THE PAPERLESS CLASSROOM IN HIGH SCHOOL PHYSICS

by

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Dedication

I dedicate this work to my twin boys, Ethan and Aiden Pascual, and to all future 21st century learners.

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ABSTRACT

At my high school, many of the classrooms have class sets of devices, such as laptops, Chromebooks, or iPads. As the school purchased more and more technology, the administration also cut back on our paper availability and began to limit our copies. Due to the influx of technology and the decrease in paper availability, I decided to study the efficiency and effectiveness of a paperless classroom.

In my high school physics class I taught one unit traditionally, all on paper, the next unit was taught nearly paperless, with work being distributed and turned in electronically. I surveyed students about their feelings towards paper versus paperless assignments, notes, and exams. Classwork completion rates were compared between the two units. I gave a pre-test and post-test for each unit to compare achievement. I also kept a time log and teacher journal each day.

Many students did not have positive attitudes towards going paperless in the beginning, but by the end, most students had a positive attitude towards the paperless classroom. The classwork completion rates showed a gain from the paper unit to the paperless unit. The test results were also better in the paperless unit. The time log showed that time spent taking out and putting away devices was saved by not having to pass out papers and transitions were quicker. The journals showed that making the switch to paperless was frustrating for both the teacher and the students at first, but the experience became more and more positive as the unit progressed.

This project had a positive outcome and I will continue to head towards a nearly paperless high school physics classroom.

INTRODUCTION AND BACKGROUND

For the past five years, I have been teaching physics. My current position involves teaching physics and Project Lead the Way Principles of Engineering. I teach at Artesia High School in Lakewood, California. It is a traditional high school with about 1,500 students. Our school culture is aimed at college readiness through rigor and providing academic support to help students meet high standards. Approximately 71% of our students are Hispanic/Latino, 11% of our students are African American, 4% are Caucasian, and 13% are Asian/Filipino/Pacific Islander. Seventy-seven percent of our students qualify for free or reduced lunch. When Artesia High School was scored based on how we do with our students compared to similar schools in California, we scored a ten out of ten ("California School Ratings: Artesia High School," 2014). We perform better than other schools with similar demographics, and that is something for which we are very proud.

The principal of my school is very enthusiastic about technology and asked me to be one of the first teachers to pilot using a class set of iPads. Over the past couple of years, the teachers at my school have had our allotment of paper greatly reduced. In the past year, our copies have been reduced from being unlimited to extremely limited. These changes have led teachers to find more creative ways to manage their classrooms. Currently, I am focused on implementing new science standards and revising outdated curriculum. This task means that I must effectively distribute information to students without relying on old textbooks. To distribute this material, it must either be copied or distributed electronically. This situation led me to consider the best way to make my classroom nearly paperless.

Teaching physics, a course which is not require for high school graduation, I typically have college bound students enrolled in my class. These students decided not to take an Advanced Placement level science course, but still chose to take more science than is required of them. This results a class full of mid to upper level students in my course. I am looking for ways to efficiently enact a paperless classroom. I currently have a class set of Chromebooks and the time it takes for students to get out and put away their devices in addition to the time it takes to log in and log out of their accounts is something that needs to be considered. I am interested in finding ways to make classroom activities and transitions more efficient to make up for the additional time needed to manage the technology during each class period.

To monitor achievement levels, I gave pre- and post-tests for my unit before implementation and my implementation unit. I also tracked classwork completion rates for each unit. To find an effective way to implement the paperless classroom, I surveyed students and kept time logs. I gave students a pre- and post-survey to determine their attitudes towards technology in the classroom. I also surveyed students to determine how many students had access to technology while they were off campus. As I don't typically assign homework, my concern for off campus access is students' ability to study for exams if their work is all technology based. Lastly, I kept a journal about how my class time went and was spent both before paperless implementation and after implementation.

This led to the creation of my focus question, what technology-based tools can I utilize to create an effective and efficient paperless classroom with one-to-one in-class Chromebooks in a high school physics classroom? In addition, the following sub questions were researched, what classroom procedures can be implemented to create

greater efficiency in utilizing technology? and can the use of technology in the classroom improve achievement and learning?

CONCEPTUAL FRAMEWORK

Schools and school districts have many decisions to make related to infrastructure when implementing technology in the classroom. When purchasing technological devices, schools or districts try to choose devices that are both cost effective and can meet the needs of their students and teachers (Minshew & Anderson, 2015). Some schools or districts decide to implement the use of iPads or other tablets because students can write and draw on them (Hesser & Schwartz, 2013). Other schools or districts decide to provide laptops with full keyboards. Another important decision is to decide if students will use their devices in class only or if they will be able to be taken home (Storz & Hoffman, 2013). The schools and districts must also set up a robust Internet infrastructure to accommodate all the additional devices on the network (Minshew & Anderson, 2015).

Once decisions about devices have been made, teachers and other staff must decide what types of software need to be added before students receive the devices Teachers need to have access to devices prior to distribution to students or classrooms. This provides an opportunity for teachers to become familiar with the technology prior to implementation (Storz & Hoffman, 2013). Technology coordinators and administrators often do not give teachers and students access to download new programs onto student computers or tablets. When a teacher finds new, helpful applications or software, it is often a very long process to get the program approved and added to the device (Minshew & Anderson, 2015). In other cases, if the software used changes partway through the class, the entire method for facilitating the class may change. It is important that as the

new technology is implemented, the teachers have a plan in place and have tried activities on the devices themselves (Hofstein et al., 2012).

