2018

Evaluation of a flipped classroom on student achievement in a low income school district

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EVALUATION OF A FLIPPED CLASSROOM ON STUDENT ACHIEVEMENT IN A LOW INCOME SCHOOL DISTRICT

An Abstract of Action Research

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Science Education

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July 2018

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This Paper by: Michael Yeoman

Entitled: Evaluation of a Flipped Classroom on Student Achievement in a Low Income School District

has been approved as meeting the non-thesis requirement for the

Degree of Master of Arts

Date: July 9, 2018 Dr. John Ophus, Advisor

Date: July 9, 2018 Dr. Kyle Gray, Outside Reader

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in a Low Income School District

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TABLE OF CONTENTS

PAGE

LIST OF TABLES

TABLE PAGE

CHAPTER 1

INTRODUCTION & FRAMEWORK

"Flipping" a classroom (assigning as homework low-level instruction via videos or voiced over slideshows, instead using contact hours for problem-solving, enrichment, and hands-on activities) has been documented repeatedly as a positive change in instruction that increases student achievement (He, Swenson & Lents, 2012; Fulton, 2012). He, et al. (2012) found that students who received a video tutorial of a chemistry concept produced a 59% absolute improvement value, whereas students who did not receive a video tutorial only produced an 18% absolute improvement value. Kathleen Fulton (2012) documented a 5.1% increase in median assessment results when providing content online, and shared anecdotal evidence that a math classroom improved proficiency from 29.9% to 65.6% on the Minnesota Comprehensive Assessment while implementing digital content and a flipped classroom. In Erika Smith's "The Digital Native Debate in Higher Education: A Comparative Analysis of Recent Literature," (2012) the author articulates the influential claims that younger generations respond better to using technology, but also communicates research showing that college students still preferred the traditional teaching style. However, most of the studies that tout the positives of a flipped classroom have taken place in colleges or economically advantaged districts, typically in the suburbs. As flipping classrooms becomes more widely practiced, the impact of this strategy may or may not translate into success for populations that are typically inhabited by families of low socioeconomic status (SES). The lack of research regarding flipped classrooms and low income schools creates a question about its efficacy on particular populations. The purpose of this study was to determine the effectiveness of a flipped classroom on student achievement in a school district with high rates of poverty. This information leads the author to the following research questions:

Research Question #1 - What is the impact of a flipped classroom on achievement in a predominantly low income school?

Research Question #2 - Will less-structured class time decrease engagement, specifically for the economically disadvantaged?

Research Question #3 - Are economically disadvantaged students as comfortable using digital tools as their economically advantaged peers?

CHAPTER 2

RELEVANCE & LITERATURE REVIEW

Flipped Classroom Goals

Prensky (2001) indicates that flipping a classroom has two major goals: 1) re-prioritize how class time is used; and 2) appeal to the technology striving youth. Roehl, Reddy, and Shannon (2013) describe the desired outcome of a flipped classroom is for educators to move from a low-level Bloom's taxonomy of knowledge and understanding into higher levels including, but not limited to, analysis, problem-solving, and hands-on activities (which might utilize creation and evaluation). This may be executed in a variety of ways, but most popularly is using internet videos or screen capture software to deliver direct, low-level instruction. Zayapragassarazan and Kumar (2012) suggest that active learning components that could take place during the scheduled class time may include concept maps, collaborative writing, brainstorming, collaborative learning, free writing, project-based learning, panel discussions, case studies, and peer teaching.

The flipped classroom model supports many of the seven principles for good practice (Chickering & Gamson, 1999) which encourage student-teacher contact, cooperation among students, active learning, emphasize time on task, and respect diverse ways of learning. Bill Tucker (2012) reaffirmed these claims by suggesting that lecture becomes homework and class becomes the place to solve problems, advance concepts, and engage in collaborative learning. Jon Bergmann and Aaron Sams (2014), pioneers in flipped classrooms, reflected on the reasons they chose to change their teaching methods. They had many students who were absent for illness or school activities, so they began recording the lectures to keep those students caught up. Other students also used the videos for review, so Bergmann and Sams decided to have all students use the videos in order to maximize educational class time for enrichment activities.

Why Use Flipped Classrooms with "Digital Natives?"

The case has also been made that Millennial students prefer a digital learning environment where they can control the pace and, to a degree, the direction of their education (Prensky, 2001). Flipped classrooms meet these needs by allowing students to speed up, slow down, or repeat low-level knowledge delivered in a lecture format. Prensky (2001) and Tapscott (2008) would like to replace the current "broadcast learning" system of education with collaborative learning. Tapscott claims that digital natives have already begun, and will continue, to change the workplace into an online and multitasking community, so he condones that school should also reflect those changes. Prensky claims that collaborative learning is beneficial due to the alleged changes in brain function of digital natives which lends themselves to more interactive and immersive activities rather than passively receiving information from instructors. The flipped classroom would provide for these needs by delivering more digital content while providing time for collaboration and guided, self-directed learning in the classroom. However, researchers like Sue Bennett and Sherry Turkle disagree. Bennett claims that there is as much variation within the "digital native" generation as there is between other generations. This variation is relevant in that a single teaching style or shift to complete technology use may be harmful to as many students within those classrooms as it is helpful to others. In Turkle's book Alone Together (2017), she asks the question of whether multitasking, a skill that digital natives tend to possess, is beneficial when multi-taskers do not perform any better or more efficiently. Neuroscientist Earl Miller debates whether multitasking even truly exists. He suggests that multitasking is just the ability to switch between different tasks easily, but that the brain can only focus on one task at a time (Hamilton, 2008).

