IMPLEMENTING COMPUTER DEVICES IN A PRIVATE CATHOLIC HIGH SCHOOL

by

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DEDICATION

Paper is dedicated to Erin and all her support throughout this process. I would also like to thank the many teachers and faculty members who helped me gather information about Holy Cross especially the religion department, math department, and secretaries. I want to thank all the teachers and students who gave up a moment of their time to answer surveys and be a part of this experience with me.

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ABSTRACT

Holy Cross High School is transitioning to allow more computer devices in the classroom for the 2019-2020 school year. During the 2018-2019 school year teachers allowed computer devices in their classroom as they saw fit. I wanted to know about how these computer devices impacted students in their achievement and engagement in the classroom. Surveys, student interviews, faculty interviews, and test grades were used to compare previous years with less computer use to computer use at the time of this study. The study showed that after content chapter tests were analyzed student achievement in honors chemistry classes stayed the same while the college preparatory advanced classes showed positive achievement improvement when students used a learning management software. Learning management systems indicated that they could improve the scores of lower achieving students. Students felt more engaged with the use of computer devices in both honors and college preparatory advanced classes. Throughout the school students and faculty agreed that computer devices help improve the achievement and engagement levels of students.

INTRODUCTION AND BACKGROUND

Holy Cross High School (HCHS) is a small Catholic High School located in Waterbury, Connecticut. Holy Cross High School is a private high school which had a student population of 416 students during the 2018-2019 school year. The student body is predominantly Caucasian with about 27% of the remaining population being African-American, Hispanic, and international students. Many of our international students, at the time of this study, were from China and had been in our foreign exchange program. Each class typically had 104 students (K. Partin & J. Oczkowski, personal communication, March 1, 2019). Many of our students come from wealthy homes but 63% of the student population receives some financial aid or scholarships. The financial support for students allows students from lower income homes to still attend HCHS. Holy Cross High School relies on donations and tuitions to fund the school. Classes were taught on a block schedule that allowed for 80-minute periods. I taught two sections of honors chemistry and three sections of college preparatory advanced (CPA) chemistry to sophomores.

Many faculty had young children in Catholic middle and elementary schools that were using Chromebooks every day during school. These faculty members made the connection that their son or daughter did not have a computer device in the classroom while they attended HCHS. Holy Cross High School did not have a device policy in place at the school before the 2018-2019 school year. A point was made during our review for accreditation that the school was lacking computer devices and updated technology throughout the school. Many classrooms still had chalk boards and pull-down screens for projectors. Many classes did not have consistent access to a projector and needed to sign out a projector from the library every day a teacher wanted to use it. Enrollment had been an issue for HCHS for several years and without students, technology could not be updated for every

classroom. All of this added to another problem with enrollment. Students coming from a middle school that used computer devices throughout the school, examined HCHS and noticed that there was little, or no technology and computer devices being used. It became apparent that HCHS needed to implement more technology in the school.

Holy Cross High School decided to move forward with a new plan which added more computer devices in the classroom. Holy Cross High School implemented this strategy for the 2019-2020 school year. During the 2018-2019 school year HCHS had a transition period where teachers could promote the use of computer devices in their classrooms. During this time the faculty and staff worked to add digital textbooks, gained strategies on how to use different computer devices applications, and updated the school curriculum to better suit today's digital learner.

During the duration of the 2018-2019 school year, teachers were encouraged to have students bring in their own devices to acclimate themselves with how computer devices work in their classrooms. This research study looked at how students and faculty perceived this shift in culture at HCHS, specifically how chemistry students achieved and how much these students were engaged due to an increase in the use of computer devices in the classroom. The focus of this study was, does increasing the number of computer devices in the classroom positively impact student achievement? The sub question was, does increasing the number of computer devices in the classroom positively impact student engagement?

CONCEPTUAL FRAMEWORK

Over the last decade a trend in education emerged that involved the use of technology, specifically computer devices, in the classroom. A wealth of research was conducted which investigated the best practices and use of computer devices, but less has been done to see how these

devices are being effectively implemented in the classroom (Selwyn, Nemorin, Bulfin, & Johnson, 2017). Today's students, and future students are digital natives. This means they grew up with technology and are accustomed to using it as their main source of communication and platform of presentation (Thomas, 2011). Current students feel more comfortable with technology, so it is imperative that these devices made their way into the classroom (Perrotta, 2013).

Students born in the 21st century have become accustomed to the flexibility that technology affords them. This accessibility has allowed students to go at their own pace and even to go beyond what was assigned in class. Education systems need to adapt to this change in how students learn or be left behind. Teachers do not have the luxury of being complacent and cannot continue to use methods that are outdated (Rao & Singh, 2011). Classrooms have evolved from chalk to whiteboards, to smart boards. Teachers today must keep up with the devices students are using, and the students themselves (Al-Derbashi & Abed, 2017).

Teaching is an art that relies on pedagogy, social interactions, and technology to be successful (Wang, 2008). Computer devices have assisted in fostering a social aspect with students such as building cooperation and friendships between groups of students. Wang (2008) continued by saying that social situations and interactions became more flexible when they were done using computer devices. With incorporation of more computer devices a teacher can design lessons and activities to promote a more positive learning environment in the classroom (Wang, 2008).

The implementation of devices into the classroom was shown to have a positive impact on student achievement. In an analysis of studies conducted from 2004 to 2014 by Harper and Milman (2016), when student achievement was examined, one to one devices were shown to have high correlations with test scores. An interesting note was that one study presented the idea that one to

one classrooms were more effective than one to five classrooms (Clariana, 2009). In this study, one to five means that there was one device for five students. This study also said that this change was most likely based off different instructional approaches by the teachers. In a study that compared how tests were delivered, it looked at paper based, computer based, and mobile based tests. This study found that students who took computer-based and mobile based tests were more motivated to take the test, and low-achieving students scored better compared to their paper-based peers (Nikou, & Economides, 2016). Lin, Shao, Wong, Li, & Niramitranon (2011) did a study which indicated that tablets positively decreased the achievement gap between high and low achieving students. Their study also concluded that laptops might be able to positively reduce the achievement gap as well, with the help of the program the students were using (Lin et al., 2011).

Screen size was proven to impact how a student does on a pre and post assignment. A larger screen was shown to capture the student's attention and create more engagement in the activity than a smaller screen on a smart phone for instance (Harper & Milman, 2016). For this reason, it was believed that teachers use more than cell phones as the devices they use in the classroom. Teachers were also encouraged to use computer devices outside of the class as well. One study showed that while no statistical change was evident for achievement in the classroom with devices, when the students used their devices outside of the classroom on homework and learning games, evidence was shown that achievement did increase (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010).

When a study compared teaching styles, such as teachers who used computers and laptops in comparison to normal "chalk talk" methods, the most effective teaching style was using technology. In this study, pre and posttests were used, and the conclusion was that students taught using computer devices scored 25% better than students being taught by "chalk talk" methods (Rao &

Singh, 2011). It is evident that having computer devices in the classroom should be adopted by more educators to have more success in the classroom.

While many studies have indicated positive results with integrating computer devices into the classroom, not all have. When three different schools that adopted digital technologies into their classrooms were investigated, it showed that technology had little positive change in the classroom (Peck, Hewitt, Mullen, Lashley, Eldridge, & Douglas, 2015 & Selwyn et al., 2017). One reason there might have been little positive change could be due to how the devices were rolled out (Selwyn et al., 2017). Selwyn states that there was a bottom up approach, with various teachers implementing more computer devices in their classrooms and with no clear direction from the administration. This could have been a problem as students would get conflicting views when they changed from one teacher's class who used computer devices to another who preferred either not to use the devices or would use them sparingly (Selwyn et al., 2017).

With digital technology at the hands of every student, there were bound to be problems. Some of these problems included restrictions on teacher approved websites, slow computers or tablets, and students becoming distracted by other sites (Sahin & Delen, 2016). The schools' infrastructures also presented a problem for integrating computer devices. Most classrooms did not have enough outlets for every student to charge their device. In addition, schools had to pay for the increased electricity bill. Other research showed that even the teachers themselves were a problem. One study found that age played a part in determining whether teachers would accept more technology in their classroom. Teachers over the age of 50 showed that they were less likely to accept new technology in their classroom (O'Bannon & Thomas, 2014).

Frameworks for Integrating Technology into the Classroom

Improving pedagogical practices by using technology is not a new idea. In a study done by Baturay, Gökçearslan & Sahin (2017), teachers were able to implement the technological, pedagogical, and content knowledge (TPACK) framework. The TPACK framework provided the teacher with a guide to integrate technology into their content area by understanding three knowledge areas (Baturay, Gökçearslan, & Sahin 2017). The first area was technological knowledge (TK), which was a measure of how much the teacher knew about technology. The technology that a teacher used was dependent on the educator's experience. The second area was pedagogical knowledge (PK), which was how the teacher taught their students. A teacher should try new ways to incorporate technology to teach their students (Kihoza, Zlotnikova, Bada, & Kalegele 2016). The teacher needs to keep in mind the result they want for their students as well, such as learning objectives, goals, and strategies. The final area was content knowledge (CK), which was how much the teacher knew about the area they were teaching. A classroom teacher should be a lifelong learner and continue to develop their knowledge along with their students. By combining these three areas into the TPACK framework technology can be incorporated a teacher's classroom while also focusing on the content they want their students to learn (Prasertsilp, 2016).

In addition to TPACK there was another framework to help educators evaluate how they were implementing technology in their classrooms. This model was called SAMR which stands for substitution, augmentation, modification, and redefinition (Lund, 2015). The first level of technology integration was to substitute either an older technology or another resource with current technological instruments. An example of this would be replacing the textbook in a classroom with an e-book. The second level of SAMR was augmentation. In augmentation a teacher can use

technology to deliver their content in a different way. An example of this would be to run a virtual laboratory experiment online using a web browser. The third level of SAMR was modification. Modification was when the educator changed how the lesson or project was constructed by using the technology at their disposal. An example of this would be if a teacher incorporated audio or video tools to edit a project for an English class. The highest level of SAMR was redefinition. Redefinition means to create an entirely new task that would not be possible without the use of new technology. An example of this would be if a teacher used a 3D printer to create a model of a historic battlefield in a history class (Kihoza et al., 2016).

Before adding new technology into a school, the faculty and staff needed to be properly trained in the computer devices. The goal for the professional development focused on the three areas of TPACK (TK, PK, and CK) and the leveling scheme for SAMR. Even after the training was completed, no single technological solution or framework would solve every teacher's problem in their classroom. Teachers were encouraged to continue to learn about new technology, so they could implement it more effectively in their own classes (Prasertsilp, 2016). Once the faculty had seen the technology and how it worked, they were able create their own plan using these resources. Once the faculty felt confident in their ability to use computer devices, they used them to engage their students. Engagement has been correlated to achievement among students. The more a student was engaged then the better their grade was (Perry & Steck, 2015).

METHODOLOGY

Table 1
Data Triangulation Matrix

Focus Question	Data Source 1	Data Source 2	Data Source 3
Primary Question: Do computer devices positively impact student achievement?	Chapter tests (Chapter 5, 7, 8, and 10) compared to previous year	Achievement with Technology surveys	Sophomore Chemistry Interviews
Sub-Question: Do computer devices positively impact student engagement?	Achievement with Technology surveys	Sophomore Chemistry Interviews	Sophomore Teachers Interviews

Table 1 shows the data triangulation matrix for the focus questions as well as how those questions will be answered. In my chemistry classes, I promoted the use of computer devices such as laptops, iPads, and tablets for the students to do their work, look up examples, and open digital worksheets or activities. I also integrated the learning management software, Canvas, into all five chemistry classes. On Canvas, students took digital quizzes and had online discussions all from a personal computer device brought from home or borrowed from the library.