There are different software programs that can be used to manage a paperless classroom. The goal of the paperless classroom is to have all the resources for the course in one place online that can be accessed from anywhere. However, in many cases, a physical textbook is still in use to supplement the online resources (Lopresto, 1990). Much of the research on paperless classrooms has been done at the university level. Some schools moved towards paperless classrooms to save money on paper, while others did it to try to get ahead of the online learning trend (Wattles, 2001). Professors previously had to write their own codes and computer programs to host their materials and have students submit work. The trend then moved towards simple websites used in conjunction with email. Now teachers have many learning management system options. Teachers can use Google Classroom, Canvas, Blackboard, Moodle, and many more. With these programs, teachers can host class documents, class notes, assignments, and exams. Students can take exams, download documents, and turn in assignments. Each learning management system needs to be evaluated before one is chosen. Some are free while others have a cost. There are differences in the ease of use and ease of grading when using these systems (Wang, 2010).

Administering exams in a paperless classroom can be a difficult task. Instructors want to ensure that their exams are secure and that students are completing them within set parameters. The instructors also want to be able to use various types of questions, not all of which work well when being answered on a device. Another issue is that many test

banks are currently incompatible with the online systems to administer exams (Braun, & Crable, 1998).

In general, students are hesitant to start the transition from paper to paperless, but typically end up liking the experience. Teachers, on the other hand, are often left frustrated by the process. Some of the frustration stems from unreliable infrastructure such as Internet or devices not working, but other frustrations come from policies that do not allow teachers to utilize specific software. The use of devices is very new to teachers and they want more training. They are being given some training, but do not feel that it is sufficient to effectively implement a new way of running their classrooms (Minshew & Anderson, 2015). As one-to-one computing and paperless classrooms become more and more common, some of the training could be moved to teacher training programs so that teachers enter the classroom prepared to utilize any technology that is available to them (Spires, Oliver, & Corn, 2012).

METHODOLOGY

To study the effectiveness and efficiency of the paperless classroom I implemented two units in my physics classes, one using paper (non-treatment) and the other paperless (treatment). The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A). I taught these two units to 99 students in the 10^{th}, 11^{th}, and 12^{th} grades. During the non-treatment unit, everything was done traditionally and electronics were not used. For the treatment unit, nearly everything was done and submitted on the computer. For each unit, I administered a pre-tests and post-tests on the content. In addition, the students completed fill-in-the-blank

notes handouts, did homework problems, read articles, and did lab activities. I was then able to compare the students' achievement on tests, completion of notes, homework problems, and activities between the non-treatment and treatment units. I also surveyed and interviewed students to gauge their feelings towards using technology in the classroom before and after these two units of instruction.

Prior to and after my study, I administered the Student Technology Pre/Post-Survey to determine student preference, perceived learning, and home access when using technology (Appendix B). The survey included 11 questions using Likert style rankings of strongly agree, somewhat agree, somewhat disagree, and strongly disagree. The results were compared and reported using stacked histograms. At the end of the study I also interviewed students to gain further insights about their experiences and preferences when completing assignments on paper or on the computer (Appendix C). The interviews were analyzed for common themes and used to support other data analysis claims.

During both units, each day during class, I recorded how much time was spent on each activity, and after class I recorded my thoughts about the day's activities in the Time Log and Teacher Journal (Appendix D). The time logs were compared between the two units to assess efficient and effective use of time. The journal entries were analyzed for common themes and used to support other claims made when data was analyzed.

At the end of each unit, I assessed students' classwork based on completion and compared completion rates. I was looking to see if students completed a different percentage of their work when using paper versus using technology. The scores for their classwork were analyzed using normalized gains and reported with box and whisker plots.

The first unit on waves and sound was done traditionally. Students took notes on fill in the blank handouts, did labs, problem sets, and activities all on paper. I gave the students the 20 question, multiple choice Waves and Sound Pre/Post-Test to measuring their learning at the beginning and end of the unit (Appendix E). The results of the Waves and Sound Pre/Post-Test were analyzed using normalized gains statistical analysis and reported with box and whisker plots (Hake, 1998).

For the second unit on waves and light, I administered the Waves and Light Pre/Post-Test at the beginning and end of the unit to measure learning (Appendix F). The results of the Waves and Light Pre/Post-Test were analyzed using normalized gains statistical analysis and reported with box and whisker plots. During the second unit, I conducted the activities on the computers. Students accessed notes and submitted assignments through Google Classroom. Students took exams online through Google Forms and interacted with their peers through Verso Learning and Google Drive.

During the technology based unit, I distributed documents through Google Classroom, making a new document for each student. On the different documents, students were able to fill in notes, answer reading questions, fill in lab assignments, and complete conceptual problems. Some items required drawings or equations, students would typically use a white board or piece of paper to draw or solve problems and take a picture of it to insert into their documents. Students also complete some classwork and all tests and quizzes through Google Forms. Some tests required that students use scratch paper, but all the answers were recorded in the Google Form. When watching a video that involved a misconception, students were able to anonymously record their thoughts through Verso and respond to each other. I knew who wrote what, but to the students it

was anonymous, students were able to interact based on shared thinking, instead of choosing to respond only to their friends.