In this situation, can the average high school student be depended on to focus their brain on the task of learning, rather than social networking, popular videos, and online games? In addition, how do students feel about using these technological tools? According to Kaznowska, Rogers, and Usher (2011), students had mixed feelings about online learning. Many students still preferred the direct instruction from an instructor, but also appreciated the increased freedom of e-learning. The authors made the following conclusions from their data analysis:

These do not quite sound like the views of the "digital natives" we have heard so much about. Far from preferring to be immersed in a digital world of self-directed learning, students seem to still have an enormous desire to learn directly from a "sage on the stage." The advantage they see in e-learning resources is that they give them the freedom to make occasional mistakes – missing class, forgetting a textbook at home, etc. – with less fear of falling behind. However, while this all provides grounds for suspicion with respect to glib claims about digital natives, there is not enough evidence here to dismiss the notion entirely. (pp. 17-18)

This researcher agrees with Kaznowska, et al in that there may be issues with delivering instruction online and relying more on technology, but that does not negate that there is much potential for increased engagement outside of the physical classroom. Even with the critiques that multitasking may not truly exist and that not all Millennials are comfortable with technology, the benefits of self-pacing and student choice may very well outweigh any drawbacks of implementing a flipped classroom.

What are the Results so Far?

There is debate to be had about the theories surrounding flipped classrooms, but the research to date is mostly positive in regards to student achievement. Undergraduate students in an analytical chemistry course improved on selected concept questions from 46% to 75%, 46% to 79%, and 46% to 92% in three different trials, with students responding that online tutorials were helpful at a rate of 88% (He, Swenson, & Lents, 2012). Wilson (2013) was able to show significant improvement (an average increase of 9.99 points for the course grade) in a flipped undergraduate statistics course. Hu, Gao, Ye, Ni, Jiang, & Jiang (2018) performed a meta-analysis of flipped teaching in nursing programs between 2015 and 2017. They found that nursing students who were in flipped classrooms had theoretical knowledge and skill scores that were significantly higher than their lecture only peers. Likewise, engineering education increased the amount of time spent on application of concepts and improved “soft” skills like critical thinking and design analysis for first-year engineering students using the flipped classroom model, according to Saterbak, Wettergreen, & Roberts (2016).

Much of the research done has been on college undergraduates, who are not representative of the public high school general population. However, research done within high schools has shown similar results. Byron High School saw an improvement from 29.9% mastery in 2006 to 65.6% mastery in 2010 on the Minnesota Comprehensive Assessment (Fulton, 2012). In full disclosure, a second variable was present in that the school was switching to a new digital curriculum, which may have further impacted the results. In his physics classroom, Dave Kawecki experienced more time to work with students during a flipped unit, while students performed equal to or better than students in previous years on the unit test (Brunsell & Horejsi, 2013). In reading about the courses and student bodies that are engaging in flipped classrooms, a common factor continually surfaces: a vast majority of the classrooms that have seen success happen to include already high performing students (undergraduates and advanced students) and/or communities that are economically advantaged. Flumerfelt and Green (2013) did show an 11% increase in achievement among at-risk students in a ninth grade flipped science classroom, and a 22% increase for the rest of the 9th grade students. At-risk students are already identified as a student in need of assistance, and the demographics for the rest of the student population were not available.

Challenges of Flipped Classrooms

Flipped classrooms have unique challenges. Students, who are used to predominantly direct instruction and lecture, must adjust to a new, more student-centered style of teaching. Loh, Wong, Quazi, & Kingshott (2016) demonstrated that Australian students felt uncomfortable with the freedom of a self-paced flipped classroom. Videos or other interactive material must be prepared ahead of time, placing more time demands on the instructor. Without direct supervision and strong intrinsic motivation to learn, there can be a struggle to get students to study on their own, as well as having reliable access to internet and appropriate technology (Herreid & Schiller, 2013).

Theoretical Framework

A variety of psychological, sociological, and pedagogical documentation has shown that students come to class with a variety of learning styles. Borg and Shapiro

(1996) assert that students perform best when an instructor's teaching style matches that student's learning style. In classrooms that contain dozens of students, there are bound to be some learners who will remain mismatched with their teacher. Time being the greatest constraint, flipping a classroom allows instructor's to differentiate instruction (create different learning opportunities) and introduce activities that help solidify content topics.

Reichmann and Grasha (1974) developed the Grasha-Reichmann learning styles questionnaire that placed students into one of three categories: 1) dependent workers, who require a significant amount of direction from teachers; 2) collaborative workers, who learn best as working part of a team; and 3) independent workers, who are solitary and achieve at their highest levels when left to produce on their own. In addition, learning styles can be further influenced by personality traits that can be measured using the Myers-Briggs type indicator. Attitudes of being extroverted or introverted, sensing or intuition to process information, making decisions by thinking versus feeling, and evaluating one's environment by judging or perceiving may influence the student's ability to achieve at high levels based on how the curriculum is presented. The assumption is that by shifting lecture and low-level Bloom's taxonomic activities to outside of class time, teachers are better able to differentiate student learning during the available direct contact with students.