In order to see a potential difference in student achievement and engagement in relation to this study, a posttreatment survey was distributed to the chemistry students in the Honors and CPA level classes (*N=70)*. This survey was administered through Google Forms and was called Achievement with Technology Survey (Appendix A). These questions were Likert style questions that asked the students how they viewed technology use in the chemistry classroom. In conjunction with the survey, I randomly selected a group of 15 sophomore students to be interviewed after the treatment was conducted. The questions asked about the use of computer devices in their chemistry class and in their other classes as well. These students volunteered after an explanation of the research project was explained. The students answered questions about how computer devices

impacted their learning in the classroom and about how the computer devices were used at home. These interviews were called the Sophomore Chemistry Interviews (Appendix B). Sophomore teachers that also teach many of the same sophomores that took part in the study, were asked to respond to how they used technology and computer devices in their classes. These interview questions were used to examine how they use technology to engage their students. These interviews were called the Sophomore Teachers Interviews (Appendix C).

The treatment was implemented using new websites to the classroom and expanding on applications previously used in the chemistry curriculum, such as Google forms and Kahoot.com. The students were assessed on four chapters, chapter ten, five, seven, and eight, in that order. For chapter ten, the students were given a website to help them solve moles to mass problems, then they played a review game of Kahoot and were required to complete Google forms as their homework (Appendix D). For Kahoot, students were required to type in a pin number on their device and answer multiple choice questions against other teams. For chapter five, the students were given a website to help them practice making electron configurations and students played a review game of Kahoot and were required to complete Google forms for homework (Appendix D). For chapters seven and eight, I signed my students up for the learning platform, Canvas. Canvas is a learning management system where students can take online quizzes and tests, have a discussion board, submit assignments, and see their grades. For these last two chapters, students were required to sign into canvas every day and complete the assigned task. For chapter seven, students had to first read an article about how batteries use ions, then students could use the PowerPoint on Canvas to follow along with the notes. Students were also required to complete Google forms as homework and students played a review game of Kahoot (Appendix D). For chapter eight, students were required

to post onto the discussion board a picture of a joke, or meme, that connects to ionic or covalent bonding and explain how the picture relates to the type of bonding. Then students had to follow along on the PowerPoint provided on Canvas to write down their notes. Students were able to review covalent bonds by going to a website that allowed students to move the atoms to connect the bonds and practice naming the molecules (Appendix D). Students also completed Google forms for homework and used a review game of Kahoot (Appendix D). All students of honors and CPA levels were given the same websites, Kahoots, Google forms, discussion prompts, articles, and PowerPoints. Honors students were given less time to cover the material than the CPA students. The specific computer device content for each chapter is summarized in Table 2.

Table 2
Computer Device Content by Chapter

Chapter 10	Chapter 5	Chapter 7	Chapter 8
Mole to mole practice problems website	Electron configuration practice problems website	Canvas practice problems on ionic bonding	Canvas Practice problems on covalent bonding
Kahoot review	Kahoot review	Ion batter article	Canvas discussion post about ionic or covalent bonds
Google forms homework	Google forms homework	Kahoot review	Kahoot review
		Google forms homework	Google forms homework

Student's achievement was gaged using test scores compared from the 2017-2018 CPA and Honors chemistry classes. The CPA classes' achievement was examined using the CPA Chapter 5 Test (Appendix E), CPA Chapter 7 Test (Appendix F), CPA Chapter 8 Test (Appendix G), and the CPA Chapter 10 Test (Appendix H). The honors classes' achievement was examined using the Honors Chapter 5 Test (Appendix I), Honors Chapter 7 Test (Appendix J), Honors Chapter 8 Test (Appendix K), and the Honors Chapter 10 Test (Appendix L). Each of the chapter tests were

analyzed using a two – sample t-test where the second sample is from the previous year's test scores. The p-value was valued to be statistically significant if it was under 0.05. The averages and standard deviations were also evaluated from the tests.

To evaluate student engagement with technology, surveys were distributed to students at every grade level. The initial pretreatment survey went out to all the students in the school through the student's religion class. This survey was distributed through Google Forms and was called the Holy Cross High School Technology Student Survey Part 1 (Appendix M). The Holy Cross High School Technology Student Survey Part 1 primarily consisted of Likert style questions along with questions that asked the students what their engagement level with computers devices present in the classroom was. A survey for the faculty was also developed and sent out over email through Google forms and was called the Faculty Computer Device Survey Part 1 (Appendix N).

Along with the surveys to the students and faculty, students were also interviewed about the technology they have used and noticed in the classroom. The students were randomly chosen to be interviewed from a list of students in three different ability levels. Two students were chosen from the sophomore, junior, and senior classes from each ability level. Freshmen were omitted because they had not had a full year of school at HCHS and I wanted students who had more than a few months of knowledge of the school to tell me what they think about the technology in the school. In total, 18 students were asked to be interviewed and all 18 agreed to participate in the study. The set of questions that was first distributed to this round of students was called Technology and Computer Devices Interviews Part 1 (Appendix O). These were distributed during November 2018.

The second stage of this study involved looking for growth from the pilot study to the second semester of the 2018-2019 school year for the faculty in the classes at Holy Cross High School. A

second round of survey questions was sent out to students of all grades, and to faculty. These two surveys were called Holy Cross High School Technology Student Survey Part 2 (Appendix P), and Faculty Computer Device Survey Part 2 (Appendix Q). Students were interviewed again, this time they were asked about what changes they had noticed from last year to this year and if the subjects that were using technology well the year before were still using technology well this year. These questions were called the Technology and Computer Devices Interviews Part 2 (Appendix R). These surveys and interviews were conducted during late March and early April of 2019.

For analysis the Likert style questions were analyzed by creating bar graphs showing the number of student and faculty responses. The interviews were used to look for inconsistencies and to gain an insight as to what teachers were doing well, according to students, regarding computer devices in their classrooms and at home. The faculty interviews were used to correlate the student data and see if any trends could be seen. This study was given an exemption from the Institutional Review Board through Montana State University (Appendix S).

DATA AND ANALYSIS

Student Achievement

The College Preparatory Advanced (CPA) class results for the chapter tests were compared (Table 3). The results of the comparison show that during the 2018-2019 school year students had a higher mean score for all four tests and had a lower standard deviation than the 2017-2018 school year students. The biggest difference in mean score came in the chapter seven test with 2018-2019 students scoring 4.7 more points than students from the previous year. The biggest drop in standard deviation came in the chapter five test with 2018-2019 students being 0.91 points closer to the mean (Table 3).

Table 3
College Preparatory Advanced Chemistry Classes Chapter Tests Means and Standard Deviations for the 2017-2018 School Year and 2018-2019 School Year

	CPA 2017-2018	CPA 2018-2019	Difference in points (2018-2019 – 2017-2018)
Chapter Ten Mean Score	73.68 points	77.92 points	+4.24
Chapter Ten Standard Deviation	13.52 points	13.97 points	+0.45
Chapter Five Mean Score	75.54 points	78.82 points	+3.28
Chapter Five Standard Deviation	12.22 points	11.31 points	-0.91
Chapter Seven Mean Score	76.24 points	80.94 points	+4.7
Chapter Seven Standard Deviation	12.94 points	10.84 points	-2.1
Chapter Eight Mean Score	79.63 points	82.98 points	+3.35
Chapter Eight Standard Deviation	9.54 points	9.33 points	-0.21

Note. 2017-2018 school year, (*N*=41) 2018-2019 school year, (*N*=50) in total, (*N*=91).

A two-sample t-test was ran on these two classes where *N=41* for 2017-2018 and *N=50* for 2018-2019 and in total *N=91*. The confidence for the two-sample t-test was 0.05 (Table 4). The differences in the averages between the two years were also compared (Table 4). The 2018-2019 class did consistently earn a higher average than the 2017-2018 class but only two of the chapter tests were statistically significant, those being the chapter seven and chapter eight tests. The chapter seven test also had the biggest change in average score with the 2018-2019 class earning 4.70 more points than the 2017-2018 class.

Table 4
Two-sample T-test of the CPA Four End of Unit Chapter Tests During the 2017-2018 School Year and the 2018-2019 School Year

Chapter Test	Difference in means 2018-2017	t-value	p-value	Statistical Change
Chapter ten	4.24 points	-1.45	0.074	No
Chapter five	3.28 points	-1.32	0.097	No
Chapter seven	4.7 points	16.82	0.034	Yes
Chapter eight	3.35 points	2.00	0.049	Yes

Note. 2017-2018 school year, (*N*=41) 2018-2019 school year, (*N*=50) in total, (*N*=91).

The honors class results for the chapter tests were compared (Table 5). The results of this comparison show that the two classes were usually within one point of each other for their means. The biggest difference in mean score came in the chapter five test with 2018-2019 students scoring 4.13 more points than students from the previous year. The biggest drop in standard deviation came in the chapter seven test with 2018-2019 students being 0.91 points closer to the mean (Table 5)

Table 5
Honors Chemistry Classes Chapter Tests Means and Standard Deviations for the 2017-2018 School Year and 2018-2019 School Year

	Honors 2017-2018	Honors 2018-2019	Difference in points (2018-2019 – 2017-2018)
Chapter Ten Mean Score	86.69 points	86.56 points	-0.13
Chapter Ten Standard Deviation	10.19 points	8.12 points	-2.07
Chapter Five Mean Score	81.06 points	85.19 points	+4.13
Chapter Five Standard Deviation	10.31 points	9.65 points	-0.66
Chapter Seven Mean Score	86.14 points	85.69 points	-0.45
Chapter Seven Standard Deviation	10.31 points	6.60 points	-3.71
Chapter Eight Mean Score	87.49 points	87.91 points	+0.42
Chapter Eight Standard Deviation	9.02 points	7.49 points	-1.53

Note. 2017-2018 school year, (*N*=35) 2018-2019 school year, (*N*=32) in total, (*N*=67).

A two-sample t-test was ran on these two classes where *N=35* for 2017-2018 and *N=32* for 2018-2019 and in total *N=67*. The confidence for the two-sample t-test was 0.05 (Table 6). The differences in the averages between the two years were also compared (Table 6). The only statistically significant chapter test was the chapter five test. The chapter ten, seven, and eight all were not statistically significant. The chapter five test also had the highest difference in mean with the 2018-2019 class earning 4.13 more points than the 2017-2018 class.

Table 6
Two-sample T-test of the Honors Four End of Unit Chapter Tests During the 2017-2018 School Year and the 2018-2019 School Year

Chapter Test	Difference in means 2018-2017	t-value	p-value	Statistical Change
Chapter ten	-0.13 points	0.054	0.522	No
Chapter five	4.13 points	-1.69	0.048	Yes
Chapter seven	-0.45 points	0.213	0.586	No
Chapter eight	0.42 points	-0.206	0.418	No

Note. 2017-2018 school year, (*N*=35) 2018-2019 school year, (*N*=32) in total, (*N*=67).

Data from Student and Faculty Surveys

When the treatment was completed, the Chemistry Achievement Survey was examined from the 70 chemistry students who answered, the first question, “Computer devices help me get better grades in school” showed that students answered an average score of 3.83 out of a five-point scale. The results showed that students 24.3% strongly agree, 48.6% agree, 15.7% neither agreed nor disagreed, 8.6% disagreed, and 2.9% strongly disagreed with the statement (Table 7).

Table 7
Chemistry Achievement Survey Responses

Likert Score	5	4	3	2	1
Computer devices help me get better grades in school	24%	48%	16%	9%	3%
Using computer devices in the classroom is beneficial to me because it keeps me engaged in class	31%	33%	24%	9%	3%
I would like to use more computer devices in the classroom	30%	31%	26%	9%	4%
I use computer devices outside of school to help me with my schoolwork	47%	41%	9%	3%	0%
Using different computer device applications is better than using the same thing every time (such as using PowerPoint every day)	24%	47%	24%	5%	0%
I find the Google forms homework is a good way to review the content of the chapter	30%	46%	15%	6%	3%
I find the Kahoot review is a good way to review the content of the chapter	64%	27%	6%	3%	0%

Note. 5=Strongly Agree, 4=Agree, 3=Neither Agree nor Disagree, 2=Disagree, 1=Strongly Disagree. (*N*=70).

The second question, "Using computer devices in the classroom is beneficial to me because it keeps me engaged in class" showed that students answered an average score of 3.81 out of a five-point scale. The results showed that students 31.4% strongly agreed, 32.9% agreed, 24.2% neither agreed or disagreed, 8.6% disagreed, and 2.9% strongly disagreed with the statement (Table 7).