The results from the Waves and Sound Pre/Post-Test (Appendix B) and the Waves and Light Pre/Post-Test (Appendix F) were compared for significant differences in gains by comparing normalized gains. The normalized gains are assessed as high (>.7), medium (.3-.7), or low (<.3) (Hake, 1998). The methods of collection are summarized in the Triangulation Matrix (Table 1).

Table 1
Data Triangulation Matrix

Question	Data Sources		
Focus Question: What technology-based tools can I utilize to create an effective and efficient paperless classroom with one-to-one in-class Chromebooks in a high school physics class?	Time Log	Teacher Journal	Student Technology Pre/Post-Survey
Sub-question #1: What classroom procedures can be implemented to create greater efficiency in utilizing technology?	Time Log	Student Interview Questions	Teacher Journal
Sub-question #2: Can the use of technology in the classroom improve achievement and learning?	Waves and Sound Pre/Post-Test	Waves and Light Pre/Post-Test	Classwork Completion Rates

DATA AND ANALYSIS

Prior to implementation, 57% of the students agreed that turning in assignments digitally was effective for them (*N*=99). By the end of the study, 83% agreed that turning in assignments digitally was effective (Figure 1). When asked if students agreed that they preferred to turn in assignments digitally versus on paper, 50% agreed prior to the paperless unit, whereas 78% agreed after the paperless unit. One student said, “I prefer to

do class work digitally because it is all saved online and I don't have to worry about losing papers.” Prior to implementation, 58% of students agreed that they were organized when their work was digital, 76% agreed after implementation. One student stated, “I prefer to do classwork digitally because it is easy to keep track of assignments and helps with organization problems.” Only 45% of students preferred to take notes digitally prior to the Waves and Light unit. After taking all our notes digitally for the whole unit, 78% of students agreed that they preferred to take notes digitally. One student said that they preferred to take notes digitally because “when taking notes on paper I get upset about how fast I am writing and how I’m not learning anything because my handwriting is so messy and I know I’ll never look at it in my notebook, but with online notes everything is neat and the writing is nice.” When asked to agree or disagree with the statement “I would feel confident taking a computerized exam,” 58% agreed prior to paperless implementation, whereas 78% agreed after the paperless classroom implementation. One student said, “I do not have a preference when taking multiple choice tests. However, it is easier to type free response answers, rather than write them out by hand.”

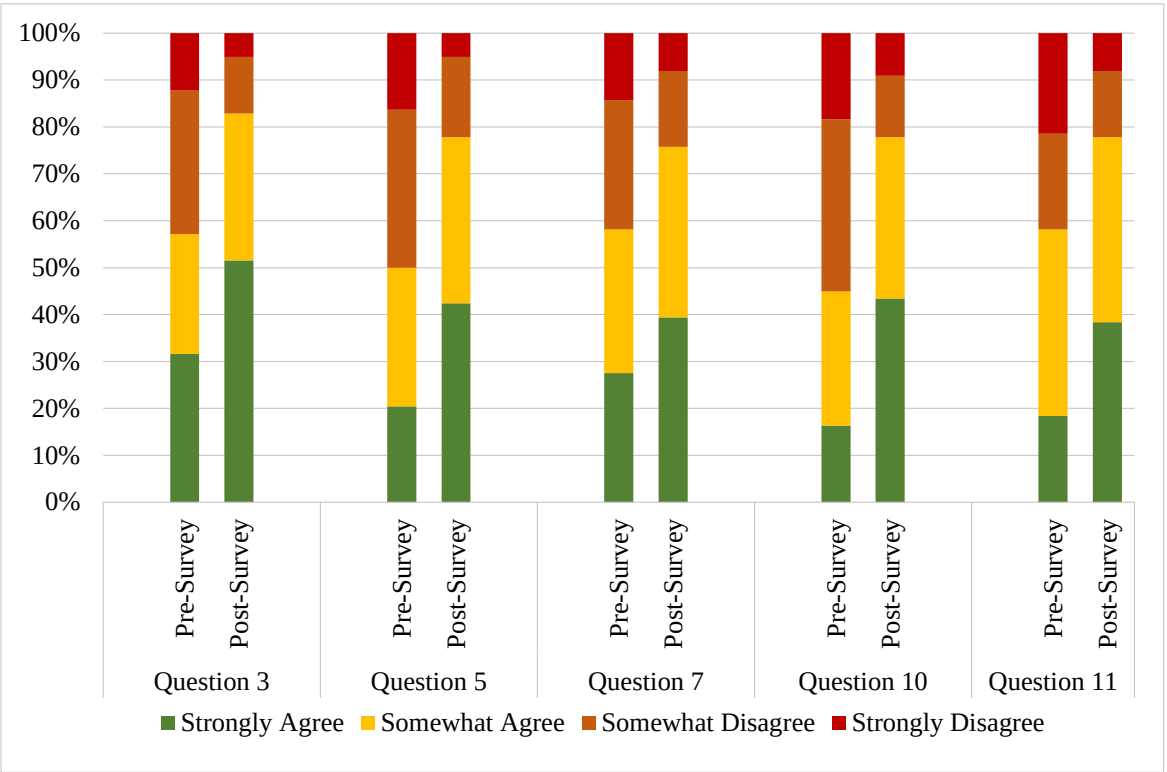


Figure 1. Student Technology pre/post survey results, (*N*=99). Question 3: Turning assignments in digitally is an effective way for me to submit my work. Question 5: I prefer to turn in assignments digitally. Question 7: I feel organized when all of my assignments and notes are digital instead of on paper. Question 10: I prefer to take notes digitally. Question 11: I would feel confident taking a computerized exam.