However, according to Maslow's hierarchy of needs, before students can reach higher levels of learning, low levels like physiological needs and safety must be met. Poverty stricken homes already face significant challenges in meeting needs such as food and stable living environments, but there is also a high correlation between poverty, violence, and drug addiction (Lipton, Yang, Braga, Goldstick, Newton & Rura, 2013).

These variables may decrease the ability of students to perform school work in their home environment, due to concerns for personal safety and/or a lack of self-esteem. The district being studied is a mixed rural and urban district on the outskirts of a medium-sized city which has a one-to-one computer initiative, but also has a higher than average population of the economically disadvantaged. In the 2016-17 year, the free and reduced lunch rate for this district had dropped to 41.7% from 56.9% three years earlier, but was still higher than the state average (Iowa Department of Education, n.d.). Reiterating the difference in populations, the study at Byron High School in Minnesota, which demonstrated a high rate of achievement growth, had a free and reduced lunch rate of 10.49% in the 2013-14 school year (Hunger Free Minnesota, n.d.). Even with the school district providing appropriate hardware, limited income may prevent reliable internet access, and therefore, diminish any advantages the flipped classroom would have provided.

CHAPTER 3

PROJECT

A mixed-method approach was used in order to analyze student achievement results quantitatively, while surveys were incorporated to help illustrate possible reasons for the results we saw and any changes in attitude.

A pretest-treatment-posttest design (Creswell, 2014) was used to analyze changes in student achievement. Students were assigned to either the control or treatment groups by a third party according to the best fit for their daily class schedule. The group designated a “flipped” classroom was chosen randomly. Four class periods were available, two in the morning (9:25 to 10:11 and 10:15 to 11:01) and two in the afternoon (1:11 to 1:56 and 2:00 to 2:45) Monday through Friday. One morning and one afternoon class were selected as the treatment group, while the other two classes remained a control to minimize impacts that time of day may have on the results.

Both groups used the same learning targets and took the same assessments for the chemistry unit on stoichiometry. Both groups completed the same assignments and labs, with the “flipped” group having greater access to additional supplementary worksheets and lab activities. Due to more time during the class period being available to work independently rather than being used for direct instruction, I had anticipated more students in the treatment group being able to study the topics in greater depth. Otherwise, the direct instruction in the control group was based off of the videos created for the treatment group and the anchor activities (four skill building activities, five lab activities, and a summative engineering/design project) were the same for both groups. Any biases should not have played a role in this research since both groups were provided with the same instruction, same activities, and same assessments; the only difference being the manner in which the instruction was delivered.

Participants

The students consisted of males and females who are enrolled in an introductory chemistry class. This includes the age groups from 14 to 18, and exclude students who were repeating the class. The control contained 19 students, while the treatment group contained 17 students. The district had a free and reduced lunch rate of 56.9% in the 2013-14 school year, and both groups contain an average free and reduced lunch rate that falls within one standard deviation of this percentage. All parents of participating students signed a consent form and all participating students signed an assent form (APPENDIX B) which were both approved and documented with the institutional review board.

Measures and Data Collection

Quantitative data regarding achievement was collected through a pretest and posttest (APPENDIX A) based off of standardized multiple-choice questions on stoichiometry for chemistry. An average gain (posttest – pretest) will be calculated for each group and subjected to a Mann-Whitney U test. Flyvbjerg (2006) and Zikmund (2003) agreed that participant interviews provide depth and detail, as well as greater insight into research problems. For that reason, this study used open-ended questions that encourage students to answer freely, providing increased depth and a richer base of information than closed questions (Minichello, Aroni, Timewell & Alexander, 1995).

Six of the students out of the thirteen individuals in the treatment group were selected as interviewees because this number fell in the middle of the range that Kathleen

Eisenhardt (1989) suggested was ideal for the number of case studies to be studied. Cooper and Schindler (2001) insisted that judgment samples be used to ensure that the interviewees' diversity and backgrounds reflect the larger sample population.

The interviews ranged from 5 to 20 minutes and were documented using a digital recorder. The information from the interviews was transcribed (APPENDIX D) and major concepts entered into a spreadsheet in order to identify patterns (Table 6). Using a matrix to organize data into sections is a practical method for facilitating pattern matching of qualitative data (Yin, 1994).

Results

Students were given a multiple-choice Pretest over stoichiometry questions, the chemistry concept being assessed in this unit. It is safe to assume that most, if not all, students had no previous exposure to performing stoichiometry since the state standards do not address this skill at any previous grade level. The students were re-tested after completing the unit on stoichiometry. The results for the Pre- & Post-Tests are in Table 1.

The control group produced an average gain of 1.83 points while the treatment group produced an average gain of 1.18 points. A Mann-Whitney U-test was used to determine whether the difference between groups was statistically significant. The U statistic is calculated using the following formula where U_c is the test statistic of the control group, U_t is the test statistic of the treatment group, n_c is the sample size of the control group, n_t is the sample size of the treatment group, R_c is the rank sum of the control group, and R_t is the rank sum of the treatment group.

