

THE EFFECTIVENESS OF CONCEPT CHECKS USED PRIOR TO LECTURE IN A
FLIPPED CHEMISTRY CLASSROOM

by

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ABSTRACT

The *focus* of this classroom research project was to determine the effectiveness of concept checks in effort to overcome the obstacle of the current watered-down Pre-AP Chemistry course. Sophomore students at Lewisville High School Harmon completed concept checks in a flipped Pre-AP Chemistry class as a means to acquire more content throughout the duration of the 18-week course. Students viewed lecture videos and displayed their understanding of chemistry topics presented in the videos through the completion of concept checks. The effectiveness of teacher-created concept checks was determined from data analysis of student interviews and surveys, summative assessment scores, and response data from concept checks. Through completion of this classroom research project, I gained insight on the effectiveness of teacher-created lecture videos and concept checks utilized in my flipped course.

INTRODUCTION AND BACKGROUND

During my post-baccalaureate education certification program, I conducted one semester (18 weeks) of student teaching at Lewisville High School Harmon. Halfway through my student teaching experience, I was offered a full-time chemistry educator position for the following school year. I immediately decided to advance my education in order to become more adept in the science education profession. This led me to my current endeavor of earning my Masters of Science in Science Education. I have enjoyed gaining a deeper understanding of science education throughout this program and its courses. Upon completion of this classroom research project, my goal is to find a way to improve and advance my teaching skills, thus, cultivating a better learning experience and environment for my students.

School Demographics

Lewisville High School Harmon (LHSH) campus is home to a diverse population of students within Lewisville Independent School District (LISD) in Lewisville, Texas. The district serves approximately 60,000 students from Pre-K to 12th grade. LISD spans across four counties and reaches nine cities north of the Dallas-Fort Worth metropolitan area. There are currently five high schools within the district and four of those schools have separate 9th/10th grade centers. LHSH and its sister school, Lewisville High School Killough, serve only 9th and 10th grade students. These schools feed into Lewisville High School, consisting of only 11th and 12th grade students. LHSH (commonly referred to as Harmon) is located on the south side of the city of Lewisville (population of 90,000) and serves approximately 1,300 students within the school's zone.

There are a variety of ethnic groups represented at Harmon to include (but not limited to) Hispanic (39%), Caucasian (28%), African American (22%), and Chin (7%). Harmon is a Title I school, meaning more than 63% of its students participate in either free or reduced lunch programs. Many of the students have single parent or blended families and live in apartment housing. The majority of the students work part time jobs in order to contribute to the overall source of family income. Although students work multiple hours outside of school, their families still value continuing education and support their students in attending school daily. According to the Texas Education Agency, the 12th grade graduation rate is consistently around 85% (TEA, 2014) for Lewisville High School.

Classroom Environment

A typical Pre-AP Chemistry class consists of approximately 28-32 students with ~40% male and ~60% female. Due to the advanced academic content within the course, diversity within the individual classroom is much different from that of the school overall. Caucasians (~70%) predominate among the different ethnic groups, followed by Asians (~10%), and the remaining (~20%) of students are of other various ethnic groups. Over the course of 18 consecutive weeks, students attended four classes that met for 90 minutes daily.

Project Background

Since high school chemistry is no longer a required science class in the state of Texas, it is my belief that the content taught within this course has become watered-down. From observations of my colleagues, I have found there has been little to no drive

to teach more than just the basics. Moreover, the line that differentiates a Pre-AP class from an on-level class has become incredibly blurred. A simple solution to overcome this issue would be to cover more advanced content within the 18-week course.

However, including more direct lecture into the already tightly scheduled daily lessons poses a problem, as most educators will attest to the fact that “time is of the essence”.

Thus, the simplicity of this solution dissipates as time limitations become the reality. It is, however, possible to cover more content (by the end of the 18-week course) if the responsibility is placed on the student to acquire new content outside of the normal classroom lecture time frame. Students’ academic success within the course is then based on their conceptual understanding of chemistry topics acquired individually at home prior to class lecture.

The potential for academic errors to arise increases by placing the learning responsibility on students. The biggest issue being how to ensure students are acquiring and retaining content knowledge before coming to class the next day. I intend to analyze the effectiveness of content knowledge acquisition that takes place outside of the classroom through the use of teacher-created concept checks. Concept checks are questionnaires (approximately five questions in length) that I created to assess students’ knowledge of newly acquired material. Prior to attending class, students will view teacher-created lecture videos and complete concept checks. These concept checks will serve as a way for the students to demonstrate academic proficiency over the topics from the lecture video. The effectiveness of concept checks will be determined throughout this classroom research project.

Focus Questions

The focus of my classroom research project is centered on the assumption that students *will* acquire content specific information at home. Lecture videos and content specific resources (print and reference materials) will be provided to students on the days when it is necessary for students to interact with content outside of class. Students will need to view lecture videos and complete required concept checks prior to attending the next class. My focus question is “Does the completion of concept checks improve content mastery of out-of-class lecture?”. Analysis of summative assessment scores and student interview and survey data will be conducted to determine the effectiveness of concept checks. Three additional questions will be presented and researched to support the focus question.