From the Time Logs, I found differences in transition times and times to get class started each day between a paper based classroom and a paperless classroom. In the paper based unit, it took students an average of one to two minutes for students to have their notebooks out and ready to begin class. It also took an average of one to two minutes each time that I handed out papers. When students handed out papers, it took two to four minutes. Transitions averaged two to three minutes in the paper based unit. In the paperless unit, I had students pack up 30 seconds to 1 minute before the bell.

During the paperless unit, it took an average of three to four minutes after the bell for students to have their lap tops logged into Google Classroom and ready to start. There

was not any time spent passing out papers, although I did have to spend one to two minutes posting saved items to Google Classroom on a few occasions. The transition times were typically 30 seconds to 2 minutes, but averaged about 1 minute. I gave students three minutes at the end of each class to log out, put away, and plug in the laptops.

According to my teacher journal, during the unit on paper, I talked mostly about class running smoothly. In one instance I wrote, "class went well today, the students took notes on their hand outs and worked on their labs in groups." One day I noted that "students who volunteer to pass out papers are being distracted/distracting, it is making it so that I cannot really start to explain until the papers are passed out, I think it is faster to just hand them out myself." Another issue that I mentioned a couple of times was having difficulty reading what students wrote, making it harder to grade for content, as opposed to completion. Towards the end of the unit I stated that "I am having to make new copies of papers because absent students never picked them up and some students lost them and took an extra set, now I am out of copies and everyone realizes they need a paper right before their notebooks are due."

During the paperless unit, my journal entries showed frustration in the beginning. On the very first day I thought that the pre-test was loaded onto Illuminate for students to take it, but when they logged in, all they saw was a blank test without any questions. "I was scrambling to get the pre-test into Google Forms since after messing around with the settings in Illuminate for a few minutes my students still could not see the test. I could see the test, I don't know why they could not. I got it into Google Forms, but my morning students lost a good chunk of class time while I did it." One day I stated that "some

students are complaining a lot about not liking to type their notes, they are slow at typing and take a very long time to copy the notes into their slides. It is fill in the blank, I hope they get quicker at this." As the unit progressed, most of my journal entries became more positive. I commented that "if I add a one by one table into the Google Doc where I want students to answer, they can type into that box and it grows as they type, without messing up the formatting." Test taking and grading were talked about positively saying "students know exactly where to sit for computer based tests now" and "that quiz was so easy to grade because I could read their answers and didn't have to decipher different penmanship." Towards the end of the unit I stated that "it has been so nice to be able to post links or supporting documents for absent students to access so that they could complete the work and to be able to just assign a missed quiz or test digitally. I did not have to find old papers or make new copies when students were absent or forgot about something and students did not lose their work because it was all electronic." The post-test was multiple choice and the day I gave that test I wrote "my students were studying their notes on Google Drive before the test today and they were so excited to know their test scores as soon as they submitted their tests."

During the traditional unit on paper, my students scored an average of 34% on the Waves and Sound pre-test. They scored an average of 52% on the Waves and Sound post-test (Figure 2). These scores result in a normalized gain of 0.27 which is considered a low gain. For the paperless unit, Waves and Light, my students averaged a 34% on the pre-test again, but this time, they averaged a 75% on the post-test (Figure 2). This is a normalized gain of 0.62, a medium gain.

After accepting late work and allowing absent students to get caught up, when grading based on completion, my students earned an average of 91% on their classwork assignments during the unit on paper. During the paperless unit, the classwork average increased to 95% (Figure 2). The normalized gain in classwork percentages is 0.36, this is a medium gain. In the unit on paper 18% of the students completed 100% of their work, whereas in the paperless unit 58% of the students completing all their work, earning a 100% on their classwork for the unit.