$U_c = n_c n_t + \{n_c(n_c + 1)\} / 2 - R_c$

$U_t = n_c n_t + \{n_t(n_t + 1)\} / 2 - R_t$

Table 1

Stoichiometry pre- & post-test results

# of correct answers	Pre-test Control	Pre-test Treatment	Post-test Control	Post-test Treatment
0	7	0	0	0
1	4	6	3	3
2	2	5	2	3
3	4	6	7	3
4	1	0	3	4
5	0	0	4	4
Mean Score	1.33 (∓.32)	2.00 (∓.21)	3.16 (∓.31)	3.18 (∓.36)
Standard Deviation	1.37	.86	1.34	1.47
Mean point increase from Pre-Test	N/A	N/A	+1.83	+1.18

Note: These are the number of correct answers completed on a five-question multiple-choice chemistry pre-test, along with mean, error, standard deviation, and amount of increase.

The smaller of the two is considered the U statistic and is used with a critical values table to determine significance (APPENDIX C).

Students in the treatment group also completed a Pre- and Post-Unit Survey to determine if and how their perceptions of a “flipped” classroom had changed throughout the unit. The Pre-Unit Survey results are located in Table 2, while the Post-Unit Survey results are located in Table 3.

Table 2

Pre-unit survey

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
From what I have experienced so far, the flexible learning/flipped classroom approach in this course will suit my learning needs.	24.1%	41.4%	27.6%	6.9%	0%
From what I have experienced so far, the flexible learning/flipped classroom approach in this course will provide a more stimulating learning experience for me.	34.5%	44.8%	20.7%	0%	0%
From what I have experienced so far, the flexible learning/flipped classroom approach in this course is an effective way to teach the content material.	24.1%	34.5%	37.9%	3.4%	0%
I am excited to be in a flexible learning/flipped classroom.	24.1%	41.4%	27.6%	0%	6.9%
I believe at this stage (beginning of the course) that being in a flexible learning/flipped classroom will involve less work and time commitment for me than a regular class (face-to-face lectures and tutorials)	20.7%	27.6%	34.5%	6.9%	10.3%
My preference is going to traditional face-to-face lectures than watching mini-lectures online.	24.1%	27.6%	41.4%	6.9%	0%

Table 3

Post-Unit Survey

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
From what I have experienced so far, the flexible learning/flipped classroom approach in this course will suit my learning needs.	30%	50%	20%	0%	0%
From what I have experienced so far, the flexible learning/flipped classroom approach in this course will provide a more stimulating learning experience for me.	5%	65%	30%	0%	0%
From what I have experienced so far, the flexible learning/flipped classroom approach in this course is an effective way to teach the content material.	30%	45%	20%	5%	0%
I am excited to be in a flexible learning/flipped classroom.	40%	35%	25%	0%	0%
I believe at this stage (end of the course) that being in a flexible learning/flipped classroom has involved less work and time commitment for me than a regular class (face-to-face lectures and tutorials)	10%	40%	50%	0%	0%
My preference is going to traditional face-to-face lectures than watching mini-lectures online.	20%	20%	35%	20%	5%

Six students were interviewed and their answers were compiled into common themes. Three (3) primary themes and one (1) secondary theme were identified through the interview process. Table 4 contains the themes and the number of interviewees who identified each theme during their interview.

Table 4

Interview themes

Theme	Number of participants who identified this theme
Increased class time to perform labs and experiments	6
Increased class time for guided practice	4
Ability to review content at own pace	3
Dislike the daily time requirement	2

CHAPTER 4

REFLECTION ON THE PROJECT

Science education has evolved from what was perceived to be a memorization of a body of knowledge, to the current concept that science is a way of thinking more than a body of knowledge, and that students should understand the nature of science as opposed to the facts that make up its body of evidence (Lederman, 2014). The goals of science education proposed by the National Research Council (NRC) and the Next Generation Science Standards (NGSS) are identical, since the NRC formed the committee that developed the framework that the NGSS is based upon (Keller & Pearson, 2012). NRC (2012) stated that there are three necessary dimensions of science education: the science and engineering practices; crosscutting concepts; and the disciplinary core ideas. All three of these are represented in the NGSS.

The disciplinary core ideas are the most likely to be addressed in a “traditional” classroom. The author believes that “traditional” classrooms lend themselves to a more behaviorist model of teaching, where students tend to memorize facts and reproduce major concepts. B.F. Skinner used reinforcement techniques to train individuals, which is useful in education if a specific knowledge set is trying to be learned, but the transition to a skill based economy requires learners to be able to manipulate information and adapt to new situations. Theoretically, the social constructivist perspective would provide learners with a better foundation to learn knowledge through authentic experiences and discuss concepts with peers. Greater collaboration with peers increases time spent in the zone of proximal development by aiding learners who otherwise could not complete the tasks on their own. This more fluid perspective of constructing knowledge also allows learners greater ability to adapt to new situations in comparison to the concrete knowledge that is obtained through behaviorist learning. For that reason, a “flipped” classroom should be beneficial to students by allowing more class time to construct knowledge and skills through authentic experiments and interpretation of data sets.

The purpose of this research was to address the three following questions:

Research Question #1 - Are economically disadvantaged students as comfortable using digital tools as their economically advantaged peers?