- 1) “Does the completion of concept checks increase students’ understanding of the material prior to attending class?”
- 2) “Was the completion of concept checks crucial to students’ content processing during the following class period?”
- 3) “Were only the provided resources utilized by the students for completion of concept checks OR were additional resources utilized?”

Upon the completion of my classroom research project and data analysis, my ambition is to have determined the effectiveness of my teacher-created lecture videos and concept checks. This will then provide myself with insight on how to develop and conduct a more content rich, or less watered-down, Pre-AP Chemistry course.

CONCEPTUAL FRAMEWORK

Until the late 1970s, classroom lecture has been a ‘movie style’ approach with the students (audience) soaking up every word that is spoken by the teachers (actors). This ‘movie style’ or traditional way of educating has worked very well for many years until now (Tucker, 2011). With the transition into the 21st century classroom, students’ academic success has become dependent on active learning and continuous engagement. Furthermore, “educators must shift from a teaching-centered paradigm to a learner-centered paradigm” (Roehl, 2013). This shift brings on a whole new way of presenting information to students. Thus, the traditional style of teaching no longer proves to be effective with the 21st century student learner (Fulton, 2010).

One approach to a student-centered classroom is the flipped classroom model. A flipped classroom is a pedagogical model in which the typical lecture and homework components are reversed. In a flipped classroom, lecture (typically presented in class by the teacher) is conducted at home and traditional homework is performed in class through various practice assignments and hands-on activities (Tucker, 2011). Guidelines for successfully implementing a flipped classroom have been set forth by Aaron Sams and Jonathan Bergmann. Commonly referred to as “The Grandfathers of Flipped Learning”, Sams and Bergmann developed an innovative teaching style to overcome their struggles with time constraints during class. These two high school science teachers struggled to find time (in class) to reteach lessons to students who were absent while continuing to teach the rest of the class. They devised a plan to create and annotate videos that contained their lessons’ lecture material for students to view if they were absent from

class (Bergmann & Sams, 2008). Sams and Bergmann observed additional free time opening up in class when they required *all* students to watch lecture videos at home prior to coming to class. These two educators restructured their teaching styles and implemented what is now called a *flipped classroom* (Tucker, 2011).

Due to differentiation of its approach, flipped learning quickly gained popularity and is now apparent in different grade levels and content areas around the world (Bergmann & Sams, 2008). Although this method is widely used, if not implemented correctly, flipped instruction can be a disservice to students. Dr. J. Baker, a professor of applied communication at Cedarville University in Ohio, identified a set of best practices to consider when implementing a flipped classroom (Baker, 2000). Those best practices and goals include:

- providing students with more opportunities to peer teach,
- providing students with more control over their own learning,
- giving students more ownership and a greater responsibility for their own learning,
- finding a way for the teacher to be a guide in his/her own classroom,
- reducing the amount of time spent in class on lecture, thus, opening it up for active learning, and
- focusing more on application (critical thinking) rather than recollection of facts (basic thinking).

Taking these best practices into consideration, one might conclude that implementing a flipped classroom would be the best approach for the majority of teachers and students. However, as Dr. Baker noted, there is much to consider with this style of

teaching. Two of the main components for a successfully flipped classroom are the integration of lecture videos prior to class and the incorporation of engaging activities during class (Tucker, 2011). With lecture videos replacing direct in-class lecture, these videos become the main delivery method of information to students. The videos must be concise yet also convey the message and meaning of content that the teacher wants students to understand (Lage, 2000). If lecture videos are not designed and implemented properly, the students will learn nothing and will spend time watching meaningless videos. Teachers must then ensure that the lecture videos are followed up with related and meaningful in-class activities the next day. These activities must focus on the students interacting, practicing, and applying the content they received the evening before.

The majority of educators would say the ability to reach all students in the classroom is nearly impossible since student to teacher ratios are often 30:1. In a traditional style classroom, only one type of learner (visual, audio, etc.) is being reached at any given time during the lecture. However, in a flipped classroom, various forms of media and resources can be made available to the student for him or her to choose which media form provides for the best learning experience (Westberg, 2012). Lecture videos also allow students to work (at home) at their own pace, pausing the video when needed rather than the teacher pausing and holding up the rest of the class. Thus, students have the ability to learn new content in a manner that is best suited for each student individually, making the ability to reach all students more of a reality for educators (Kingsley, 2009).

Richard Pierce, a professor at Shenandoah University in Virginia, created and examined the effectiveness of his own “Vodcasts” or video-podcasts. Pierce desired more discussion time with his pharmacology students during the scheduled class time. In effort to free up additional class time, Pierce implemented a flipped classroom and redesigned his entire course. He required his entry-level pharmacology students to watch teacher-created Vodcasts before lecture in lieu of traditional homework. The following class meeting began with 15 minutes of question and answer over the Vodcasts. During this question and answer (Q & A) session, Pierce asked students specific questions (over the Vodcasts) to ensure their viewing and understanding of the Vodcasts. Once the Q & A was complete, students spent the remainder of class time working collaboratively on mini projects. This process made it apparent to Pierce as to which students watched the Vodcasts and which students had not. Pierce noticed the accountability was placed on the students for their own learning. The students quickly adapted to this style of teaching and learning and were able to embrace the flipped structure. Furthermore, Pierce witnessed evidence of students performing higher academically on summative assessments, which was a clear indication for the occurrence of student learning. Pierce concluded that the key to academic success for these students was the viewing of concise and effective Vodcasts (Pierce, 2012).