The third question, "I would like to use more computer devices in the classroom" showed that students answered an average a score of 3.74 out of a five-point scale. The results showed that students 30.0% strongly agreed, 31.4% agreed, 25.7% neither agreed or disagreed, 8.6% disagreed, and 4.3% strongly disagreed (Table 7).

The fourth question, “I use computer devices outside of school to help me with my schoolwork” showed that students answered an average score of 4.33 out of a five-point scale. The results showed that students 47.1% strongly agreed, 41.4% agreed, 8.6% neither agreed or disagreed, and 2.9% disagreed with the statement (Table 7).

The fifth question, “Using different computer device applications at school is better than using the same thing every time (such as using PowerPoint every day)” showed that students answered an average score of 3.91 out of a five-point scale. The results showed students 24.2% strongly agreed, 47.1% agreed, 24.2% neither agreed or disagreed, and 4.3% disagreed with the statement (Table 7).

The sixth question, “I find the Google forms homework is a good way to review the content of the chapter” showed that students answered an average score of 3.94 out of a five-point scale. The results showed that students 30.0% strongly agreed, 45.7% agreed, 15.7% neither agreed or disagreed, 5.7% disagreed, and 2.9% strongly disagreed with the statement (Table 7).

For the seventh question of “I find the Kahoot review is a good way to review the content of the chapter," the results showed students answered an average score of 4.61 out of a five-point scale. The results showed that students 64.3% strongly agreed, 27.1% agreed, 5.7% neither agreed or disagreed, and 2.9% disagreed with the statement (Table 7).

During the sophomore interview questions, the first question asked students how the technology in this class has helped them succeed. Overall the responses were positive. Many students expressed how they used the Google forms to help them study before the test as they believed those were similar type questions to the test. Several students also reported that taking notes on the computer was easier for them and that it made transporting materials to and from school

easier. One student said “Kahoot is how I study for class. The Google forms are a good way to help people study. Doing things online keeps people engaged.” Another student went on to say “It is easier to take notes on Google Docs if you forget your notebooks. Google forms is helpful to review and the Kahoots help too.” A different student talked about the websites that were used in class by saying, “when you gave us the website links, they helped me understand the information better because we got to move the protons around and it wasn’t just words because I can picture it.” When Canvas was introduced students had opinions about the learning management platform as well. Many students liked that Canvas kept them organized and neat. Some honors students said after quizzes that they did not like how Canvas automatically gave a grade back after the quiz was completed because it showed a lower score, due to open-ended questions not being graded by the teacher. Responses were still positive though, one student said, “If everyone switched to Canvas it would be better.”

In another interview question, students were asked how they used technology to help them with assignments at home. The most common responses to this question were that students used their computer to do their homework, watch YouTube videos for clarification of a topic, or to use Google to research questions. Some students also said that they made a Quizlet to help them study for tests and quizzes. One student responded by saying, “Technology makes it 100 times easier than going through a book and read through the entire section, on the internet I can go and get a brief summary.” Another student reluctantly turned to technology, “I’ve noticed I’m on my phone a lot, I tried not to use it but found I had to use it. Plus Portals has my homework on it and then I use my computer for my notes.” One student noticed a change from last year, “This year compared to last

year, more classes are using my laptop more. The school is using a lot more technology especially the younger teachers are pushing that, and I like that."

In general, the students liked using computer devices as an alternative to take notes on paper. One student responded by saying, "I get the PowerPoint ahead of time so I can get the notes and then I can pay attention in class. Technology grabs more attention on a big display than the writing on a chalkboard." There were some students who offered to give cautionary tales of the use of technology in the classroom. One student said, "I think that the amount of technology is a good amount, a combination of technology and pen and paper. In some cases, technology can be a distraction if you use technology on the phone or computer." Another student said, "I think Canvas is good because you can see if you go off the screen the teacher will know. Kids will still cheat and use their phones behind the screen." She went on to say that, "Computers are not a problem, but the phones have the social media. If students are using their phones as a device that's where the problems may be." One student was adamant about taking paper tests over online tests and quizzes, "I like the paper tests, for me I don't want to go 100% technology. There is no scratch pad, I would want a piece of paper because there is more room for error."

When the sophomore teachers were interviewed, many of them said that they used technology daily. The technology they were referring to was PowerPoint and other presentation materials. Computer devices being used in the class seemed to be almost non-existent in the sophomore classes. One math teacher said that she did not use any technology in her geometry class. The English classes seemed to be using the most computer devices. One teacher had also implemented Canvas into his class while the other sophomore English teacher used devices to look up definitions of words or to find the root meanings of words. Teachers in religion and history

classes used devices to do research and share information. Some teachers indicated that they were aware of the potential problems that technology could bring. One teacher stated that "Best practices states that faculty actually need four to five years of development combined with a systematic roll out of the technology in the class." This teacher also expressed problems in the past with the internet connection, and he was not alone. Another teacher expressed concerns over reliable internet while yet another shared that the technology needed to be kept up to date.

The whole school was also surveyed to collect data about how HCHS views technology regarding achievement and engagement in the classroom. When the faculty were asked about how often they used computer devices in the classroom since the end of last year, 38.1% used computer devices once a period, 23.8% used computer devices several times a week, 19% used computer devices once a week, and 19% used computer devices once every few weeks (Figure 1). When the faculty were asked about how often they use computer devices in the classroom since midterms, 17.4% used computer devices once a period, 43.5% used computer devices several times a week, 13% used computer devices once a week, 13% used computer devices once every few weeks, and 13% never used computer devices (Figure 1).

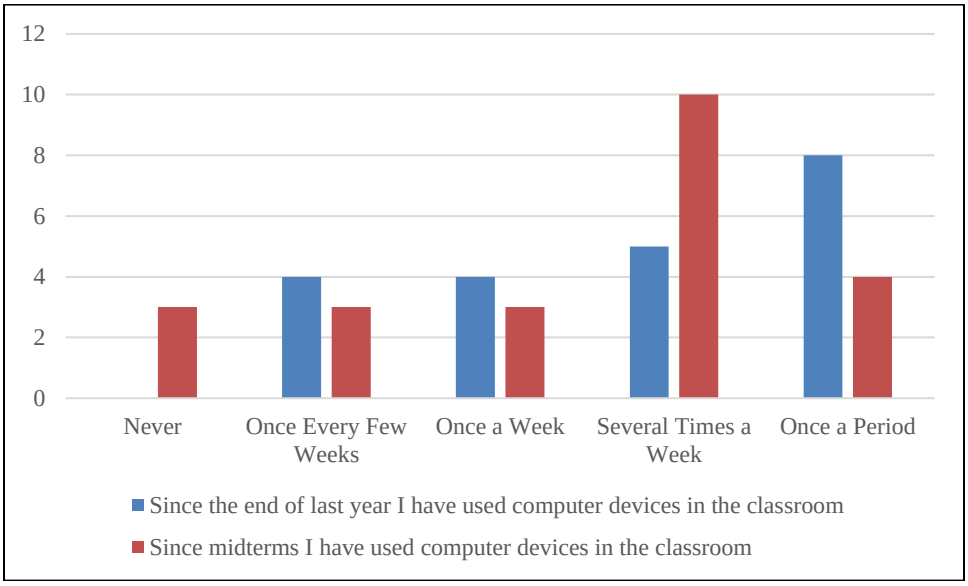

Figure 1. Faculty answering the question, "Since last year I have used computer devices in the classroom," (*N*=21). Faculty answering the question, "Since midterms I have used computer devices in the classroom," (*N*=23).

The faculty were asked to respond to the following statement, "Computer devices are an important part in helping increase the achievement of my students." The faculty responded before midterms and three months after midterms were over. Before midterms, faculty reported that 28.6% strongly agreed, 33.3% agreed, 28.6% neither agreed or disagreed, and 9.5% disagree (Figure 2). After midterms the faculty reported that 17.4% strongly agreed, 43.5% agreed, 26.1% neither agreed or disagreed, and 13% disagreed (Figure 2).

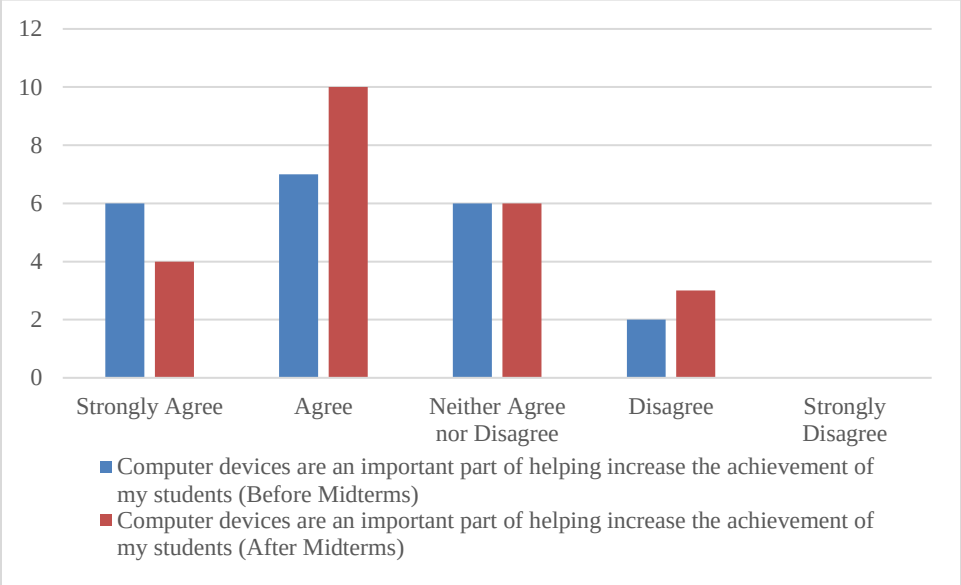

Figure 2. Faculty answering the question, "Computer devices are an important part in helping increase the achievement of my students," before midterms, (*N*=21), and after midterms, (*N*=23).

The faculty were asked to respond to the following statement, "Computer devices are an important part in helping increase the engagement of my students." The faculty responded before midterms and three months after midterms were over. Before midterms, faculty reported that 23.8% strongly agreed, 42.9% agreed, 28.6% neither agreed or disagreed, and 4.8% disagree (Figure 3). After midterms the faculty reported that 17.4% strongly agreed, 47.8% agreed, 2.7% neither agreed or disagreed, and 13% disagreed (Figure 3).

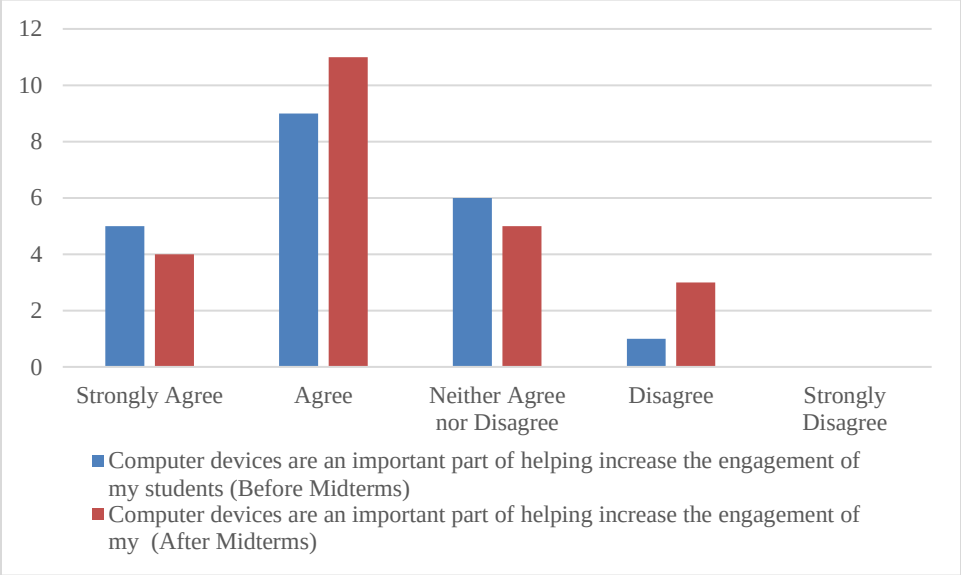

Figure 3. Faculty answering the question, "Computer devices are an important part in helping increase the engagement of my students," before midterms, (*N*=21), and after midterms, (*N*=23).