According to the interviews, no students self-reported that neither comfort with technology nor internet access hindered their ability to perform in the flipped classroom. Future research could include a larger sample population as well as identifying individual students as representing specific socioeconomic classes. In addition, researchers could compare the proficiency and efficacy of students representing particular socioeconomic classes rather than relying on self-reporting by students.

Research Question #2 - Will less-structured class time decrease engagement?

How the change in course structure impacted engagement is difficult to address because of mixed results from the pre- and post-surveys as well as incomplete results from the interviews. Students remained virtually unchanged in the percentage of agreeable responses as to whether they would require less work and time commitment from the Pre- (48.3%) to Post- (50.0%) Unit Survey responses. The greatest change in perception of their time commitment came from students shifting from disagreeable answers in the Pre-Unit Survey of 17.2% to 0.0% in the Post-Unit Survey. This may be due to prior experiences since many students had expressed that they had experienced a flipped classroom in a Math course offered in the same school.

The survey also indicated a decrease in the number of students who thought that a flipped classroom would be more engaging, dropping from 79.3% to 70.0% of students who agreed or strongly agreed with the statement that a flipped classroom would provide a more stimulating learning experience. In hindsight, a better survey question may have been to compare their stimulation in a traditional classroom to the flipped classroom. From this data, it is difficult to gauge whether the 79.3% agree/strongly agree response was the student's current level of engagement or their anticipated level of engagement in a different learning style.

The other piece of evidence from the survey that the author has linked to engagement, is whether students felt that a flipped classroom was an effective way to teach the content. The percentage of students who agreed or strongly agreed that a flipped classroom was an effective way to teach the content increased from 58.6% to 75.0%. This indicates to the author that even if students did not see a change in the amount of time and work that they must devote to a class or even if they felt less stimulated, they also communicated that it was effective, and therefore, that if the students felt that a flipped classroom was effective, then it was most likely engaging.

Research Question #3 - What is the impact of a flipped classroom in a predominantly low income school?

The central question of this research is whether a flipped classroom works as well with low-income students as it does in the wealthy districts where much of the research on flipped classrooms appears to have been performed. This question appears to be superficially answered in the data that the control group had a greater average growth than the treatment group. This would seem to indicate that using a flipped classroom method actually decreased student achievement. There are a number of rationale that could explain this trend, but the data is inconclusive. After running a Mann-Whitney U-Test, a U statistic of 56.5 was found, which with sample sizes of 13 in each group, the critical value is 45 (APPENDIX C). This gives a p-value of 0.153, which is far above the 0.05 that is required to be significant. Statistically, there was no difference between the control and treatment groups.

Even though the differences between the groups were not statistically significant, the data raises questions as to why the average growth was higher for the control group rather than the treatment group. A number of variables may have impeded the effectiveness of the flipped classroom, including meeting Maslow's Hierarchy of Needs. As evidenced by the high rate of free and reduced lunches, many students are food insecure and that may have prevented students from advancing in their understanding no matter what teaching method was used. Physical safety also may be an inhibitor since domestic violence is strongly correlated with poverty (Slabbert, 2016). In addition, after the release of consent forms to the researcher, it was found that the control group was composed of 13 students, of which 6 were identified as Talented and Gifted (TAG), whereas the treatment group contained 2 of its 13 students identified as TAG. This may or may not have impacted the outcome, but is a variable to be considered in future research.

Areas of further research might include whether students watch the videos outside of class time and whether that content is retained equally as well as face-to-face lectures. Although the interviews did not indicate this, internet access may have inhibited some students from watching videos, as well as student attitude. The true impact would not be able to be assessed without larger research groups, a wider number of interviews, and determination of which interviews are associated with low-SES students. Determining how student attitude impacts the use of flipped classrooms as well as whether those attitudes differ across socioeconomic boundaries would be valuable information for future flipped implementation. Lastly, the quality of the hands-on activities and guided practice could be evaluated, since increased time to work on minimally challenging activities will not likely increase student achievement.

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APPENDIX A

Stoichiometry Pre -Test

1. For the reaction, $S + O_2 \rightarrow SO_3$, the number of grams of oxygen required to produce 64 grams of sulfur trioxide is
1) 2 grams; 2) 16 grams; 3) 38 grams; 4) 55 grams; 5) 64 grams.

2. What mass of water is produced by the complete combustion of 126 grams of propene, C_3H_6? $C_3H_6 + O_2 \rightarrow H_2O + CO_2$.
1) 18.0 grams 2) 54.0 grams 3) 126 grams 4) 162 grams 5) none of these

3. Calculate the mass of hydrogen nitrate that reacts with iron (II) sulfide to produce 50.0 grams of ferrous nitrate.
1) 17.5 grams 2) 35.0 grams 3) 71.3 grams 4) 86.4 grams

4. The total mass of the substances taking part in a chemical change 1) always increases; 2) always decreases; 3) remains unchanged; 4) sometimes increases and sometimes decreases.

5. In the following equation, which is the **limiting** reactant if 2.6 moles of aluminum are reacted with 5.2 moles of HC1? 1) Al 2) HC1 3) H 4) Cl

Stoichiometry Post-Test

1. For the reaction, $S + O_2 \rightarrow SO_3$, the number of grams of oxygen required to produce 64 grams of sulfur trioxide is
   1) 2 grams; 2) 16 grams; 3) 38 grams; 4) 55 grams; 5) 64 grams.

