how it was implemented. Figure 4 shows what benefits students felt they received strictly from the new digital interactive notebook, and 90% of students felt as if they were able to record notes quickly. This was an expected benefit since most modern-day students have extensive experience with typing; however, this is often viewed as a double-edged sword. Although students are able to record information quicker and get through lessons more efficiently, there is more opportunity for content to be lost or not fully comprehended. This is why stress was put on the interactive element of the digital notebook, to counteract the mindless copying that teachers often associate digital note-taking with. As far as the other benefits noted in Figure 4, 55% of students appreciated the better accessibility, from their phone to their laptop to anywhere in the world, they can access, edit, and share their notes. This is a great sign as the majority of students now have more opportunities to go over notes no matter where they are, and there is no unnecessary stress of potentially losing their tangible notes. Only 30% of students, however, experienced the benefits of unique customization. This implies that the majority of students prefer structured notes to make note-taking smoother and clearer. However, 30% is still a sizable portion, meaning that students should be allowed opportunities to customize their notes to their preference in order to maximize each student's note-taking experience individually. Each student is a different kind of note-taker, so it is important to accommodate students by collaborating with them throughout a unit, and seeing what they enjoy and what they don't.

It is also important to note that only 40% of students preferred the new note-taking style to their previous chemistry note-taking method (Figure 3), and 70% of students felt as if they would've comprehended information better if they had taken handwritten notes. These results imply that there were mixed opinions on the new note-taking style, with the majority of students preferring other methods; however, there are other factors that would have contributed to this. For one, the note-taking method was only implemented for one chemistry unit, midway through the second semester. Students were likely already accustomed to their teacher's previously enforced note-taking style. This was reflected in some responses in the survey as well, with one student writing, "It wasn't necessarily missing anything, but it took me a bit more time to understand the lesson completely." Perhaps if digital interactive notebooks were enforced from the beginning of the school year, students would adjust quickly and score better on tests gradually throughout the year.

It is also important to mention that the Mole Concept unit is one of the most difficult units. Introducing stoichiometry is a tall task, and this was reflected across all test scores, with the average of all students combined being 73.175%. Some students likely felt overwhelmed with having to conceptualize a tough unit while trying to use an unfamiliar note-taking platform. This feeling was expressed in some survey responses, with one student replying, "I feel like the interactive notebook was confusing for me, and it wasn't how I would organize my notes in my notebook." Perhaps students would feel more open to the digital interactive notebooks if they had been introduced in an easier unit.

Finally, a reasonable interpretation as to why there was little variation in the results can be attributed to the lack of sufficient interactive elements in the notes themselves. The purpose of the new note-taking system was to implement the benefits of digital notes while counteracting the lack of comprehension typing notes face; however, the experimental group saw little benefits in test scoring. Students expressed this in the survey, with results like "In written notes it's more easier to write formulas and jot down any tips the teacher might include in their lecture in the margins compared to the digital notes," or "Paper creates the environment of learning, while digital note-taking serves more as a regular assignment, not engaging learning but rather practice." Several students expressed how they felt they would've comprehended more if notes were written by hand. Students also had issues with the slides themselves, with responses such as "Some of the slides could've been formatted better," to "(There should be) better interface and use of photos of the topic for visual learners," or " (There should be) easier ways to type equations and a more organized set up." To address this limitation, slides should include more interactive elements and perhaps encouragement of writing some information by hand, too.

4. Conclusion

Although the implementation of the digital interactive notebook did not yield the expected outcome of improving test scores, the experiment offered meaningful insights and important considerations that point to future directions. In their current form, digital interactive notebooks do not improve test performance, but promising indicators were observed. Students had fun with their new note-taking, enjoyed typing information quicker, and experienced the benefits of having their notes on all of their personal devices. These were expected results from transforming notes online. However, students did not receive benefits in their performance or comprehension. More interactive elements should be implemented in the digital notes to make up for the lost understanding of the material. Perhaps putting more emphasis on images and diagrams, videos, embedded links with toggle buttons, or communication/collaboration with each other can make up for any lost comprehension. An optimal combination of both digital notes and hand-written notes can still be reached through a “digital interactive-notebook” approach to help all chemistry students, from struggling to succeeding, to reach their full potential in science; longer periods of note-taking, starting implementation at the beginning of the school year, prioritizing engagement in the notes themselves, and talking to students directly to understand their worries are the first steps of a successful digital-notes wave.

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