While Pierce’s main goal to implementing a flipped classroom was to create more in-class time for discussion, Amy Roehl, a professor at Texas Christian University in Texas, focused on creating engaging in-class activities that followed lecture videos. She came up with “four broad categories of instructional approaches for use in an active

learning flipped classroom...: (a) individual activities, (b) paired activities, (c) informal small groups, and (d) cooperative student projects” (Roehl, 2013). These instructional methods encompass many different types of activities that appeal to all student learners. Roehl focused primarily on keeping the 21st century student, the “millennial” student, actively engaged throughout the duration of class. A focus that was only possible in a flipped classroom model. Roehl stated, “in a flipped classroom, class time is spent to work through problems, advance concepts, and engage in collaborative learning instead of direct lecture”. The success of the planned, engaging lessons during the next class period is dependent on the fact that students *actually* watched the lecture videos and retained information. Ensuring student participation with the videos and the impact of flipped learning on students are additional components to consider with a flipped classroom structure.

Relevant literature provides studies over the impact of a flipped learning environment on student learning. Students in a flipped high school level algebra class received an average GPA of 3.2 on a 4.0 scale compared to students in a traditional style algebra class who received a 2.5 (Szoka, 2013). Students in these two classes covered the same material throughout the duration of the course; the difference in these courses was on the activities taking place during class time. In the traditional classroom setting, predominately direct lecture and basic practice was completed. On occasion (two to three times per week), hands on activities and cooperative learning took place, but the main focus within the classroom was direct lecture so that the students would receive the content. In the flipped classroom, students interacted with the material more during class

time. They were able to receive individual help from the teacher, work in small groups, practice with the material more and cover the content in more detail. Providing more ‘depth versus breadth’ with the content allowed for deeper understanding by the student learner (Szoka, 2013). As a result, summative assessment performance greatly increased and students retained the information longer since the interactions with the content were of a higher cognitive level. In general, students in a flipped classroom interact with the content more, thus, achieving a deeper level of understanding compared to the traditional style of learning and teaching (Szoka, 2013).

The aforementioned research shows a multitude of benefits, and a few implications, to the flipped classroom structure. The efficacy of a flipped classroom depends on several people including the students, the teacher, the students’ parents, and the schools’ administration. Support is needed to ensure success of each 21st century student with this non-traditional style of teaching. Throughout this classroom research project, I will attempt to ensure the effectiveness of teacher-created lecture videos and improve student participation with these videos through the use of concept checks.

METHODOLOGY

High school sophomore students will be completing concept checks in a flipped Pre-AP Chemistry classroom as a means to acquire more content throughout the duration of an 18-week course. To aid in student engagement with the material, concept checks were required on evenings when at home learning was conducted. The *focus* of this classroom research project is to determine the effectiveness of these concept checks in effort to overcome the obstacle of the current watered-down Pre-AP Chemistry course.

Participants

Participants of the classroom research project will be students in three sections of a Pre-AP Chemistry course. The first section consists of 27 students ($N= 27$), the second section consists of 24 students ($N= 24$), and the third consists of 32 students ($N= 32$). These students are high school sophomores both male (~40%) and female (~60%) ranging from 14-17 in age. Ethnic diversity within the individual classroom is much different from that of the school overall. The predominant ethnic group represented within the class is Caucasian (~70%), followed by Asian (~10%) and the remaining students (~20%) are of other various ethnicities. Sections one and two ($N= 51$), will be required to complete concept checks, thus, serving as the intervention group. Section three ($N= 32$) will not be required to complete concept checks and will serve as the comparison group.

Intervention

Students in the intervention group ($N= 51$) must complete required concept checks based on topics that will be covered through teacher-created lecture videos. Supplemental reference materials (print and online material) will also be provided when necessary for student use. Students will view an average of two lectures videos per week throughout the nine-week intervention period. After viewing each lecture video, students will fill out an online concept check via Google Forms. Concept checks will be detailed yet concise in nature in order to capture students' understanding of the content presented in lecture videos. They are, on average, five questions in length consisting of various question formats such as multiple choice, fill in the blank, and short answer. A variety of

questions are necessary to ensure students have a comprehensive understanding of the video and reference material. The majority of questions will be content specific in nature and a few will be directly related to the media source that was used. This will enable me to determine if the intended media source was accessed specifically for the completion of concept checks *or* if other materials were used. The number of video views will also be tracked and cross-referenced with the number of concept checks submitted to further support use of the specific material. The submission of each concept check will be necessary prior to the students' attending the following class meeting.