2. What mass of water is produced by the complete combustion of 126 grams of propene, C_3H_6? $C_3H_6 + O_2 \rightarrow H_2O + CO_2$.
   1) 18.0 grams 2) 54.0 grams 3) 126 grams 4) 162 grams 5) none of these

3. Calculate the mass of hydrogen nitrate that reacts with iron (II) sulfide to produce 50.0 grams of ferrous nitrate.
   1) 17.5 grams 2) 35.0 grams 3) 71.3 grams 4) 86.4 grams

4. The total mass of the substances taking part in a chemical change 1) always increases; 2) always decreases; 3) remains unchanged; 4) sometimes increases and sometimes decreases.

5. In the following equation, which is the **limiting** reactant if 2.6 moles of aluminum are reacted with 5.2 moles of HC1? 1) Al 2) HC1 3) H 4) Cl

APPENDIX B

Research Consent Form

Project Title: Flipped Learning in the Science Classroom
Investigator: Mike Yeoman

We are doing a research study about how using videos outside of class can provide more time for practice when we are together. A research study is a way to learn more about people. We are trying to determine if watching videos as homework and then practicing during class improves student success. The videos will be used as a regular part of class and all students will be assessed on the content, which is stoichiometry. Some students will be taught a lesson during class time and will be expected to do stoichiometry problems as homework. Other students will watch videos of a lesson as homework, and then do stoichiometry problems during class time. Regardless of participation, all students will be expected to meet the requirements of the class, which may include watching videos as homework.

Before we begin our stoichiometry unit and after we have completed the unit, students will take a survey about any thoughts they have on flipped classrooms. This survey will be given by a teacher besides myself that is available during your child's class period. If you agree to allow your child to participate in this study, their coursework will be used in the research and after completion of the semester, may participate in a 5 to 10 minute interview with a different teacher (   ) during an open period or outside of the school day. If your child is interviewed, their words will be recorded, transcribed and made anonymous.

There are no serious risks involved in participating in the study since your child will be taking the class whether you decide to participate in the study or not. The major difference is that being in the study will include taking a survey before the unit and after the unit, as well as have the opportunity to be interviewed about their experience.
Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. We think these benefits might be a better understanding of chemistry because of increased one-on-one time.

When we are finished with this study we will write a report about what was learned. This report will not include your child's name or that they were in the study.
Your child does not have to be in this study if you do not want them to be. If you decide to stop after we begin, that's okay too. I will not know who is participating in the study until after the semester is over because these consent forms will be held in the office during the research.

If you agree for your child to participate in this study, please print your child's name and sign your name. Please have your child return this form to in the front office. Contact information is located on the back of this form.

I, ________________________________, agree to my child,

________________________________to participate in this research study.

____

(Sign your name here)

Principal Investigator:
Mike Yeoman
Email: yeomanmike@_________
Phone: (5__________________

Graduate Advisor:
John Ophus
Email: john.ophus@uni.edu
Phone: (319) 273-3960

University of Northern Iowa, Office of Research and Sponsored Programs:
Email: rsp@uni.edu
Phone: (319) 273-3217

Research Assent Form

Project Title: Flipped Learning in the Science Classroom
Investigator: Mike Yeoman

We are doing a research study about how using videos outside of class can provide more time for practice when we are together. A research study is a way to learn more about people. We are trying to determine if watching videos as homework and then practicing during class improves student success. The videos will be used as a regular part of class and all students will be assessed on the content, which is stoichiometry. Some students will be taught a lesson during class time and will be expected to do stoichiometry problems as homework. Other students will watch videos of a lesson as homework, and then do stoichiometry problems during class time. Regardless of participation, all students will be expected to meet the requirements of the class, which may include watching videos as homework.

Before we begin our stoichiometry unit and after we have completed the unit, you will take a survey about any thoughts you have on flipped classrooms. This survey will be given by a teacher besides myself that is available during your class period. If you agree to participate in this study, your coursework will be used in the research and after completion of the semester, may participate in a 5 to 10 minute interview with a different teacher (   ) during an open period or outside of the school day. you may be asked to participate in a short interview. If you are interviewed, your words will be recorded, transcribed, and made anonymous.

There are no serious risks involved in participating in the study since you will be taking the class whether you decide to participate in the study or not. The major difference is that being in the study will include taking a survey before the unit and after the unit, as well as have the opportunity to be interviewed about your experience.
Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. We think these benefits might be a better understanding of chemistry because of increased one-on-one time.

When we are finished with this study we will write a report about what was learned. This report will not include your name or that you were in the study.

You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too. Your parents know about the study too. I will not know who is participating in the study until after the semester is over because these consent forms will be held in the office during the research.

If you decide you want to be in this study, please sign your name and return to   in the front office.

I, _________________________________, want to be in this research study.

____
(Sign your name here)

*Identifying information has been redacted in order to protect the confidential information of students.