The whole student population was also surveyed to see what the students thought about computer devices affecting the achievement and engagement levels in their classes before and after midterms. Students were also provided and opportunity to add any other input about the technology at HCHS. The graphical representations are combined for all grade levels. Students responded to the statement, "computer devices helped improve my learning in the classroom." The data showed that before midterms 26.7% strongly agreed, 45.7% agreed, 21.3% neither agreed or disagreed, 5% disagreed, and 1% strongly disagreed with the statement. After midterms the students said that 22.1% strongly agreed, 48.6% agreed, 22.1% neither agreed or disagreed, 5% disagreed, and 2.3% strongly disagreed with the statement (Figure 4*)*. Students responded to the statement, "Computer devices help engage me more than traditional methods of teaching during class." The data showed that before midterms, 26% strongly agreed, 45.7% agreed, 21.3% neither agreed or disagreed, 8.5% disagreed, and 2.3% strongly disagreed with the statement. After midterms students reported that

22.5% strongly agreed, 42.3% agreed, 20.3% neither agreed or disagreed, 11.3% disagreed, and 3.6% strongly disagreed with the statement (Figure 5).

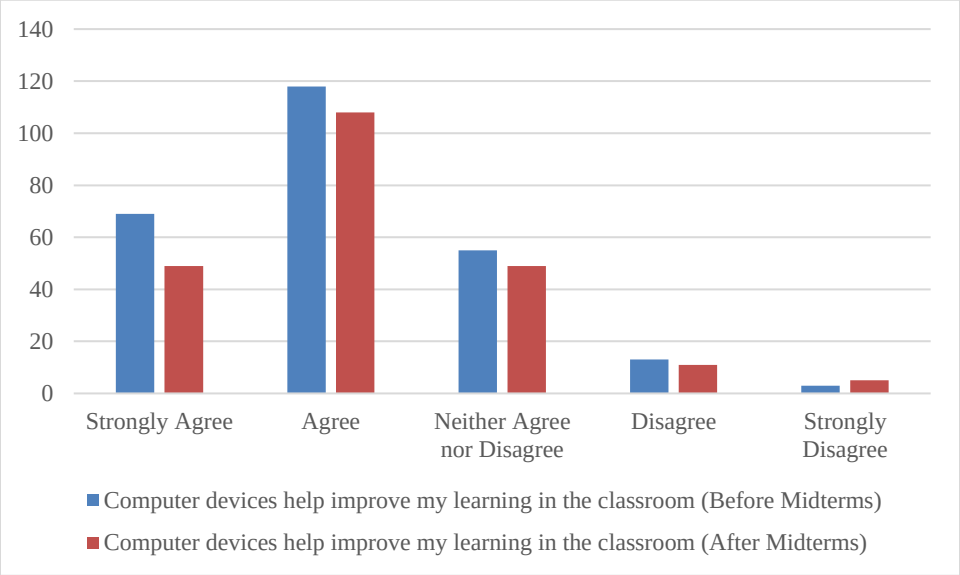

Figure 4. Students in all grades answering the statement, "Computer devices help improve my learning in the classroom," before midterms, (*N*=258), and after midterms, (*N*=222).

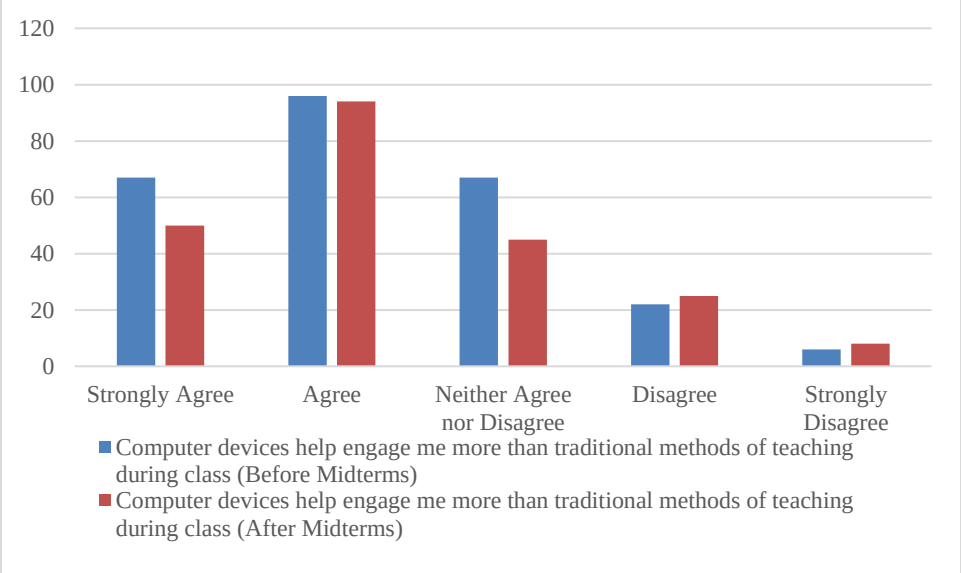

Figure 5. Students in all grades answering the statement, "Computer devices help engage me more than traditional methods of teaching during class," before midterms, (*N*=258), and after midterms, (*N*=222).

Students from the senior, junior, and sophomore classes were selected to be interviewed and asked what they noticed about the technology at HCHS before midterms and after midterms. Before midterms students said that teachers used more devices in the classroom. Students also noticed that the school was more involved on social media especially on Instagram and Facebook. One student said, "I noticed this year the teachers using more technology terms such as devices out or use your phones to look this up or grab a computer from the library." Another student commented saying, "there is just more technology use around the school, including creating that lip dub, photos being taken, and using Facebook and Instagram to post what is happening at and in the school." Some students commented about the technology that was in place at the school. One student said, "as a whole, the technology is old and has problems occasionally but overall it works pretty well." When thinking back to last year one student commented, "I also found that the WiFi is better this year."

After midterms students had the opportunity to express their feelings about the state of technology at HCHS. Overall, similar themes were described after midterms. Students commented about how the use of technology increased over the past year. One student said, "The use of technology at Holy Cross has greatly improved since last year and the students and teachers have adapted well to the change." A senior made a comment reflecting on their year at HCHS by saying, "The use of technology at Holy Cross has greatly increased during my senior year." Other students commented about the teacher's ability to use technology by saying, "Technology has a long way to come before it can be fully implemented at Holy Cross. The main thing restricting the school in my opinion would be funds. I feel the teachers are fully capable to utilize technology if it is provided." One student commented on how students were using technology, "there are more kids using laptops and phones for assignments, some kids of which aren't using it for the correct reasons."

INTERPRETATION AND CONCLUSION

The focus of this study was, does increasing the number of computer devices in the classroom positively impact student achievement? The data was inconclusive but mostly positive. While the sophomores said in their surveys that 73.5% agreed or strongly agreed computer devices helped them get better grades, only three of the eight two-sample t-tests indicated that the data was significant. For the CPA class, the averages increased by at least three points when compared to the previous school year with minimal use of computer devices. The data was significant for the two chapters that Canvas was implemented in, chapters seven and eight. This indicated that a learning management software could positively impact student achievement with lower achieving students.

The results were more ambiguous with the honors class. For two of the four tests, the previous year earned a better average than the students who used more computer devices. Neither chapter where Canvas was introduced proved to have statistically significant data. Only one chapter test proved to be statistically significant with the honors class, that chapter earned an average score four points higher than the previous year. This increase could be due to the website I introduced my students to for chapter five because in the sophomore chemistry interviews, the website for chapter five was commonly remembered. This would indicate that students were more engaged and were learning more as opposed to previous years, which could support that achievement increased due to computer devices being used.

The faculty were asked if computer devices help increase the achievement of their students. The faculty were self-reporting and not required to have data to back up their answer for student achievement. When asked before midterms and after midterms the percentage of faculty that agreed or strongly agreed with that statement decreased by 1%. While this was almost an identical value it

was interesting that the amount of computer devices in the school increased according to students. It should also be noted that not all the same faculty members responded to the before and after surveys. When senior students responded to the statement, computer devices help improve my learning in the classroom, the amount that agreed or strongly agreed decreased by 4.5%. The amount that disagreed or strongly disagreed increased by 5.4%. More senior students became more neutral. When junior students responded to the same statement the amount that agreed or strongly agreed increased by 11.8%. The amount that disagreed or strongly disagreed with the statement decreased by 4.7%. More junior students reported feeling that computer devices will help improve their learning. When the sophomore class was asked to respond to the same statement the amount that agreed or strongly agreed decreased by 9.9%. The amount that disagreed or strongly disagreed increased by 7%. A small percentage became more neutral and the rest did not think that computer devices helped their learning in the classroom. Finally, the freshmen were asked to respond to the same statement and the amount that agreed or strongly agreed decreased by 3.2%. The amount that disagreed or strongly disagreed with the statement increased by 2.9%. The amount that remained neutral was about the same, so the data suggests that the freshmen did not think that computer devices helped their learning in the classroom.

It is worth noting that for all the surveys to the whole school, not every student or faculty member completed the survey and the same students or faculty members did not fill out the before and after surveys. While many students agreed or strongly agreed that computer devices helped improve their learning in the classroom, when more computer devices were visible and used throughout the school, more students disagreed or strongly disagreed with the statement. While the faculty decrease with the statement was concerning, the most pressing concern was the large drop off

for the sophomore class. The percentage of sophomores that became discouraged by computer devices was almost 10%. Many of these sophomores were participating in Canvas either through their chemistry class or their English class.

This led to the conclusion that Canvas could discourage how students view their grades. The rationale for this was that when taking a quiz or a test on Canvas the teacher has the option to let the students see their grades immediately after they submitted the assignment. I did this for my chemistry classes and if the student did not do well, then they were immediately seeing a bad grade. Another problem with this was that any open-ended questions need to be graded by the teacher. When a student submitted the assignment and filled out open-ended questions, Canvas did not mark it correct or incorrect and instead showed the current grade. For example, if an open-ended question was worth ten points, then the best the student could receive immediately was a 90 on their assignment. If you had multiple open-ended questions (like I usually did) then the grade can be lower than what the student expected, ultimately leading to the student to become disheartened with their work and the technology. Some of the honors students expressed in the interviews that they did not like it when Canvas showed the grade right after the assignment because it was lower and incomplete. Some students reported issues in Canvas as well, such as when a student chose a wrong answer or clicked on something accidentally and did not know how to go back. These issues could lead to conclude that some sophomore students had a bad experience and that led to them disagreeing more on the surveys.

The sub question this study aimed to answer was, does increasing the number of computer devices in the classroom positively impact student engagement? When sophomore chemistry students were asked to respond to the statement, using computer devices in the classroom is

beneficial to me because it keeps me engaged in class, 64% agreed or strongly agreed with the statement. When students were asked if using different computer device applications was better than using the same thing every time (such as using PowerPoint every day), 74.2% of female students agreed or strongly agreed, and 69.2% of male students agreed or strongly agreed. While both males and females agreed that teachers should use more than just one type of computer application in their classes, the percentage of females was 5% higher than males. This indicated that female students liked a diverse range of computer applications when using computer devices. This relationship went deeper, in the interviews with sophomore teachers and students. The teachers said they used technology daily, but the students said that not all their classes used computer devices. Religion teachers said that they were using technology daily by presenting PowerPoints and looking up prayers online. The students did not mention that their religion classes used technology to help them with assignments. Research has shown that technology needs to be more than a simple substitution of replacing "chalk talk" with a PowerPoint. The SAMR model talked about how technology can have different levels of use, and if teachers are only using the most basic level then their students are not as engaged in their class. These teachers could have used the same applications or techniques with technology and did not implement new ideas into their lessons. The students did not find their classes engaging and therefore might not have remembered them when being interviewed about technology.