Lecture videos and concept checks provided during the intervention period covered topics such as: stoichiometry (Appendix A), moles (Appendix B), nomenclature, periodicity, and bonding. Students in the comparison group will have access to the same lecture videos and reference materials as the intervention group. However, concept checks will *not* be available to the comparison group.

Data Collection

To measure the effectiveness of concept checks, I will be administering regularly scheduled quizzes and summative assessments, collecting grades, and conducting student interviews and surveys. Quiz and summative assessment data will be collected from every student (intervention group and comparison group, $N= 83$) on routinely scheduled occurrences throughout the semester. Data collection for quizzes and assessments is consistent with the data that I collect and analyze each semester. Data that is not normally collected each semester consisted of the student interviews and surveys, which was necessary for the completion of my classroom research project.

Student interviews will be conducted in a selective manner. Provided student consent, 10 students ($N=10$) from the intervention classes (five students from each section ($N=5$)) will complete student interviews. These students will be of different gender, ethnicity, and cumulative content grade within the class. Per class section, I will have two “A” students, two “B” students and one “C” student to ensure a proper, unbiased representation of the class. Furthermore, there will be one “A” female student, one “A” male student, one “B” female student, one “B” male student, and the “C” student will be randomly selected as either male or female. The majority of student interviews will be held around the time of summative assessments. There will be one summative assessment given approximately every three weeks. For each summative assessment, one Pre-Assessment Student Interview (Appendix C) and one Post-Assessment Student Interview (Appendix D) will be conducted. In addition to the pre- and post-summative assessment student interviews, one Nine-Week Completion Student Interview (Appendix F) will also be conducted. A total of 70 student interviews will be completed within the nine-week intervention period (summation of pre- and post-summative assessment interviews and nine week completion interviews for each of the 10 students).

In addition to student interviews, student surveys will also be conducted and analyzed. A Post-Summative Assessment Student Survey (Appendix E) will be given after each of the three summative assessments. These will be given to all intervention students ($N=51$) as a warm up the day after a summative assessment. The surveys will provide data that supports the students’ thoughts and feelings regarding the concept checks. I will also gain insight as to whether or not the students believed that they

benefited from completing concept checks. Furthermore, information collected from student interviews and surveys will help me conclude whether or not concept checks are effective in a flipped classroom environment.

Comparisons between concept checks and summative assessment scores were made based on assessment and concept check data. I compared responses from specific questions on concept checks to those on summative assessments to see if patterns existed. Further comparisons included 1) the number of times a specific video was viewed to the number of submitted concept checks for that video and 2) the number of submitted concept checks to the responses from video specific questions. This provided insight as to whether or not the lecture videos were utilized to complete concept checks or if additional resources were used.

The Triangulation Matrix further depicts the focus and sub-questions as well as the methods of data collection for each question (Table 1). The research methodology for this classroom research project received an exemption by Montana State University’s Institutional Review Board and compliance for workers with human subjects was maintained.

Table 1
Triangulation Matrix

Focus Question: Does the completion of concept checks improve content mastery of out-of-class lecture?			
Sub-Questions	Data Source		
Does the completion of concept checks increase students’ understanding of the material prior to attending class?	Student interviews: pre-summative assessment	Student interviews: post-summative assessment	Student surveys: post-summative assessment

Was completion of the concept checks crucial to students' content processing during the following class period?	Student surveys: post-summative assessment	Major summative assessment scores	Student interviews: nine-week completion
Were only the provided resources utilized by the students for completion of concept checks OR were additional resources utilized?	Comparison of video views to submitted concept checks	Comparison of concept check questions to summative assessment questions	Resource specific questions embedded in concept checks

DATA AND ANALYSIS

Throughout the course of a nine-week intervention period, 10 selected students ($N= 10$) individually completed seven student interviews, totaling 70 student interviews. These students provided proper consent and were of mixed sex, race, and current class grade average in order to provide a true representation of the student body within each class. Two of the interviews, pre- and post-summative assessment (Appendices C and D) were completed three times within the nine-week period per student; and the nine-week completion interview (Appendix F) was completed at the end of the intervention period. Additionally, all students in the intervention group ($N= 51$) completed surveys (Appendix E) at the conclusion of each three-week period.

Student Interview: Pre-Summative Assessment

Ten students completed the Student Interview: Pre-Summative Assessment (Appendix C), which required each student to respond to three total questions. These questions were initially answered in a “Yes” or “No” format with additional explanation

provided. The additional explanation provided by the students allowed me to further understand students' attitudes and feelings towards concept checks. For analysis, initial student responses of "Yes" or "No" were recorded on a per question basis for each of the three rounds of pre-assessment interviews (Tables 2, 3, 4).