APPENDIX C

Critical Values for the Mann-Whitney U-Test

Level of significance: 5% (P = 0.05)

Size of the largest sample (n_2)

Size of the smallest sample (n_1)

n_1 \ n_2	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	13	13
4	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	17	18	19	20	21	22	23
5	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20	22	23	24	25	27	28	29	30	32	33
6		5	6	8	10	11	13	14	16	17	19	21	22	24	25	27	29	30	32	33	35	37	38	40	42	43
7			8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
8				13	15	17	19	22	24	26	29	31	34	36	38	41	43	45	48	50	53	55	57	60	62	65
9					17	20	23	26	28	31	34	37	39	42	45	48	50	53	56	59	62	64	67	70	73	76
10						23	26	29	33	36	39	42	45	48	52	55	58	61	64	67	71	74	77	80	83	87
11							30	33	37	40	44	47	51	55	58	62	65	69	73	76	80	83	87	90	94	98
12								37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	97	101	105	109
13									45	50	54	59	63	67	72	76	80	85	89	94	98	102	107	111	116	120
14										55	59	64	67	74	78	83	88	93	98	102	107	112	118	122	127	131
15											64	70	75	80	85	90	96	101	106	111	117	122	125	132	138	143
16												75	81	86	92	98	103	109	115	120	126	132	138	143	149	154
17													87	93	99	105	111	117	123	129	135	141	147	154	160	166
18														99	106	112	119	125	132	138	145	151	158	164	171	177
19															113	119	126	133	140	147	154	161	168	175	182	189
20																127	134	141	149	156	163	171	178	186	193	200
21																	142	150	157	165	173	181	188	196	204	212
22																		158	166	174	182	191	199	207	215	223
23																			175	183	192	200	209	218	226	235
24																				192	201	210	219	228	238	247
25																					211	220	230	239	249	258
26																						230	240	250	260	270
27																							250	261	271	282
28																								272	282	293
29																									294	305
30																										317

The Open Door Web Site

APPENDIX D

Interview Transcripts

Student Interview 1

Interviewer: During parts of the last semester, you have been taking a flipped chemistry class, meaning that direct instruction such as lecture is recorded and assigned as homework, leaving class time for alternative activities like application scenarios and labs. Do you think that this type of class helped you be more successful, less successful, or neither? In other words, do you think that you learned more, less, or an equal amount as you would have learned in a lecture or discussion based class?

Student 1: I guess it was fine. I'm a really good student so I pick up on things really easily. I don't usually have to do any homework, so it bothered me that I had to watch the videos outside of class. I usually just watched it in government, but I don't see why I couldn't do it in class.

I: What are your attitudes towards education (Do you like school?)? Did this class impact your opinion of school? If so, how?

S1: Schools fine. I know it's important because I don't wanna end up like my brothers. I know Yeoman was trying to do something new, but I would just rather have him explain it to me so I don't have to spend time outside of class.

I: Can you identify any factors that may have impacted your success? If so, what are they and how did they affect you?

S1: I don't know. I guess it was nice to have time for him to check to see if we were doing the math right. Like I said, I didn't really struggle, but it was nice that when he saw I got the problems right, he would give me harder ones to try. I heard a lot of people say that they learned more math in chemistry than in Algebra 2.

I: Did access to technology impact your ability to do coursework outside of class? Was lack of access to the internet an obstacle?

S1: No.

I: Overall, did you think that class time was used well this semester, or do you think that a traditional, lecture-based, class would have been a better use of time? Why or why not?

S1: It was okay. I liked that we did a lot of labs, but like I said, I would have rather had him tell me what I needed to know in class. I guess I like lecture classes better.

Student Interview 2

Interviewer: During parts of the last semester, you have been taking a flipped chemistry class, meaning that direct instruction such as lecture is recorded and assigned as homework, leaving class time for alternative activities like application scenarios and labs.

Do you think that this type of class helped you be more successful, less successful, or neither? In other words, do you think that you learned more, less, or an equal amount as you would have learned in a lecture or discussion based class?

Student 2: It was fine. I didn't always know what I was supposed to do.

I: What are your attitudes towards education (Do you like school?)? Did this class impact your opinion of school? If so, how?

S2: It's more fun than other classes, I guess. We did a lot of labs and liked that. If I have to be here I guess that's better than just sitting at a desk.

I: Can you identify any factors that may have impacted your success? If so, what are they and how did they affect you?

S2: I don't know. I don't really get chemistry. Yeah. This is the last science class I'm taking.

I: Did access to technology impact your ability to do coursework outside of class? Was lack of access to the internet an obstacle?

S2: No. I've got Schoology on my phone. The videos and quizzes are right there.

I: Overall, did you think that class time was used well this semester, or do you think that a traditional, lecture-based, class would have been a better use of time? Why or why not?

S2: No. I liked that we could get up and move around. I had chemistry right after math on block days. I would sit in there for, like, an hour without getting up. It was nice that we would come in and go straight into lab.

Student Interview 3

Interviewer: During parts of the last semester, you have been taking a flipped chemistry class, meaning that direct instruction such as lecture is recorded and assigned as homework, leaving class time for alternative activities like application scenarios and labs. Do you think that this type of class helped you be more successful, less successful, or neither? In other words, do you think that you learned more, less, or an equal amount as you would have learned in a lecture or discussion based class?

Student 3: I'm a really hands-on person and I think that this helped me. I have friends in one of the other chemistry classes and it seems like we did about twice as many labs as they did. Seeing the reactions and Mr. Yeoman explaining it helped a lot. I think that I learned better like this than if I just heard it once in class or had to read it out of the book. I like to have notes to look back at, and watching the videos gave me time to write everything down. I would watch a little bit, pause it, then start it again so that I didn't miss anything.