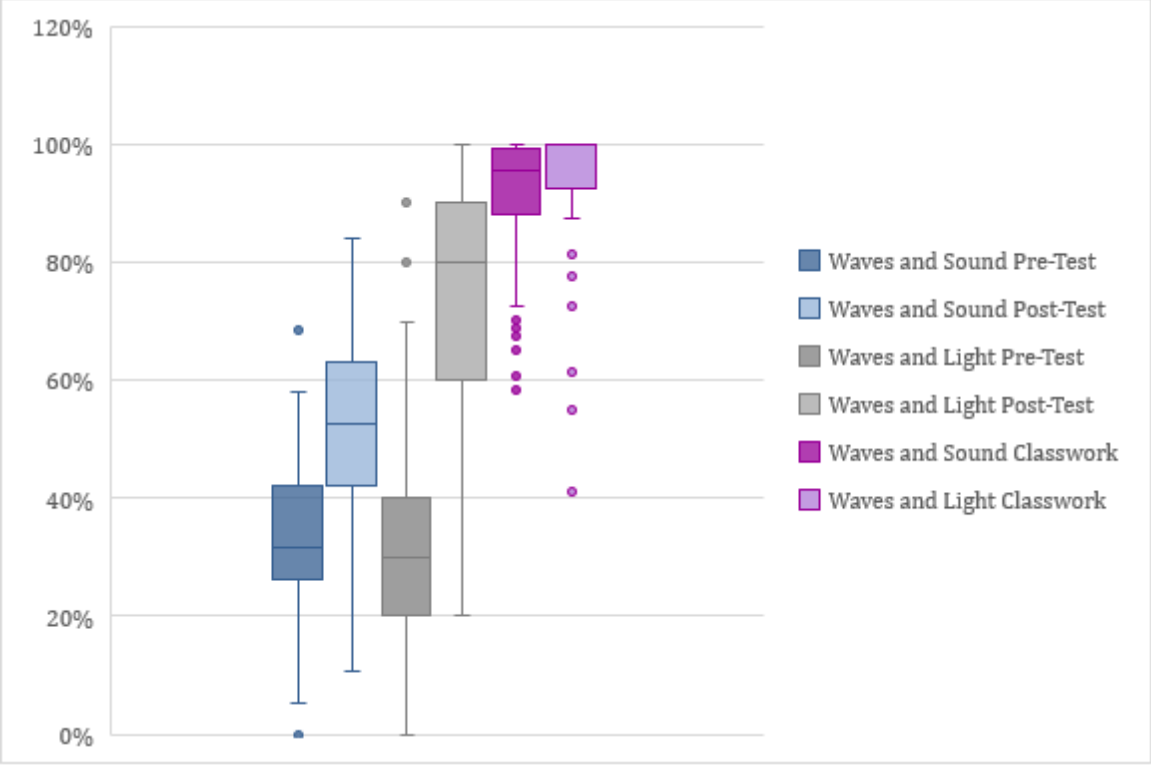


Figure 2. Test score and classwork score distributions, (*N*=99).

INTERPRETATION AND CONCLUSION

The paperless unit had positive results when it came to time use, student preference, and performance. I was quite surprised by how much time was being spent handing out and collecting papers. It turned out that the time spend taking out and putting away computers was made up for in time savings from not having to hand out papers and

from transitions going more quickly. The beginning and ending of class combined was about three minutes prior to implementation and about six to seven minutes after implementation. These three to four minutes were made up by saving minutes in transition times and paper passing times. Even when my students are working on paper I usually have technology incorporated on the teacher end of the lesson, so technology issues, like the internet being down, were still issues, weather the unit was being conducted on paper or on the computer. For me, I spent time converting documents into Google Docs with spaces for student to put their answers, instead of spending time at the copy machines. When grading, I can see students' work wherever I am, without carrying around stacks of papers. I am also able to read students' answers, this is important to me, since I struggle to read different penmanship. I could grade quizzes much more quickly than I had been able to in the past, however, I did not give a quiz during the Light and Sound unit, so I cannot compare real times, but I had the quizzes from the Light and Sound unit graded by the end of the period they were given, the quiz was several multiple-choice questions, followed by one short answer question. It seems that when comparing a paper unit versus a paperless unit each has its own places where time will be saved, resulting in similar efficiencies.

The students and I had frustrations at the beginning of the paperless unit. On the pre-implementation survey, many students did not view the exclusive use of technology in the classroom in a positive light. At the beginning of the paperless unit I had some technical issues and my students had a learning curve to get used to a new way of taking notes and doing assignments. There was a significant amount of complaining at the beginning. After a few days, the complaining stopped, except for from a small, vocal

minority, and the students and I got better at doing things in a paperless environment. Change is hard for humans, so it makes sense that the students would be reluctant at first, but the students who embraced the change had great results. Most students began to view turning in assignments and taking notes digitally in a much more favorable way. By the end of the paperless unit, the post-survey and interviews showed large gains in students' favorability in doing things digitally. They thought that they were more organized, could easily access assignments, could take notes easily, learned well, studied well, and could take tests well. I do agree with a student who said that they "like calculation assignments on paper instead because it is easier to work questions out, but assignments that have to do with reading and words, I'd rather do it on the computer." As we move away from problem based physics and focus more on concepts with the new Next Generation Science Standards, there should be less and less problem sets, but the math will likely still need to be done on paper or whiteboards.

For students and myself to use technology in an effective way, I utilized the Google suite of tools, including Classroom, Docs, Slides, and Forms. I also utilized an application called Verso where students could interact and have a guided discussion. I ran into some issues with having students fill out PDF documents and have tried having students use a plug in called Kami, but there are glitches and I am in contact with the developers to help pinpoint and fix the issues. Additional tools such as PhET simulations and a wave table simulator were utilized as well.

For my students to be ready to learn as quickly as possible, through this process systems were set up. One such system was that students get their computers as they walk into the room and log into Google Classroom. The students then put their laptops at "30

degrees," meaning that the surface of the keys and the screen make approximately a 30-degree angle. When I saw all students with their screen tilted down, I knew that they were ready for instructions. I also asked students to give me 30 degrees when I was showing a video clip or giving instructions in the middle of class, this helped to ensure that I had the students' attention and that they were not distracted by what was on their screen. Giving students enough time to log off and put away and plug in their computers was vital for keeping the computers organized and in working order, three minutes seemed to be sufficient in my classroom.