Table 2

Student Interview: Pre-Summative Assessment; 1st Assessment, (N= 10)

Question asked	Student Reponses (number)	
	Yes	No
1. Did completing concept checks prior to class increase your understanding of the specific material? Please explain.	7	3
2. Did you feel more prepared for class the next day due to completing concept checks? Please explain.	8	2
3. If concept checks were not required, would you still have self-reflected on the material acquired from the lecture video/reference material? Please explain.	7	3

Table 3

Student Interview: Pre-Summative Assessment; 2nd Assessment, (N=10)

Question asked	Student Reponses (number)	
	Yes	No
1. Did completing concept checks prior to class increase your understanding of the specific material? Please explain.	8	2
2. Did you feel more prepared for class the next day due to completing concept checks? Please explain.	9	1
3. If concept checks were not required, would you still have self-reflected on the material acquired from the lecture video/reference material? Please explain.	8	2

Table 4

Student Interview: Pre-Summative Assessment; 3rd Assessment, (N=10)

Question asked	Student Reponses (number)	
	Yes	No
1. Did completing concept checks prior to class increase your understanding of the specific material? Please explain.	9	1
2. Did you feel more prepared for class the next day due to completing concept checks? Please explain.	10	0

3. If concept checks were not required, would you still have self-reflected on the material acquired from the lecture video/reference material? Please explain.	10	0
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Over the nine-week period, 84% (76 responses) of student responses were recorded as “Yes” in comparison to 16% (14 responses) “No” responses. This data indicates that concept checks were beneficial in preparing my students for their summative assessment. Comparing the data from the 1st assessment to the 3rd assessment, there was an overall increase in the number of “Yes” responses. After completing the first summative assessment, some students may have noticed the direct relationship between concept check questions and summative assessment questions. Alternatively, students may have found a greater sense of value for completing concept checks. Whichever the case, more students realized the benefit of accurately completing concept checks, thus, the increase in “Yes” responses received on the interviews.

Student Interview: Post-Summative Assessment

Similar data was collected for the three rounds of Student Interviews: Post-Summative Assessment (Appendix D). Questions one, two, and four were initially answered in a “Yes” or “No” format with additional explanation provided. For analysis, initial student responses of “Yes” or “No” were recorded on a per question basis for each of the three rounds of post-assessment interviews (Tables 5, 6, and 7). On all three rounds of interviews, 100% of students responded “Yes” to questions two and four, while question one only received 100% “Yes” response in the third round of interviews. Question three provided only open-ended responses, thus, “Yes” and “No” response data was irrelevant.

Table 5

Student Interview: Post-Summative Assessment; 1st Assessment, (N=10)

Question asked	Student Responses (number)	
	Yes	No
1. Did you feel confident in your academic performance on this past unit exam? Please explain.	8	2
2. Did you witness similarities in concept check questions and test questions? If so, please explain.	10	0
4. For this upcoming unit and test, would you like to continue completing concept checks? Please explain.	10	0

Table 6.

Student Interview: Post-Summative Assessment; 2nd Assessment, (N=10)

Question asked	Student Responses (number)	
	Yes	No
1. Did you feel confident in your academic performance on this past unit exam? Please explain.	7	3
2. Did you witness similarities in concept check questions and test questions? If so, please explain.	10	0
4. For this upcoming unit and test, would you like to continue completing concepts checks? Please explain.	10	0

Table 7

Student Interview: Post-Summative Assessment; 3rd Assessment, (N=10)

Question asked	Student Responses (number)	
	Yes	No
1. Did you feel confident in your academic performance on this past unit exam? Please explain.	10	0
2. Did you witness similarities in concept check questions and test questions? If so, please explain.	10	0
4. For this upcoming unit and test, would you like to continue completing concepts checks? Please explain.	10	0

Over the nine-week period, 94% (85 responses) of student responses were recorded as “Yes” in comparison to 6% (5 responses) “No” responses on the post-summative assessment student interviews. Pre- and post-summative assessment student

interview data supports the benefit of completing concept checks from the students' perspective.

Student Interview: Nine-Week Completion

The same 10 student interviewees also conducted a one-time interview at the end of the intervention period (Appendix F). In similar fashion to the previous student interviews, questions two, three, four, and five were initially answered in a “Yes” or “No” format ($N= 10$). Overwhelmingly, 100% of students' responses were “Yes” to these questions (Table 8). Question one provided only open-ended responses, thus, “Yes” and “No” response data was irrelevant. The responses received from all questions, are a clear indication of the benefits students experienced from completing concept checks.

Table 8

Student Interview: Nine-Week Completion, (N=10)

Question asked	Student Reponses (number)	
	Yes	No
2. Were there similarities between questions asked on concept checks and summative assessments? Please explain.	10	0
3. When asked a question on the summative assessment that was also covered in a concept check, could you answer those questions more confidently? Please explain.	10	0
4. We did not complete concept checks for the first two major topics in this course, would you have preferred to complete concept checks for those topics as well? Please explain.	10	0
5. For this upcoming unit, would you like to continue completing concept checks? Please explain.	10	0

Student Survey: Post-Summative Assessment

At the conclusion of each three-week period, all students in the intervention classes ($N= 51$) completed a post-summative student survey (Appendix E). The survey

was intended for more of an overall class census of students' attitudes towards concept checks. Further explanation from each statement was not needed due to the data collected from the multitude of student interviews. Thus, response choices were limited to "Disagree", "Neutral", or "Agree" for simplicity. Responses from each three-week period were combined to reflect total responses per statement for all students on the three surveys (Table 9). Furthermore, responses were tabulated between all questions and three different response choices (*Figure 1*).