I: What are your attitudes towards education (Do you like school?)? Did this class impact your opinion of school? If so, how?

S3: I never thought that I was good at science, but having chemistry with Mr. Yeoman and Anatomy with Miss _____ made me want to try something in science. I think I want to be a dental hygienist. I don’t think it was just this class, but I am less scared to do something science related.

I: Can you identify any factors that may have impacted your success? If so, what are they and how did they affect you?

S3: I already said it, but I think that the videos helped me take better notes and actually seeing the reactions helped me understand things better.

I: Did access to technology impact your ability to do coursework outside of class? Was lack of access to the internet an obstacle?

S3: No.

I: Overall, did you think that class time was used well this semester, or do you think that a traditional, lecture-based, class would have been a better use of time? Why or why not?

S3: When teachers just talk, I get lost. I felt like I could ask more questions since we spent a lot of time at the lab stations. I don't like to ask questions in front of the whole class. I don't really like math, either, so it was nice that he would check in and see how each of us was doing when we worked on equations. I get so mad when I spend two hours doing math problems at home and then come to school the next day and find out I did them all wrong.

Student Interview 4

Interviewer: During parts of the last semester, you have been taking a flipped chemistry class, meaning that direct instruction such as lecture is recorded and assigned as homework, leaving class time for alternative activities like application scenarios and labs. Do you think that this type of class helped you be more successful, less successful, or neither? In other words, do you think that you learned more, less, or an equal amount as you would have learned in a lecture or discussion based class?

Student 4: Yeah. It was good. I liked it.

I: What are your attitudes towards education (Do you like school?)? Did this class impact your opinion of school? If so, how?

S4: School's fine. I don't think this class really changed my opinion of school.

I: Can you identify any factors that may have impacted your success? If so, what are they and how did they affect you?

S4: To be honest, I really just did what I had to. I'm sure I could have done better, but I just need this class to graduate.

I: Did access to technology impact your ability to do coursework outside of class? Was lack of access to the internet an obstacle?

S4: Not really.

I: Overall, did you think that class time was used well this semester, or do you think that a traditional, lecture-based, class would have been a better use of time? Why or why not?

S4: I think I probably liked this better. Like, ______ is a really good speaker and he tells great stories, and I get that there isn't as much to get up and do in history, but if it was like that in science, too, I don't know that I could do it. I liked that we did a lot of labs and he didn't just talk at us.

Student Interview 5

Interviewer: During parts of the last semester, you have been taking a flipped chemistry class, meaning that direct instruction such as lecture is recorded and assigned as homework, leaving class time for alternative activities like application scenarios and labs. Do you think that this type of class helped you be more successful, less successful, or neither? In other words, do you think that you learned more, less, or an equal amount as you would have learned in a lecture or discussion based class?

Student 5: I liked doing the labs. I think I learn better when I can see it.

I: What are your attitudes towards education (Do you like school?)? Did this class impact your opinion of school? If so, how?

S5: I like school. It didn't change my mind.

I: Can you identify any factors that may have impacted your success? If so, what are they and how did they affect you?

S5: I play basketball here at school and I am on a club volleyball team, so I don't have a lot of time for doing homework after school. I think the videos really helped me because when I missed class to go to games, I could just watch the videos on the bus and know I wasn't going to fall behind. Kind of the same thing, but I liked that we did all of the math in class because I can't do very much homework.

I: Did access to technology impact your ability to do coursework outside of class? Was lack of access to the internet an obstacle?

S5: No.

I: Overall, did you think that class time was used well this semester, or do you think that a traditional, lecture-based, class would have been a better use of time? Why or why not?

S5: I liked what we did. The labs were fun and it sounds like the other classes didn't do as many labs.

Student Interview 6

Interviewer: During parts of the last semester, you have been taking a flipped chemistry class, meaning that direct instruction such as lecture is recorded and assigned as homework, leaving class time for alternative activities like application scenarios and labs. Do you think that this type of class helped you be more successful, less successful, or neither? In other words, do you think that you learned more, less, or an equal amount as you would have learned in a lecture or discussion based class?

Student 6: It was good. I think that I learned a lot.

I: What are your attitudes towards education (Do you like school?)? Did this class impact your opinion of school? If so, how?

S6: School's good. I liked this class better than most classes.

I: Can you identify any factors that may have impacted your success? If so, what are they and how did they affect you?

S6: I think the most important thing for me is that we did most of the work in class. I have to be at (local grocery store) by 4:00 most days, so I have to do any homework I have after I get off, which is usually 10:00. The videos were a pain to watch since he doesn't give us time in class, but they weren't usually that long. I guess if I have to do homework, that's the easiest it gets.

I: Did access to technology impact your ability to do coursework outside of class? Was lack of access to the internet an obstacle?

S6: No.

I: Overall, did you think that class time was used well this semester, or do you think that a traditional, lecture-based, class would have been a better use of time? Why or why not?

S6: I don't know. I wish that what he taught was done in class, but if it wasn't the videos, it would probably be something else. Yeoman said we had time for more labs since he wasn't lecturing, so that was good, I guess.