When faculty were asked to respond to the statement, computer devices are an important part in helping increase the engagement of my students, before midterms 66.7% agreed or strongly agreed with the statement and after midterms 65.2% agreed or strongly agreed. This was a decrease in agreement of 1.5% among faculty. For students, they were asked to respond to the statement,

computer devices help engage me more than traditional methods of teaching during class. The trends showed that seniors and sophomores decreased in their percentages from before and after midterms, and the juniors and freshmen increased in their percentages from before and after midterms. These percentages indicated that anywhere from about 60% to about 70% of the student and faculty population agreed that computer devices helped increase engagement levels in the classroom over traditional methods of teaching. When computer devices were introduced, sometimes the engagement decreased. The biggest decrease was notably in the senior class whose percentage dropped by almost 18%. This decrease could be because after midterms seniors tend to go into a "senior slide" where some students were less focused on work because they have done all they can to get into college. Another possible reason could be because many seniors had been exposed to Canvas at the beginning of the year and the novelty was wearing off. This could also explain why the sophomore class decreased in engagement too. Before Canvas was introduced to the sophomores in the second half of the year, many students were interested in using computer devices. Once a learning management system was introduced it is possible that the students grew tired of it and became less engaged while using devices. This same scenario could have happened with the seniors. It was interesting to note that besides the honors freshman biology class, no freshman or junior class, to my knowledge, had introduced Canvas or any other learning management system to the class. This could again explain why these percentages rose when looking at engagement in these two classes.

VALUE

The value that this research has shown is that the use of computer devices should continue to be explored in private Catholic high schools. This study has indicated that when students were

introduced to more computer devices in a classroom there was a potential to increase the level of engagement, but it was up to the teacher to keep that engagement level high. This can be achieved by implementing different computer applications for students to use instead of using the same applications and providing higher levels of the SAMR model. Teachers should try to implement different strategies that use devices in creative ways to make their lessons engaging for their students. When students were given the opportunity to prove their achievement, computer devices can increase averages among lower achieving students. The learning management system Canvas was shown to help these lower achieving students with their test scores. More research could be performed on the effect of learning management systems and how they affect student test scores of different ability levels. Honors students showed that sometimes the achievement can be improved if computer devices are used in the classroom.

I have found personal value in this capstone project because it became personally significant to myself and my school. The data that I was able to collect will influence future decisions at HCHS. This project also forced me to work with people in my building that I would not normally work with. For example, to conduct the surveys for the whole school I needed to enlist the help of the religion department because every student in the school needs to take a religion class, whereas students do not have to take a science class all four years. When it came time to do the two-sample t-test I went to the math department to ask for assistance in calculating the data. Doing the statistical calculations was one of the most rewarding parts of the whole project. After spending a few days understanding what all the numbers meant I calculated the p-values. At first it was disheartening when the values were not statistically significant. But after the first honors test came back as significant it was an overwhelming joy that what I set out to do could be accomplished.

A potential problem with this study at HCHS was that its infrastructure was lacking in development. For example, many rooms still have chalkboards and no way to consistently project a computer screen. This made implementing more computer devices hard. After reflecting on this project, it was clear to me that there were many problems and sources of error in my methods. Perhaps the most glaring is the fact that I did not ask the same survey questions to the sophomore students before the treatment was done. I asked similar questions but instead of asking, "Computer devices helps me stay more engaged in class," I asked, "Technology helps me stay more engaged in class." This minor difference could lead to vast changes in attitude and sway the results of the study. As the study went on, I tried to narrow my questions down to specifically refer to computer devices. I restructured the questions to be what students think about computer devices, versus what students think about technology. A question about technology could be misleading, while asking about computer devices was more specific. For the whole school data, I would also make sure that enough students answered both surveys. When I tallied up all the students that had done both surveys for one class it was less than ten students which I thought would bring more skewed results than all the students who took one of each survey. It was good to have this practice of what it is like to run a scientific research study but in the future, I would take more time and have everything planned out. I would double check my surveys and research questions to ensure that I am getting satisfying answers to them.

This capstone project did shape how I will teach in the future. I plan to implement more Canvas activities and use that as my area where I post any links, PowerPoints, videos, or discussions. I am curious to see how students do with more tests and quizzes online. Going through this project has also made me realize that while many students do want to use computer devices, not all of them

do. I need to be mindful of these students and make sure I do not alienate them as I bring more technology into the classroom. While going through this project I did find that I felt more connected to this group of students than in years past. I think this added to the project because I believe I truly did get honest feedback from the sophomore students who took my surveys. In the future I would like to compare the Canvas version of the chapter tests to the traditional paper tests I have been giving the last few years and see if there are any differences there. I look forward to doing more action research in the future.

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APPENDICES

APPENDIX A

ACHIEVEMENT WITH TECHNOLOGY SURVEY

1. Computer devices help me get better grades in school
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
2. Using computer devices in the classroom is beneficial to me because it keeps me engaged in class
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
3. I would like to use more computer devices in the classroom
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
4. I use computer devices outside of school to help me with my school work
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
5. Using different computer device applications at school is better than using the same thing every time (such as using PowerPoint every day)
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
6. I find the Google forms homework is a good way to review the content of the chapter
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree

7. I find the Kahoot review is a good way to review the content of the chapter
   Strongly Agree
   Agree
   Neither agree or disagree
   Disagree
   Strongly Disagree

APPENDIX B

SOPHOMORE CHEMISTRY INTERVIEWS

1. How has the technology used in this class helped you succeed?
2. How do you use technology to help you with assignments in this class?
3. Is there anything else you would like to say about technology?

APPENDIX C

SOPHOMORE TEACHERS INTERVIEWS

1. Please describe the impact that technology has in your primarily sophomore classes.

2. How many times per week are you using computer devices in the sophomore classes?

3. How many times per week are you using other technology such as projectors, videos, etc. in your sophomore classes.

4. Do you believe that the technology that you use is making a positive impact on your sophomore students? (Do you have any data that would back up this claim?)

5. Would you like any type of training or professional development with any piece of technology you currently use or would like to use?

APPENDIX D

WEBSITES USED IN METHODOLOGY

Website URL	Chapter Used
https://www.ck12.org/chemistry/Conversions-between-Moles-and-Mass/	Chapter 10
http://www.sciencegeek.net/Chemistry/Review/ElectronNotations/	Chapter 5
https://www.khanacademy.org/science/chemistry/electronic-structure-of-atoms/electron-configurations-jay-sal/e/electron-configurations-exercise	Chapter 5
https://teachchemistry.org/periodical/issues/september-2016/ionic-covalent-bonding	Chapter 8
https://pbslm-contrib.s3.amazonaws.com/WGBH/arct15/SimBucket/Simulations/chemthink-covalentbonding/content/index.html	Chapter 8
https://kahoot.com/	Chapters 10, 5, 7, and 8
https://docs.google.com/forms	Chapters 10, 5, 7, and 8

APPENDIX E

CPA CHAPTER 5 TEST

Chemistry Chapter 5 Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.

CONTENT REVIEW

____ 1. Quanta of light are called
a. electrons.
b. protons.
c. photons.
d. joules.

____ 2. The probability of finding electrons in certain regions of an atom is described by
a. orbits.
b. orbitals.
c. quanta.
d. photons.

____ 3. How is an electron's principal quantum number symbolized?
a. *s*
b. *p*
c. *n*
d. *d*

____ 4. Under what conditions can two electrons occupy the same orbital?
a. never
b. if they have opposite spins
c. if they have parallel spins
d. if they have different principal quantum numbers

____ 5. What information about electrons is given by the electron configuration of an atom?
a. paths within the principal quantum level
b. density of the electron cloud
c. average angular momentum
d. distribution among orbitals

____ 6. The principle that states that electrons are added one at a time to the lowest-energy orbitals available in an atom until all electrons have been accounted for is
a. the Aufbau principle.
b. the Pauli exclusion principle.
c. the uncertainty principle.
d. Hund's rule.

____ 7. Which principle states that electrons will occupy equal-energy orbitals so that a maximum number of unpaired electrons results?
a. the Aufbau principle
b. the Pauli exclusion principle
c. the uncertainty principle
d. Hund’s rule

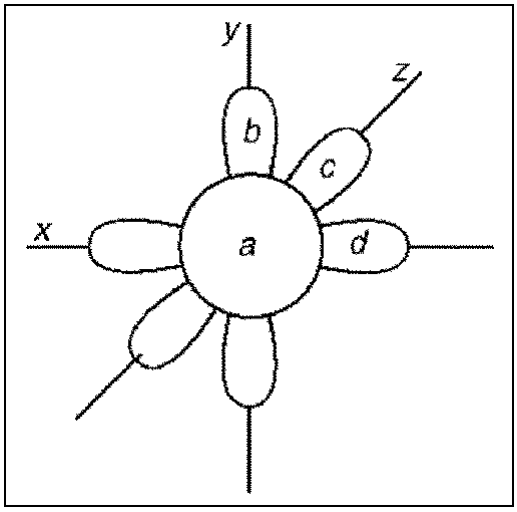


Figure 4-3

____ 8. In Figure 4-3, which orbitals are *s* orbitals?
a. a only
b. b only
c. b, c, and d
d. none of the orbitals

____ 9. In Figure 4-3, which orbitals are *p* orbitals?
a. a only
b. b only
c. b, c, and d
d. none of the orbitals

____ 10. What is the maximum total number of electrons that could be held by the orbitals in Figure 4-3?
a. 2
b. 4
c. 8
d. 14

____ 11. In Figure 4-3, what is the total number of sublevels for $n = 2$?
a. 1
b. 2
c. 4
d. 8

____ 12. In Figure 4-3, what is the total number of orbitals for $n = 2$?
a. 1
b. 2
c. 3
d. 4

____ 13. In Figure 4-3, what sublevel would have to be added to show $n = 3$, and how many orbitals are in that sublevel?
a. *d*, 5 orbitals
b. *d*, 7 orbitals
c. *f*, 5 orbitals
d. *f*, 7 orbitals

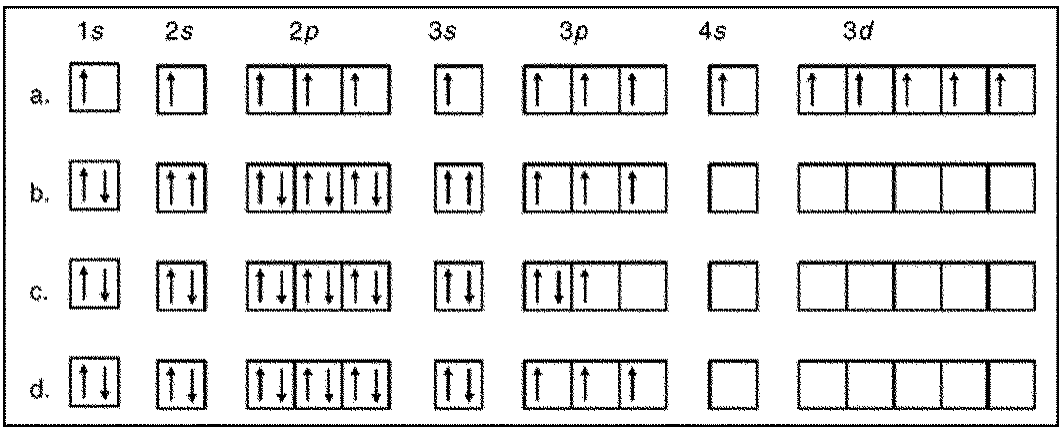


Figure 4-4

____ 14. Which of the four orbital diagrams in Figure 4-4 is correct for phosphorus?
a. a
b. b
c. c
d. d

____ 15. In Figure 4-4, what is the total number of electrons that can occupy the n = 3 level?
a. 3
b. 6
c. 9
d. 18

____ 16. Why did Bohr revise Rutherford's model?
a. The model did not have a place for neutrons
b. The model placed the protons where the electrons should be
c. The model placed the electrons where the protons should be
d. The model did not explain the chemical properties of elements

____ 17. What was the name of the scientist who named the Quantum Mechanical Model?
a. Bohr
b. Rutherford
c. Schrodinger
d. Dalton

____ 18. What would be the correct electron configuration for Lithium?
a. $1s^2\ 2s^2\ 2p^6$
b. $1s^3$
c. $1s^2\ 2s^1$
d. $1s^2\ 2s^2$

____ 19. What is the shape of the orbitals in the *d* sublevel?
a. Sphere shaped
b. Dumbell shaped
c. Pear ball shaped
d. Rectangular shaped

____ 20. What is the correct electron configuration for Gallium?
a. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$
b. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6 4s^2\ 3d^{10}\ 4p^1$
c. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6 4s^2\ 3d^{10}$
d. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6 4s^2\ 4p^1$

____ 21. Which main energy level has the most energy?
a. 1
b. 2
c. 3
d. 4

Essay

Discuss each of the following in a brief paragraph. Use complete sentences.