Table 9
Student Survey: Post-Summative Assessment

Statement	Number of Responses		
	Disagree	Neutral	Agree
Completion of concept checks enhanced my knowledge of the topic.	30	6	117
Answering concept check questions provided myself with a way to practice recalling the information.	9	21	123
In comparison to concept checks, similar style questions were asked on unit tests.	0	6	147
If concept checks were not required, I would complete them.	48	27	78
I furthered my academic knowledge of the content by completing concept checks.	12	6	135
I am more confident in understanding the material due to completing concept checks.	9	33	111
I would like to continue completing concept checks to enhance my learning.	60	12	81

Note. Three total surveys per student. ($N= 51$).

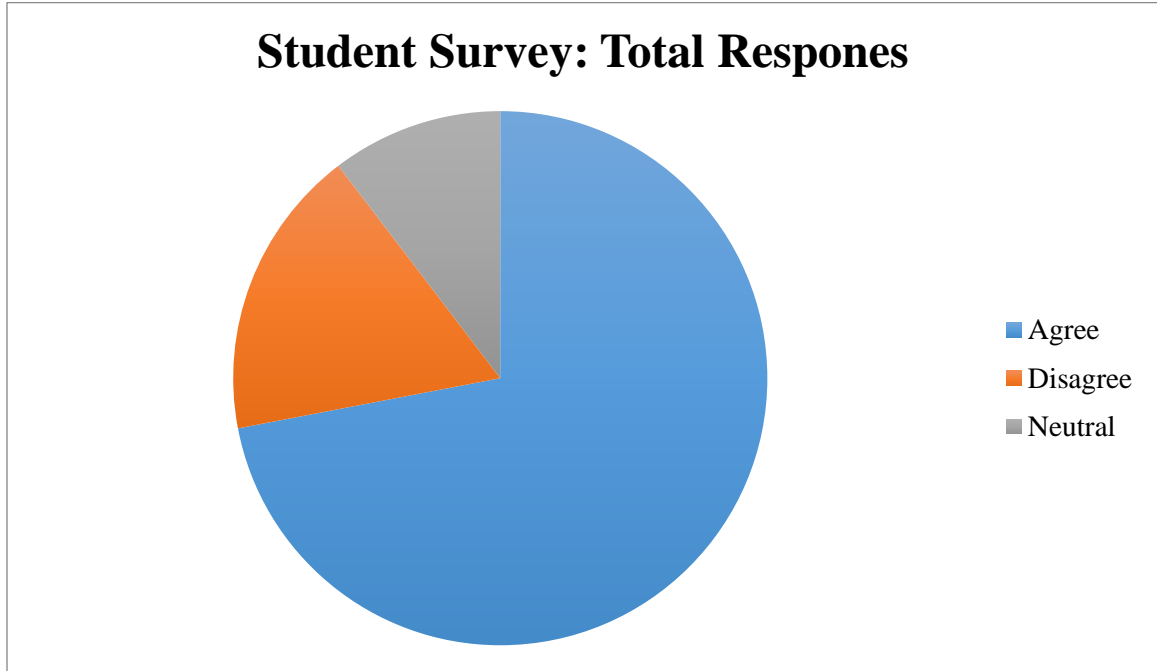


Figure 1. Student survey: total responses, ($N= 51$).

In similar fashion to the pre- and post-summative assessment data with “Yes” being the predominant response, “Agree” was the predominant response on the student surveys. “Agree” represented 74%, “Disagree” 16%, and “Neutral” 10% of total responses on the post-summative student surveys.

Comparison of Concept Check Questions to Summative Assessment Questions

Each concept checks contained at minimum one question that related directly to a question on the corresponding summative assessment. I selected four questions from the first summative assessment, which were also asked on concept checks, and compared percent of correct responses from the intervention group ($N= 51$) to the comparison group ($N= 32$) (*Figure 2*). I collected similar data from the second (*Figure 3*) and third (*Figure 4*) summative assessments and corresponding concept checks.