During the paper unit on Waves and Sound my students had low gains in achievement from pre-test to post-test. During the paperless unit on Waves and Light the students had gains that are considered medium, but on the very high end of the medium range from their pre-test to post-test. I saw the students studying more for the second unit. The students were pulling up their notes and their old assignments on the computer and really reviewing in class when given time to do so. I didn't see students utilizing study time before the test as much with the unit on paper. Some students felt like they were not learning as well because they were typing their notes instead of writing them, but once they got their test scores, immediately because the test was digital, they were happy with what they had learned.

During both units, I graded classwork based on completion. In my classes, most of my students do most of their work and I accept late work. That all being accounted for, there were medium gains in classwork completion from the paper unit to the paperless unit. During the paper unit, when students were absent or they misplaced a paper, they would have to ask me for a copy of the paper. Trying to be environmentally friendly and

resource friendly, I try to make very few extra copies. As the quarter ended and students realized they didn't have a paper, either because they never picked one up after being absent, or they misplaced it, they would ask for new copies. Often by that point, I was out of papers and would need to dig out the original to make more copies. Some students would do assignments, but couldn't find them. Others would have their packet nearly done, but would hesitate to turn it in because it wasn't complete. These problems were eliminated with the paperless unit. Now, when students were absent they had access to the assignments online. When students didn't finish an assignment, they could go back to it in Google Classroom and complete it and submit it without having to find it or ask for a new copy. When a student missed a test or quiz, all I needed to do was assign it to them at the appropriate time. I stopped needing to keep track of papers that were turned in and papers that I needed to have originals of and extras of hanging around for students to inevitably ask for more copies of. I still give grades for assignments at the end of the unit, but now I can see from my computer who has completed what, as opposed to when students turn in a notebook or a packet, I can't really see who is missing assignments along the way, until it is all turned in. This helps me to be able to remind students to get their work in.

My students changed their attitudes for the better towards taking notes and doing assignments digitally. My students saw greater gains in pre-test to post-test scores when doing the unit digitally. And my classroom ran more smoothly once procedures were in place for the digital unit. Being a Google school district, the Google suite of tools are right for my situation to implement a paperless classroom.

VALUE

As technology advances and improves, there will be changes to how it is utilized in secondary classrooms. Although the published research from a few years ago mostly shows that there were not significant gains in achievement or engagement, I think that as the tools are improving, we will see more and more gains. The results that I got seemed to be better than what researchers had found in prior years. Even being a younger teacher who has always had a computer in my home and has had internet since before middle school, it took a significant amount of training and four years with technology in my classroom for me to take the plunge into a single paperless unit. I don't think that giving teachers technology without significant support will cultivate a culture of meaningful classroom technology use. However, with support, a plan, and confidence, I see that implementing a technology based high school science classroom can have real benefits to both the teacher and the students, as long as the teacher can get past the initial frustration phase. I think that having students work on their typing skills for five minutes as a warm-up may be one way to help students feel more confident when taking notes and doing work on the computers.

As a high school physics teacher, I had previously used technology for virtual labs or to have students do research and make Google Slides presentations, but I had never attempted to conduct an entire unit without paper. Previously, when I wanted to try something new, I would try it for a little while, then if it got frustrating for me or if students complained, I would abandon it and go back to the traditional way. Since completing my Waves and Light unit, I have moved most of my assignments to electronic versions, some of my students are happy about that and when we use paper ask

why we can't do it on the computer, while others still ask for paper and complain when things are done on the computer. I have learned that I cannot please everyone, but that I have the data to back up the fact that most students prefer it and they perform better on both classwork completion and assessments, so I have the confidence to keep it up. A few weeks after the paperless unit I had students take notes on presentations given by their peers, about 85% chose to take their notes on the computer, while only 15% chose to take notes on paper. There are a vocal few who are still resisting the change, but I know that I will start off with a paperless classroom next school year and the students will never have known any other way. Overall, there were some frustrating moment, but this was a very positive experience and study.

As an educator, going through this experience has changed the way I look at embracing changes in my classroom. What I found from this study is that it may be frustrating for both the teacher and the students at first, change is hard for humans, but if you persist, then the change may be positive for all involved. I will make sure that I commit to giving a fair chance to any new processes and methods I try in my classroom by implementing them for at least one month or one unit before deciding if I will keep them. I really value the information that I obtained from student surveys and interviews, I may make surveys about new things I try a regular part of my classroom culture. I have learned that there will often be a few vocal naysayers, but with data and persistence, I can make positive changes to culture and learning in my high school physics classroom.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

Institutional Review Board Approval

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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c/o Immunology & Infectious Diseases
Montana State University
Bozeman, MT 59718
Telephone: 406-994-6783
FAX: 406-994-4303
E-mail: cherylj@montana.edu

Chair: Mark Quinn
406-994-5721
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-6783
cherylj@montana.edu