22. Describe the concept of electron spin. How many electrons can be in just one orbital? How can this number fit into the orbital?

_____

_____

_____

23. Describe the various principles that are used in order to develop an electron configuration.

_____

_____

_____

PROBLEM SOLVING

Use the skills you have developed in this chapter to solve each problem.

24. Calculate the maximum number of electrons that can exist in the $n = 3$ level. Account for the numbers of electrons within each sublevel of the principal level.

25. Write the orbital diagram, with arrows, for the element manganese (Mn, atomic number 25).

26. Write the electron configuration for iodine (I, atomic number 53).

27. Identify the element that has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2$.

28. Write the electron configuration for Gold (Au, atomic number 79).

APPENDIX F

CPA CHAPTER 7 TEST

Chapter 7 Test

Common Polyatomic Ions				
$C_2H_3O_2^-$	acetate		OH^-	hydroxide
NH_4^+	ammonium		ClO^-	hypochlorite
CO_3^{2-}	carbonate		NO_3^-	nitrate
ClO_3^-	chlorate		NO_2^-	nitrite
ClO_2^-	chlorite		$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate		ClO_4^-	perchlorate
CN^-	cyanide		MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate		PO_4^{3-}	phosphate
HCO_3^-	bicarbonate		SO_4^{2-}	sulfate
HSO_4^-	bisulfate		SO_3^{2-}	sulfite
HSO_3^-	bisulfate			

Multiple Choice
Identify the choice that best completes the statement or answers the question. (2pts)

CONTENT REVIEW

____ 1. A positively charged ion
   a. is formed when an atom loses electrons.
   b. is called an anion.
   c. is usually a nonmetallic element.
   d. has more electrons than protons.

____ 2. When a potassium atom becomes an ion, it
   a. gains one proton.
   b. gains one electron.
   c. loses one proton.
   d. loses one electron.

____ 3. The physical state of nearly all ionic compounds at room temperature is
   a. solid.
   b. liquid.
   c. gas.
   d. different for each ionic compound.

____ 4. In an ionic bond, how does a nitrogen atom most commonly achieve an octet of electrons?
   a. by gaining 5 electrons
   b. by gaining 3 electrons
   c. by losing 5 electrons
   d. by losing 3 electrons

____ 5. Which of the following is the Lewis dot diagram of the element fluorine (F)?
   a. 
   b. 
   c. 
   d. 

____ 6. Monatomic anions are named with the suffix
   a. *-ate*.
   b. *-ite*.
   c. *-ide*.
   d. *-ade*.

____ 7. What is the name of the compound whose formula is $FeSO_4$?
   a. iron(II) sulfate
   b. ferric sulfide
   c. iron(III) sulfate
   d. ferrous sulfide

CONCEPT MASTERY

Use the diagrams to answer the questions or complete the statements.

1A	2A	3A	4A	5A	6A	7A	8A
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca					Br	Kr
Rb							Xe
Cs							

Figure 7-1

____ 8. Use Figure 7-1 to determine four other elements whose ions have the same electron configuration as that of an ion of sodium.

a. Mg, Al, F, O
b. Li, K, Rb, Cs
c. Mg, Al, S, Cl
d. Ne, Mg, Al, Si

____ 9. In Figure 7-1, the ions of which three elements have the same electron configuration as Ar?

a. Ne, Kr, Xe
b. S, Cl, Ca
c. Cl, F, Br
d. Na, Mg, Cl

TABLE OF COMMON IONS

H^{1+}	Al^{3+}	NO_3^{1-}
Ca^{2+}	Fe^{3+}	SO_4^{2-}
Zn^{2+}	Cl^{1-}	CO_3^{2-}
Cu^{2+}	OH^{1-}	PO_4^{3-}
	P^{3-}	

Figure 7-2

____ 10. Using Figure 7-2, determine the formula of the compound formed between calcium and hydroxide ions.

a. CaOH
b. $Ca(OH)_2$
c. $CaOH_2$
d. Ca_2OH

____ 11. Using Figure 7-2, determine the formula of the compound aluminum phosphide.

a. AlP
b. $AlPO_4$
c. $Al(PO)_4$
d. $Al_3(PO_4)_3$

____ 12. Determine the formula of copper(II) chloride, using Figure 7-2.

a. Cu_2Cl
b. $(CuCl)_2$
c. CuCl
d. $CuCl_2$

____ 13. Determine the formula of iron(III) nitrate, using Figure 7-2.

a. $Fe(NO_3)_3$
b. FeN
c. Fe_3NO_3
d. None of these is correct.

Essay

CRITICAL THINKING AND APPLICATION

Discuss each of the following in a brief paragraph. (5pts)

14. Explain why ionic bonds tend to form between metals and nonmetals.

_____
_____
_____

15. Why is potassium fluoride, KF, more stable than the elements potassium and fluorine that comprise it?

_____

_____

_____

16. To satisfy the octet rule, how many electrons must a calcium atom gain or lose?

_____

_____

_____

17. Draw the Lewis dot diagrams for an atom of oxygen, an atom of calcium, and an atom of nitrogen.

Please name the following (3pts)

18. Li^{1+} _____

19. Al^{3+} _____

20. O^{2-} _____

21. N^{3-} _____

Common Polyatomic Ions				
$C_2H_3O_2^-$	acetate		OH^-	hydroxide
NH_4^+	ammonium		ClO^-	hypochlorite
CO_3^{2-}	carbonate		NO_3^-	nitrate
ClO_3^-	chlorate		NO_2^-	nitrite
ClO_2^-	chlorite		$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate		ClO_4^-	perchlorate
CN^-	cyanide		MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate		PO_4^{3-}	phosphate
HCO_3^-	bicarbonate		SO_4^{2-}	sulfate
HSO_4^-	bisulfate		SO_3^{2-}	sulfite
HSO_3^-	bisulfate			

22. Zn^{2+} _____

23. Ba^{2+} _____

24. LiCl _____

Common Polyatomic Ions					
$C_2H_3O_2^-$	acetate		OH^-	hydroxide
NH_4^+	ammonium		ClO^-	hypochlorite
CO_3^{2-}	carbonate		NO_3^-	nitrate
ClO_3^-	chlorate		NO_2^-	nitrite
ClO_2^-	chlorite		$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate		ClO_4^-	perchlorate
CN^-	cyanide		MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate		PO_4^{3-}	phosphate
HCO_3^-	bicarbonate		SO_4^{2-}	sulfate
HSO_4^-	bisulfate		SO_3^{2-}	sulfite
HSO_3^-	bisulfate			

25. MgF_2 _____

26. Al_2S_3 _____

27. PbO _____

28. $NiBr_2$ _____

Please write the **formulas** and **name** the compounds for the following compounds (4pts, 2 pts for formula, 2 pts for name)

29. Aluminum and Sulfate (check the chart)

30. Calcium and Iodine

31. Sodium and Hydroxide (check the chart)

32. Cobalt (II) and Phosphate (check the chart)

33. Iron (II) and Phosphorous

APPENDIX G

CPA CHAPTER 8 TEST

CPA Chemistry Chapter 8 Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.(3pts)

CONTENT REVIEW

____ 1. How does a covalent bond differ from an ionic bond?
   a. An ionic bond is the transfer of electrons and a covalent bond is a sharing of electrons.
   b. An ionic bond involves 2 electrons and a covalent bond involves 4 electrons.
   c. An ionic bond is usually between two metals and a covalent bond is usually between two nonmetals.
   d. None of these are correct.

____ 2. The formula of fructose, which is a sugar found in honey, is $C_6H_{12}O_6$. Which of the following is true for fructose?
   a. The empirical formula is $C_2H_4O_2$.
   b. There is a total of 6 atoms in each molecule.
   c. A molecule contains six carbon atoms.
   d. The ratio of carbon to oxygen atoms is 1:2.

____ 3. For the diatomic molecule Cl_2, how many electron(s) does each chlorine atom share with the other chlorine atom so that each has an octet?
   a. 1
   b. 2
   c. 7
   d. 8

____ 4. In a double bond between two atoms, the number of shared electrons is
   a. 2
   b. 4
   c. 6
   d. 8

____ 5. Which of the following bonds is primarily covalent?
   a. O–N
   b. Na–S
   c. O–K
   d. Cl–Li

____ 6. Which of the following bonds would be considered completely nonpolar?
   a. H–N
   b. O–O
   c. O–C
   d. F–Cl

____ 7. What is the name of the molecular substance PCl_5?
   a. phosphorous chloride
   b. monophosphorous pentachloride
   c. phosphorous pentachloride
   d. pentaphosphorous chloride

____ 8. In a molecule of carbon dioxide, what kinds of bonds connect the carbon atom to the 2 oxygen atoms?
   a. two single bonds
   b. one single bond and one double bond
   c. one double bond and one triple bond
   d. two double bonds

____ 9. In a polar bond, electrons are

a. shared unequally.
b. shared equally.
c. completely transferred.
d. not shared at all.

____ 10. Which of the following is true of a water molecule?
a. The hydrogen end is slightly positive and the oxygen end is slightly negative.
b. The hydrogen end is slightly negative and the oxygen end is slightly positive.
c. The oxygen atom has a 2– charge and each hydrogen atom has a 1+ charge.
d. It has neither a positive nor a negative end.

Essay

CRITICAL THINKING AND APPLICATION

Discuss each of the following in a brief paragraph.(5pts)

11. Explain why prefixes are usually used in naming covalent compounds but usually not used in naming ionic compounds.

_____
_____
_____
_____

12. If Nitrogen has 5 valence electrons why doesn't it make 5 different bonds?

_____
_____
_____
_____

13. Please name two differences and at least one similarity between ionic and covalent bonds.

_____
_____
_____
_____

For the following questions please draw the structural formula: (4pts)

14. H_2S

16. HCN

15. CCl_2H_2 17. CO_2

For the following questions please name the molecules: (4pts)

18. P_3O_4 _____

19. H_3S_2 _____

20. CF_4 _____

21. ClF _____

22. OI_2 _____

For the following questions please write the chemical formula for the molecules: (4pts)

23. Dihydrogen Monoxide _____

24. Trisulfur Tetrafluoride _____

25. Dicarbon Octoxide _____

26. Nitrogen Trifluoride _____

APPENDIX H

CPA CHAPTER 10 TEST

CPA Chemistry Chapter 10 Test

Multiple Choice (2 pts)
Identify the choice that best completes the statement or answers the question.

CONTENT REVIEW

____ 1. The sum of the atomic masses in any compound is the compound's
a. formula mass
b. molar mass
c. empirical mass.
d. molecular mass.

____ 2. How many atoms are in a sample of an element whose mass in grams is numerically equal to the atomic mass?
a. 1
b. 6.02
c. 1×10^{23}
d. 6.02×10^{23}

____ 3. Avogadro's number
a. equals 1.
b. equals 6.02×10^{23}.
c. depends on the substance.
d. depends on the number of moles.

____ 4. At the same temperature and pressure, equal volumes of different kinds of gases contain
a. equal numbers of molecules.
b. equal numbers of formula units.
c. different numbers of molecules.
d. equal numbers of atoms.

____ 5. Which of the following defines standard temperature?
a. 373 K
b. 100°C
c. 25°C
d. 0°C

____ 6. Which of the following defines standard pressure?
a. 0 atmosphere
b. 1 atmosphere
c. 10 atmospheres
d. 760 atmospheres

____ 7. What is the molar volume of a gas at standard temperature and pressure?
a. 1 L/mol
b. 22.4 L/mol
c. 22.4 mL/mol
d. depends on the gas

____ 8. The volume of a gas depends on all of the following except
a. pressure.
b. number of molecules.
c. temperature.
d. the identity of the gas.