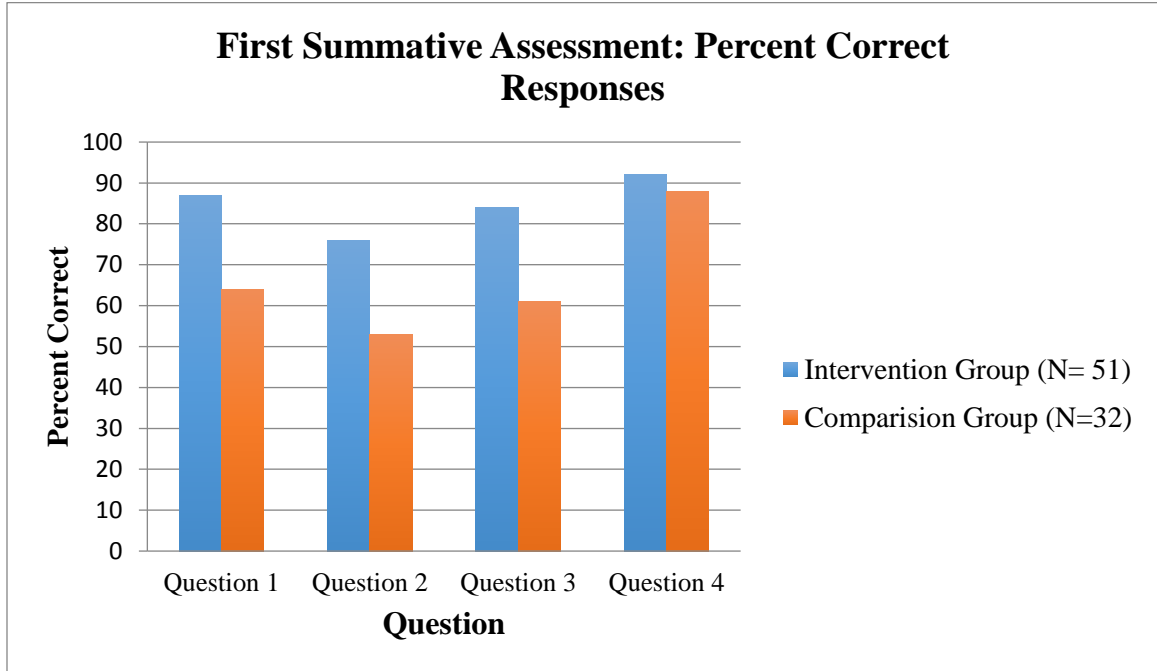


Figure 2. First summative assessment: percent correct responses, ($N=51$ and $N=32$).

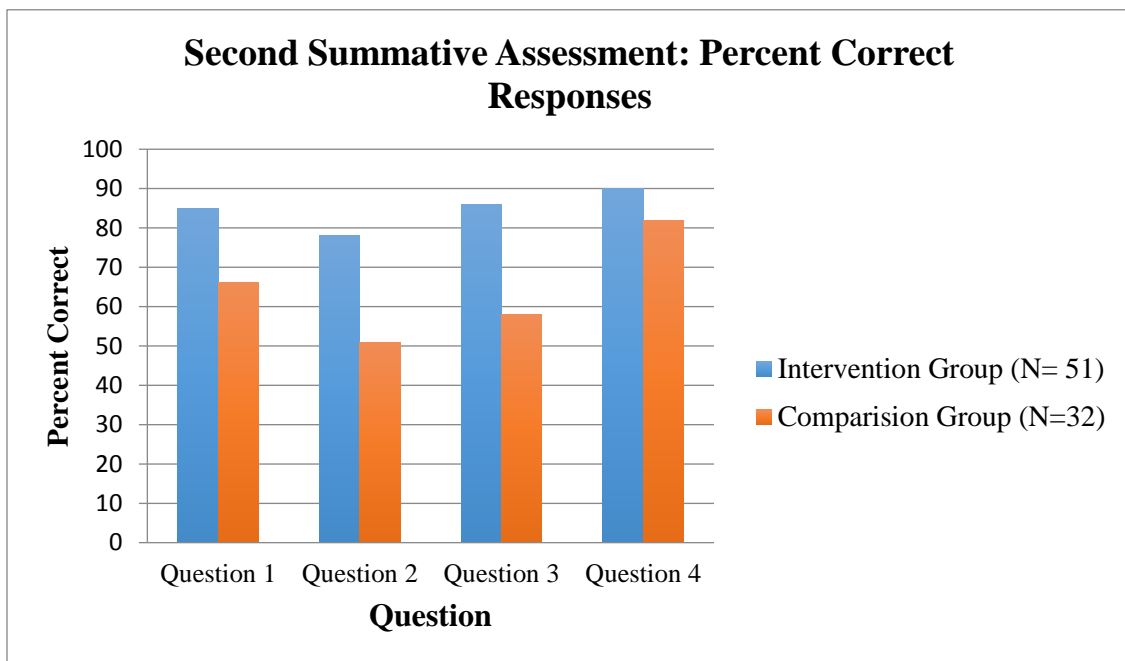


Figure 3. Second summative assessment: percent correct responses, ($N=51$ and $N=32$).