MEMORANDUM

TO: Catherine Pascual and John Graves

FROM: Mark Quinn, Chair Mark Quinn CJ

DATE: January 30, 2017

RE: *"The Paperless Classroom in a High School Setting" [CP013017-EX]*

The above research, described in your submission of January 30, 2017, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

STUDENT TECHNOLOGY PRE/POST-SURVEY

Student Technology Pre-Survey

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

* Required

First Name *

Your answer

Last Name *

Your answer

Class Period (Physics) *

Choose

Please state to what extent you agree/disagree with each of the following statements. *

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree
I like to use technology like iPads and Chrome Books in class.	○	○	○	○
I learn better when using technology like iPads and Chrome Books in class.	○	○	○	○
Turning in assignments digitally is an effective way for me to submit my work.	○	○	○	○
When I am at home, I have access to the technology necessary to work on and submit assignments digitally.	○	○	○	○
I prefer to turn in assignments digitally.	○	○	○	○
It is easier to collaborate with group members when assignments/projects are done digitally.	○	○	○	○
I feel organized when all of my assignments and notes are digital instead of on papers.	○	○	○	○
I prefer to take notes with a pen/pencil and paper.	○	○	○	○
I prefer to hold paper assignments in my hands, over doing them electronically.	○	○	○	○
I prefer to take notes digitally.	○	○	○	○
I would feel confident taking a computerized exam.	○	○	○	○

SUBMIT

APPENDIX C

STUDENT INTERVIEW QUESTIONS

1. How does the student use of technology impact your interest in your classes? In physics class?
2. How does the student use of technology impact your learning in your classes? In physics class?
3. How accessible to you are digital assignments outside of class? How do you gain access to them?
4. Do you prefer to do classwork digitally or on paper? Why?
5. Do you prefer to do homework digitally or on paper? Why?
6. Do you prefer to take tests digitally or on paper? Why?
7. Do you prefer to take notes digitally or on paper? Why?
8. Do you prefer to do group projects digitally or on paper? Why?
9. How can our school make your experience doing work digitally better?

APPENDIX D

TIME LOG AND TEACHER JOURNAL

Time Log

Date:

Start Time	End Time	# of mins	Activity

Teacher Journal

Activity	Reflection

Overall Thoughts:

APPENDIX E

WAVES AND SOUND PRE/POST-TEST

Waves and Sound Test Spring 2017

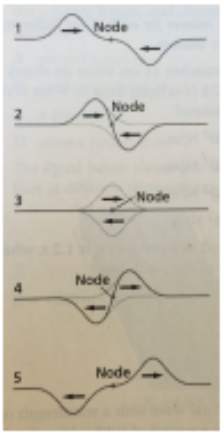
$v = \lambda f \quad f = \frac{1}{T} \quad T = \frac{1}{f} \quad v = \frac{\Delta d}{\Delta t} \quad T = 2\Pi\sqrt{\frac{L}{g}} \quad f_o = f\frac{v + v_o}{v - v_s} \quad v_{sound} = 340\ m/s$

1. Question Omitted
   c. 0.75 m
2. A longitudinal wave with a wavelength of 0.50 m has a period of 0.20 s. How far does the wave travel in 45 s?
   a. 68 m
   b. 110 m
   c. 140 m
   d. 170 m
3. _____ occurs when small forces are applied at regular intervals to a vibrating or oscillating object and the amplitude of the vibrations increases.
   a. A pendulum
   b. Resonance
   c. Larger displacement
   d. Harmonic convergence
4. What is the wavelength of a wave with a frequency of 720 Hz in air where the speed of sound is 343 m/s?
   a. 0.48 m
   b. 0.95 m
   c. 2.1 m
   d. 2.5 m
5. The loudness of sound as perceived by the ear and brain depends mainly on its _____.
   a. Doppler effect
   b. amplitude
   c. velocity
   d. pitch
6. If the velocity of sound is 343 m/s in air and 1493 in water. For sound with a frequency of 440 Hz, what is the difference between the wavelength in air and in water?
   a. 1.0 m
   b. 2.6 m
   c. 4.2 m
   d. 4.4 m
7. A car approaches a pedestrian standing on the side of the road. The car is traveling at 24.2 m/s. The horn of the car emits a sound wave with a frequency of 482 Hz. What frequency does the pedestrian hear?
   a. 478 Hz
   b. 490 Hz
   c. 519 Hz
   d. 522 Hz
8. As a train speeds away from the station, its whistle sounds with a frequency of 624 Hz. For a listener standing on the platform of the station, sound waves from the whistle have a frequency of 580 Hz. What is the velocity of the train relative to the listener at the station?
   a. -23 m/s
   b. -24 m/s
   c. -25 m/s
   d. -26 m/s
9. A sound wave travels across the room. The wave sent is a
   a. radio wave.
   b. torsional wave.
   c. longitudinal wave.
   d. transverse wave.
10. A sound wave traveling through a solid material has a frequency of 500 Hz. The wavelength of the sound wave is 2 m. What is the speed of sound in the material?
    a. 250 m/s
    b. 500 m/s
    c. 1,000 m/s
    d. 250,000 m/s
11. A sound wave is produced in a metal cylinder by striking one end. Which of the following occurs was the wave travels along the cylinder?
    a. Its amplitude increases.
    b. Its frequency increases.
    c. It transfers matter.
    d. It transfers energy.
12. Two clarinet players are tuning their instruments. One plays a perfect C at 253 Hz. The other is slightly sharp and plays at 257 Hz. What is the beat frequency?
    a. 2 Hz
    b. 4 Hz
    c. 6 Hz
    d. 8 Hz
13. If the string is 12 m long, how long is a



wavelength?
    a. 2 m
    b. 3 m
    c. 4 m
    d. 6 m

14. The diagram shows the superposition of two waves.



Which of the following is true about the waves shown in the diagram?