____ 9. The sum of the percentages in the percentage composition of a substance equals
a. 100.
b. the molar mass.
c. the molar volume.
d. Avogadro's number.

____ 10. The percentage composition of water is
a. 67% H, 33% O.
b. 2 H, 1 O.
c. 11% H, 89% O.
d. 2 H, 16 O.

____ 11. The simplest whole-number ratio of the atoms of the elements in a compound is given by the
a. formula mass.
b. molar mass.
c. molecular formula.
d. empirical formula.

Essay

CRITICAL THINKING AND APPLICATION (6pts)

Discuss each of the following in a brief paragraph. Write in complete sentences.

12. The concept of a mole is often compared to the concept of a dozen. Discuss the similarities and differences between the two.

_____

_____

_____

_____

13. Describe the steps you would take to find the molar mass of a compound. Please do not list the steps!

_____

_____

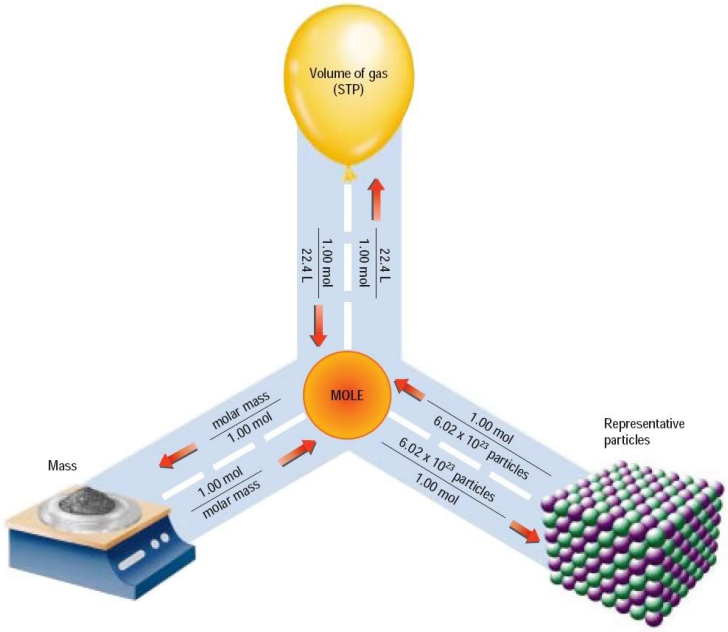
_____

_____

Open Ended (6 pts) Must show work to receive full credit.

14. How many moles are there in 3.28×10^{24} molecules of CO_2?

15. How many atoms are there in 2.87×10^{23} molecules of H_2O?



16. How many grams are there in 5.2 mol of $CaCl_2$?

17. How many grams are there in 4.91×10^{24} atoms of CH_4?

18. How many Liters are there in 4.0 mol of O_2 gas at STP?

19. How many moles are there of 50.3 L of N_2 gas at STP?

20. What is the percent composition of Carbon in a glucose molecule? ($C_6H_{12}O_6$)

21. What is the percent composition of Sodium in NaCl?

22. How many moles are there in 30.9 L of CO_2 gas at STP?

23. How many moles are there in 1.29×10^{23} molecules of Ne gas at STP?

24. Chlorophyll's molecular formula is ($C_{55}H_{72}MgN_4O_5$). What is the molar mass of chlorophyll?

APPENDIX I

HONORS CHAPTER 5 TEST

Honors Chemistry Chapter 5 Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.

CONTENT REVIEW

____ 1. Quanta of light are called
a. electrons.
b. protons.
c. photons.
d. joules.

____ 2. The probability of finding electrons in certain regions of an atom is described by
a. orbits.
b. orbitals.
c. quanta.
d. photons.

____ 3. How is an electron's principal quantum number symbolized?
a. *s*
b. *p*
c. *n*
d. *d*

____ 4. Under what conditions can two electrons occupy the same orbital?
a. never
b. if they have opposite spins
c. if they have parallel spins
d. if they have different principal quantum numbers

____ 5. What information about electrons is given by the electron configuration of an atom?
a. paths within the principal quantum level
b. density of the electron cloud
c. average angular momentum
d. distribution among orbitals

____ 6. The principle that states that electrons are added one at a time to the lowest-energy orbitals available in an atom until all electrons have been accounted for is
a. the Aufbau principle.
b. the Pauli exclusion principle.
c. the uncertainty principle.
d. Hund's rule.

____ 7. Which principle states that electrons will occupy equal-energy orbitals so that a maximum number of unpaired electrons results?
a. the Aufbau principle
b. the Pauli exclusion principle
c. the uncertainty principle
d. Hund’s rule

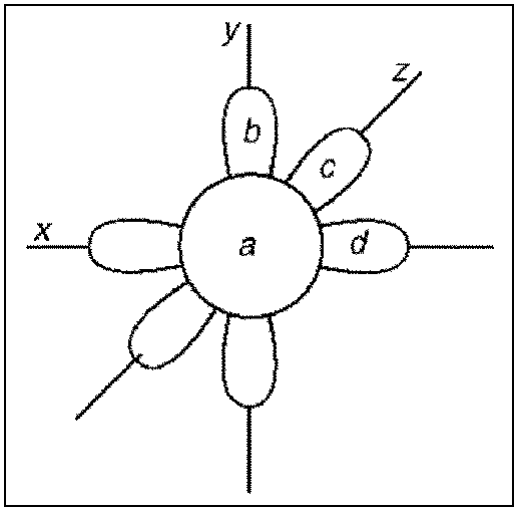


Figure 4-3

____ 8. In Figure 4-3, which orbitals are *s* orbitals?
- a. a only
- b. b only
- c. b, c, and d
- d. none of the orbitals

____ 9. In Figure 4-3, which orbitals are *p* orbitals?
- a. a only
- b. b only
- c. b, c, and d
- d. none of the orbitals

____ 10. What is the maximum total number of electrons that could be held by the orbitals in Figure 4-3?
- a. 2
- b. 4
- c. 8
- d. 14

____ 11. In Figure 4-3, what is the total number of sublevels for $n = 2$?
- a. 1
- b. 2
- c. 4
- d. 8

____ 12. In Figure 4-3, what is the total number of orbitals for $n = 2$?
- a. 1
- b. 2
- c. 3
- d. 4

____ 13. In Figure 4-3, what sublevel would have to be added to show $n = 3$, and how many orbitals are in that sublevel?
- a. *d*, 5 orbitals
- b. *d*, 7 orbitals
- c. *f*, 5 orbitals
- d. *f*, 7 orbitals

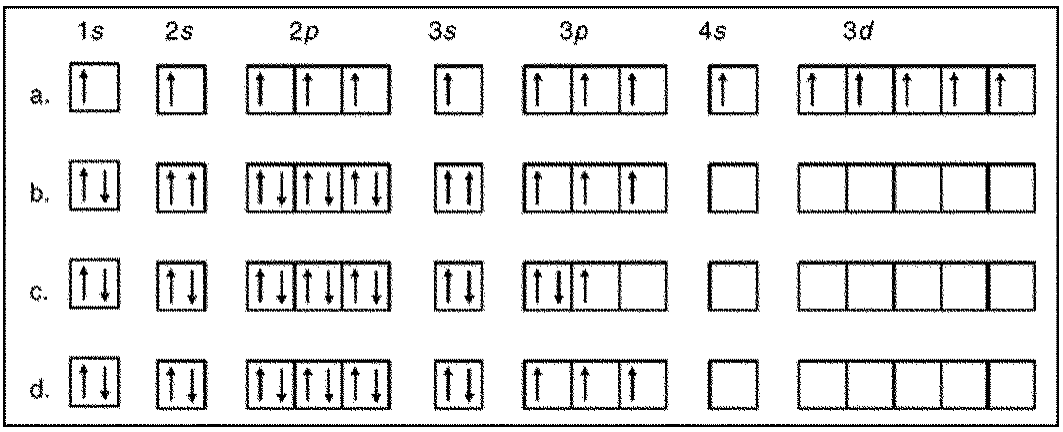


Figure 4-4

____ 14. Which of the four orbital diagrams in Figure 4-4 is correct for phosphorus?
a. a
b. b
c. c
d. d

____ 15. In Figure 4-4, what is the total number of electrons that can occupy the n = 3 level?
a. 3
b. 6
c. 9
d. 18

____ 16. Why did Bohr revise Rutherford's model?
a. The model did not have a place for neutrons
b. The model placed the protons where the electrons should be
c. The model placed the electrons where the protons should be
d. The model did not explain the chemical properties of elements

____ 17. What was the name of the scientist who named the Quantum Mechanical Model?
a. Bohr
b. Rutherford
c. Schrodinger
d. Dalton

____ 18. What would be the correct electron configuration for Lithium?
a. $1s^2\ 2s^2\ 2p^6$
b. $1s^3$
c. $1s^2\ 2s^1$
d. $1s^2\ 2s^2$

____ 19. What is the shape of the orbitals in the *d* sublevel?
a. Sphere shaped
b. Dumbell shaped
c. Pear ball shaped
d. Rectangular shaped

____ 20. What is the correct electron configuration for Gallium?
a. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$
b. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6 4s^2\ 3d^{10}\ 4p^1$
c. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6 4s^2\ 3d^{10}$
d. $1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6 4s^2\ 4p^1$

____ 21. Which main energy level has the most energy?
a. 1
b. 2
c. 3
d. 4

Essay

Discuss each of the following in a brief paragraph. Use complete sentences.

22. Describe the concept of electron spin and explain how it relates to the placement and numbers of electrons in atoms.

23. State what is meant by electron configuration and explain how such configurations are determined through the application of various principles.

PROBLEM SOLVING

Use the skills you have developed in this chapter to solve each problem.

24. Calculate the maximum number of electrons that can exist in the $n = 4$ level. Account for the numbers of electrons within each sublevel of the principal level.

25. Write the orbital diagram, with arrows, for the element manganese (Mn, atomic number 25).

26. Write the electron configuration for iodine (I, atomic number 53).

27. Identify the element that has the following electron configuration:
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^2$.

28. Write the electron configuration for francium (Fr, atomic number 87).

APPENDIX J

HONORS CHAPTER 7 TEST

Honors Chapter 7 Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.

CONTENT REVIEW

____ 1. A positively charged ion
a. is formed when an atom loses electrons.
b. is called an anion.
c. is usually a nonmetallic element.
d. has more electrons than protons.

____ 2. When a potassium atom becomes an ion, it
a. gains one proton.
b. gains one electron.
c. loses one proton.
d. loses one electron.

____ 3. The physical state of nearly all ionic compounds at room temperature is
a. solid.
b. liquid.
c. gas.
d. different for each ionic compound.

____ 4. In an ionic bond, how does a nitrogen atom most commonly achieve an octet of electrons?
a. by gaining 5 electrons
b. by gaining 3 electrons
c. by losing 5 electrons
d. by losing 3 electrons

____ 5. Which of the following is the Lewis dot diagram of the element fluorine (F)?
a. 
b. 
c. 
d. 

____ 6. Monatomic anions are named with the suffix
a. *-ate*.
b. *-ite*.
c. *-ide*.
d. *-ade*.

____ 7. What is the name of the compound whose formula is $FeSO_4$?
a. iron(II) sulfate
b. ferric sulfide
c. iron(III) sulfate
d. ferrous sulfide

CONCEPT MASTERY

Use the diagrams to answer the questions or complete the statements.