a. equal amplitudes, constructive interference
b. equal amplitudes, destructive interference
c. different amplitudes, constructive interference
d. different amplitudes, destructive interference

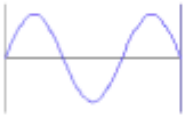
15. Sound waves cannot carry energy through
    a. water.
    b. air.
    c. a mirror.
    d. a vacuum.

16. This wave could be called the:



    a. 4th overtone
    b. 5th overtone
    c. 6th overtone
    d. 7th overtone

17. Which harmonic is shown below?
    a. First
    b. Second
    c. Third
    d. Fundamental



18. In a transverse wave,
    a. the particles move perpendicular to the direction of the wave motion.
    b. the particles move parallel to the direction of the wave motion.
    c. energy causes the particles to move forward with the wave.
    d. energy is propagated by compressions and rarefactions.
    e. the speed is unaffected by the type of medium used.

19. If an ambulance is approaching you with the siren on, the sound of the siren will
    a. decrease in frequency as it approaches you.
    b. change from quite to loud as it moves away from you.
    c. get quieter as it approaches you.
    d. increase in frequency as it approaches you.
    e. both a and c are correct.

20. The shortest time interval in which a wave motion completely repeats itself (i.e., makes one complete vibration or oscillation) is called the:
    a. amplitude
    b. period
    c. frequency
    d. wavelength
    e. speed

APPENDIX F

WAVES AND LIGHT PRE/POST-TEST

Waves and Light Test

You may use scratch paper and a calculator.

First Name

Your answer

Last Name

Your answer

Class Period

Choose

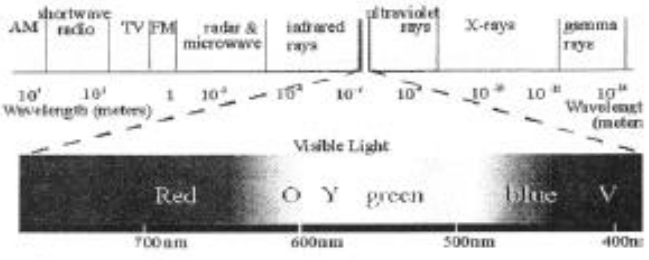
Resources

$$v = \lambda f \quad f = \frac{1}{T} \quad T = \frac{1}{f} \quad v = \frac{\Delta d}{\Delta t} \quad T = 2\Pi\sqrt{\frac{L}{g}}$$

Electro Magnetic Spectrum

Use
$c = \lambda f$
where c is the
speed of light
$c = 3 \times 10^8$ m/s

angstrom,	$A=10^{-10}$
nano,	$n=10^{-9}$
mega,	$M=10^{6}$
milli,	$m=10^{-3}$
centi,	$c=10^{-2}$
kilo,	$k=10^{3}$
micro,	$\mu=10^{-6}$
pico,	$p=10^{-12}$
giga,	$G=10^{9}$



The wavelength of a beam of light passing through a vacuum is 420 nm. What is the frequency of the light beam? 1 point

- ○ 6.7 x 10^13 Hz
- ○ 5.4 x 10^14 Hz
- ○ 7.1 x 10^14 Hz
- ○ 3.8 x 10^14 Hz

Which describes the combination of two primary colors of light to produce a secondary color of light? 1 point

- ○ Yellow light and blue light combine to produce green light.
- ○ Magenta light and cyan light combine to produce blue light.
- ○ Red light and green light combine to produce yellow light.
- ○ Green light and yellow light combine to produce white light.

The primary colors of light are: (Choose 3) 1 point

- ☐ Red
- ☐ Yellow
- ☐ Blue
- ☐ Green

A radio station transmits to a receiving antenna. The radio wave sent is a 1 point

- ○ sound wave.
- ○ torsional wave.
- ○ longitudinal wave.
- ○ transverse wave.

A color of light has a frequency of 5.1 x 10^14 Hz. What color is the light? (Use wavelength.) 1 point

- Red
- Yellow
- Blue
- Violet

If a laser beam hits a mirror as shown, where does the reflection of the laser beam hit? 1 point



- A
- B
- C
- D

The three types of radiation placed in order of increasing wavelength are 1 point

- gamma rays, radio waves, infrared radiation.
- radio waves, gamma rays, infrared radiation.
- infrared radiation, radio waves, gamma rays.
- gamma rays, infrared radiation, radio waves.

The type of electromagnetic radiation that travels at the greatest speed is 1 point

- radio waves.
- visible light.
- x-rays.
- they all travel at the same speed.

Light requires a medium to move through? 1 point

- True
- False

Young's experiment was extremely important because it validated the wave theory of light. 1 point

- True
- False

SUBMIT