1A	2A	3A	4A	5A	6A	7A	8A
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca					Br	Kr
Rb							Xe
Cs							

Figure 7-1

____ 8. Use Figure 7-1 to determine four other elements whose ions have the same electron configuration as that of an ion of sodium.
a. Mg, Al, F, O
b. Li, K, Rb, Cs
c. Mg, Al, S, Cl
d. Ne, Mg, Al, Si

____ 9. In Figure 7-1, the ions of which three elements have the same electron configuration as Ar?
a. Ne, Kr, Xe
b. S, Cl, Ca
c. Cl, F, Br
d. Na, Mg, Cl

TABLE OF COMMON IONS

H^{1+}	Al^{3+}	NO_3^{1-}
Ca^{2+}	Fe^{3+}	SO_4^{2-}
Zn^{2+}	Cl^{1-}	CO_3^{2-}
Cu^{2+}	OH^{1-}	PO_4^{3-}
	P^{3-}	

Figure 7-2

____ 10. Using Figure 7-2, determine the formula of the compound formed between calcium and hydroxide ions.
a. CaOH
b. $Ca(OH)_2$
c. $CaOH_2$
d. Ca_2OH

____ 11. Using Figure 7-2, determine the formula of the compound aluminum phosphide.
a. AlP
b. $AlPO_4$
c. $Al(PO)_4$
d. $Al_3(PO_4)_3$

____ 12. Determine the formula of copper(II) chloride, using Figure 7-2.
a. Cu_2Cl
b. $(CuCl)_2$
c. CuCl
d. $CuCl_2$

____ 13. Determine the formula of iron(III) nitrate, using Figure 7-2.
a. $Fe(NO_3)_3$
b. FeN
c. Fe_3NO_3
d. None of these is correct.

Essay

CRITICAL THINKING AND APPLICATION

Discuss each of the following in a brief paragraph.

14. Explain why ionic bonds tend to form between metals and nonmetals.

15. Why is potassium fluoride, KF, more stable than the elements potassium and fluorine that comprise it?

16. To satisfy the octet rule, how many electrons must a calcium atom gain or lose?

17. Write the formula for calcium carbonate. Why does carbonate bond with anything at all?

18. Draw the Lewis dot diagrams for an atom of oxygen, an atom of calcium, and an atom of helium.

Please name the following

19. Li^{1+} _____

20. CO_3^{2-} _____

21. O^{2-} _____

22. N^{3-} _____

23. Zn^{2+} _____

24. LiCl

_____

25. MgF_2 _____

26. Al_2S_3 _____

27. PbO _____

28. $NiBr_2$ _____

Common Polyatomic Ions				
$C_2H_3O_2^-$	acetate		OH^-	hydroxide
NH_4^+	ammonium		ClO^-	hypochlorite
CO_3^{2-}	carbonate		NO_3^-	nitrate
ClO_3^-	chlorate		NO_2^-	nitrite
ClO_2^-	chlorite		$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate		ClO_4^-	perchlorate
CN^-	cyanide		MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate		PO_4^{3-}	phosphate
HCO_3^-	bicarbonate		SO_4^{2-}	sulfate
HSO_4^-	bisulfate		SO_3^{2-}	sulfite
HSO_3^-	bisulfate			

Please write the formulas and name the compounds for the following compounds

29. Ammonium and Sulfate

30. Calcium and Iodine

31. Sodium and Hydroxide

32. Cobalt (II) and Phosphate

APPENDIX K

HONORS CHAPTER 8 TEST

Honors Chapter 8 Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.(3pts)

CONTENT REVIEW

____ 1. How does a covalent bond differ from an ionic bond?
   a. An ionic bond is the transfer of electrons and a covalent bond is a sharing of electrons.
   b. An ionic bond involves 2 electrons and a covalent bond involves 4 electrons.
   c. An ionic bond is usually between two metals and a covalent bond is usually between two nonmetals.
   d. None of these are correct.

____ 2. The formula of fructose, which is a sugar found in honey, is $C_6H_{12}O_6$. Which of the following is true for fructose?
   a. The empirical formula is $C_2H_4O_2$.
   b. There is a total of 6 atoms in each molecule.
   c. A molecule contains six carbon atoms.
   d. The ratio of carbon to oxygen atoms is 1:2.

____ 3. For the diatomic molecule Cl_2, how many electron(s) does each chlorine atom share with the other chlorine atom so that each has an octet?
   a. 1
   b. 2
   c. 7
   d. 8

____ 4. In a double bond between two atoms, the number of shared electrons is
   a. 2
   b. 4
   c. 6
   d. 8

____ 5. Which of the following bonds is primarily covalent?
   a. O–N
   b. Na–S
   c. O–K
   d. Cl–Li

____ 6. Which of the following bonds would be considered completely nonpolar?
   a. H–N
   b. O–O
   c. O–C
   d. F–Cl

____ 7. What is the name of the molecular substance PCl_5?
   a. phosphorous chloride
   b. monophosphorous pentachloride
   c. phosphorous pentachloride
   d. pentaphosphorous chloride

____ 8. In a molecule of carbon dioxide, what kinds of bonds connect the carbon atom to the 2 oxygen atoms?
   a. two single bonds
   b. one single bond and one double bond
   c. one double bond and one triple bond
   d. two double bonds

____ 9. In a polar bond, electrons are
   a. shared unequally.
   b. shared equally.
   c. completely transferred.
   d. not shared at all.

____ 10. Which of the following is true of a water molecule?
a. The hydrogen end is slightly positive and the oxygen end is slightly negative.
b. The hydrogen end is slightly negative and the oxygen end is slightly positive.
c. The oxygen atom has a 2– charge and each hydrogen atom has a 1+ charge.
d. It has neither a positive nor a negative end.

Essay

CRITICAL THINKING AND APPLICATION

Discuss each of the following in a brief paragraph.(5pts)

11. Explain why prefixes are usually used in naming covalent compounds but usually not used in naming ionic compounds.

_____
_____
_____
_____

12. Explain how $Al(PO_4)$ (Aluminum Phosphate) can have both covalent and ionic bonds.

_____
_____
_____
_____

13. Please name two differences and at least one similarity between ionic and covalent bonds.

_____
_____
_____
_____

For the following questions please draw the structural formula: (4pts)

14. H_2S

16. HCN

15. CCl_2H_2 17. $[SO_4]^{2-}$

For the following questions please name the molecules: (4pts)

18. P_3O_8 _____

19. H_9S_3 _____

20. CF_4 _____

21. ClF _____

22. OI_2 _____

For the following questions please write the chemical formula for the molecules: (4pts)

23. Dihydrogen Heptoxide _____

24. Trisulfur Tetrafluoride _____

25. Dicarbon Octoxide _____

26. Pentanitrogen Trifluoride _____

APPENDIX L

HONORS CHAPTER 10 TEST

Honors Chapter 10 Test

Multiple Choice (2 pts)
Identify the choice that best completes the statement or answers the question.

CONTENT REVIEW

____ 1. The sum of the atomic masses in any compound is the compound's
a. formula mass
b. molar mass
c. empirical mass.
d. molecular mass.

____ 2. How many atoms are in a sample of an element whose mass in grams is numerically equal to the atomic mass?
a. 1
b. 6.02
c. 1×10^{23}
d. 6.02×10^{23}

____ 3. Avogadro's number
a. equals 1.
b. equals 6.02×10^{23}.
c. depends on the substance.
d. depends on the number of moles.

____ 4. At the same temperature and pressure, equal volumes of different kinds of gases contain
a. equal numbers of molecules.
b. equal numbers of formula units.
c. different numbers of molecules.
d. equal numbers of atoms.

____ 5. Which of the following defines standard temperature?
a. 373 K
b. 100°C
c. 25°C
d. 0°C

____ 6. Which of the following defines standard pressure?
a. 0 atmosphere
b. 1 atmosphere
c. 10 atmospheres
d. 760 atmospheres

____ 7. What is the molar volume of a gas at standard temperature and pressure?
a. 1 L/mol
b. 22.4 L/mol
c. 22.4 mL/mol
d. depends on the gas

____ 8. The volume of a gas depends on all of the following except
a. pressure.
b. number of molecules.
c. temperature.
d. the identity of the gas.

____ 9. The sum of the percentages in the percentage composition of a substance equals
a. 100.
b. the molar mass.
c. the molar volume.
d. Avogadro's number.

____ 10. The percentage composition of water is
a. 67% H, 33% O.
b. 2 H, 1 O.
c. 11% H, 89% O.
d. 2 H, 16 O.

____ 11. The simplest whole-number ratio of the atoms of the elements in a compound is given by the
a. formula mass.
b. molar mass.
c. molecular formula.
d. empirical formula.

CRITICAL THINKING AND APPLICATION (6pts)

Discuss each of the following in a brief paragraph. Write in complete sentences.

12. The concept of a mole is often compared to the concept of a dozen. Discuss the similarities and differences between the two.

_____

_____

_____

_____

13. State the relationship between volume and number of moles of a gas and explain why this relationship holds for any gas.

_____

_____

_____

_____

Open Ended (6 pts) Must show work to receive full credit.

14. How many moles are there in 3.28×10^{24} molecules of CO_2?

15. How many atoms are there in 2.87×10^{23} molecules of H_2O?

16. How many grams are there in 5.2 mol of $CaCl_2$?

17. How many grams are there in 4.91×10^{24} atoms of CH_4?

18. How many Liters are there in 4.0 mol of O_2 gas at STP?

19. How many moles are there of 50.3 L of N_2 gas at STP?

20. What is the percent composition of Carbon in a glucose molecule? ($C_6H_{12}O_6$)

21. What is the percent composition of Sodium in NaCl?

22. How many grams are there in 30.9 L of CO_2 gas at STP?

23. How many Liters are there in $1.29x10^{23}$ molecules of Ne gas at STP?

24. Is chlorophyll's molecular formula ($C_{55}H_{72}MgN_4O_5$) also its empirical formula? What is the molar mass of chlorophyll

APPENDIX M

HOLY CROSS HIGH SCHOOL TECHNOLOGY STUDENT SURVEY PART 1

1. Email address:
2. Computer devices improve my learning in the classroom.
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
3. Since last year I have used more computer devices in the classroom on a daily basis
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
4. Computer Device help engage me more than traditional methods of teaching during class
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
5. What are any other observations about the use of computer devices at Holy Cross?

APPENDIX N

FACULTY COMPUTER DEVICE SURVEY PART 1

1. Since the end of last year I have used computer devices in the classroom
    Once a period
    Several times a week
    Once a week
    Once every few weeks
    Never
2. Computer devices are an important part of helping increase the achievement of my students
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
3. Computer devices are an important part of helping increase the engagement of my students
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree

APPENDIX O

TECHNOLOGY AND COMPUTER DEVICES INTERVIEWS PART 1

1. Have you noticed a change in the use of technology from last year to this year? Please explain your answer.

2. Any other observations about the use of technology at Holy Cross?

APPENDIX P

HOLY CROSS HIGH SCHOOL TECHNOLOGY STUDENT SURVEY PART 2

1. Email address:
2. Computer devices improve my learning in the classroom.
    - Strongly Agree
    - Agree
    - Neither agree or disagree
    - Disagree
    - Strongly Disagree
3. Since midterms I have used more computer devices in the classroom on a daily basis
    - Strongly Agree
    - Agree
    - Neither agree or disagree
    - Disagree
    - Strongly Disagree
4. Computer Device help engage me more than traditional methods of teaching during class
    - Strongly Agree
    - Agree
    - Neither agree or disagree
    - Disagree
    - Strongly Disagree
5. What are any other observations about the use of computer devices at Holy Cross?

APPENDIX Q

FACULTY COMPUTER DEVICE SURVEY PART 2

1. Since the end of last year I have used computer devices in the classroom
    Once a period
    Several times a week
    Once a week
    Once every few weeks
    Never
2. Computer devices are an important part of helping increase the achievement of my students
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree
3. Computer devices are an important part of helping increase the engagement of my students
    Strongly Agree
    Agree
    Neither agree or disagree
    Disagree
    Strongly Disagree

APPENDIX R

TECHNOLOGY AND COMPUTER DEVICES INTERVEWS PART 2

1. Have you noticed a change in the use of technology since midterms? Please explain your answer.

2. Any other observations about the use of technology at Holy Cross?

APPENDIX S

INSTITUTIONAL REVIEW BOARD EXEMPTION

MONTANA
STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Nicholas Lauzon and Kathryn Solberg

FROM: Mark Quinn, Chair Mark Quinn CJ

DATE: November 13, 2018

RE: *"Does Implementing More Computer Devices into the Classroom Improve Student Achievement?" [NL111318-EX]*

The above research, described in your submission of November 10, 2018, 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.