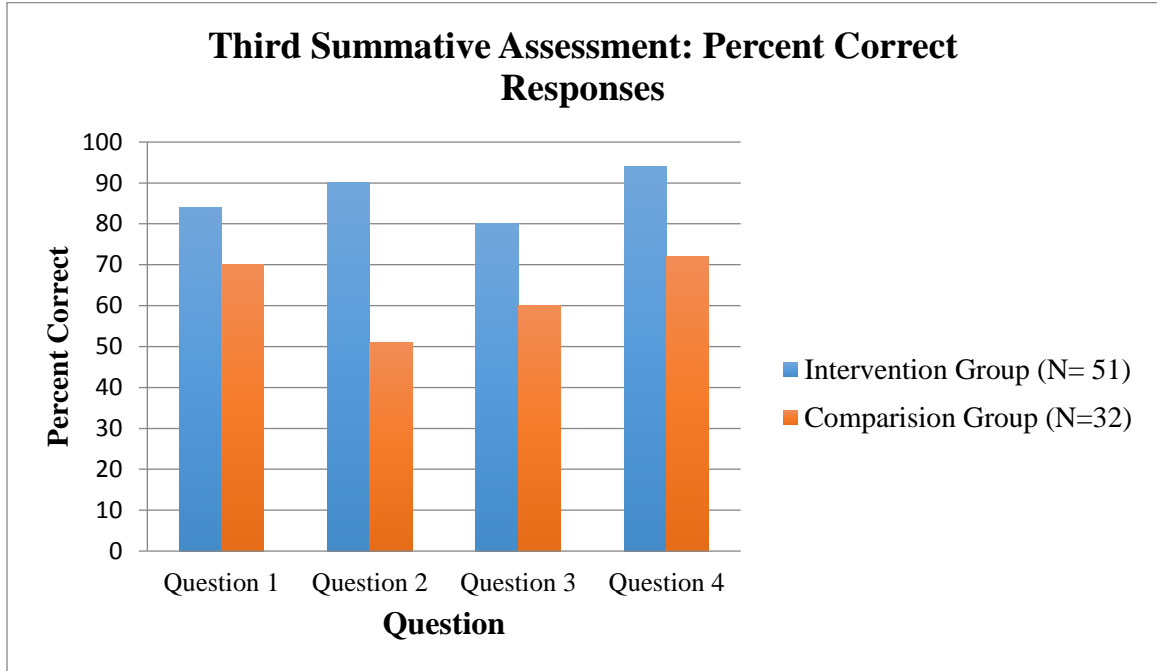


Figure 4. Third summative assessment: percent correct responses, ($N=51$ and $N=32$).

For the selected questions from the three summative assessments, students in the intervention group ($N=51$) answered questions more correctly a higher percent of the time when compared to the students in the comparison group ($N=32$).

Comparison of Summative Assessment Scores

Grade averages for the three summative assessments were taken and compared for the intervention group to the comparison group. The intervention group received an average of three grade points higher than the comparison group overall on the summative assessments (*Figure 5*).

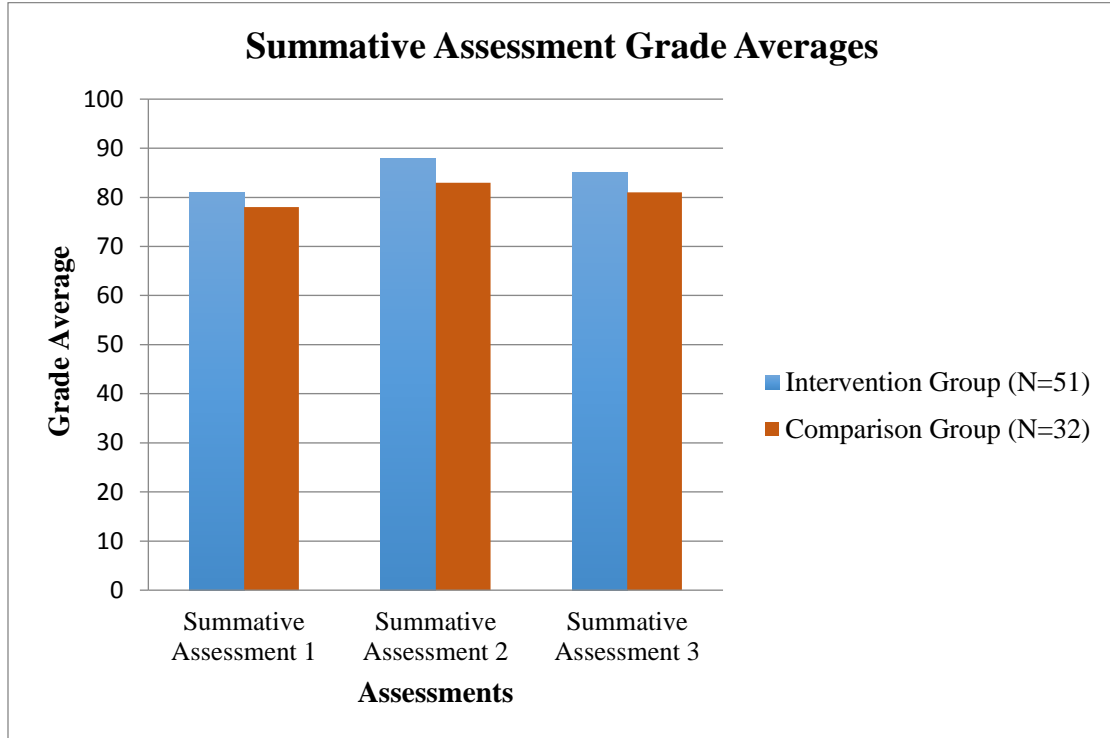


Figure 5. Summative assessment grade averages, ($N=51$ and $N=32$).

Comparison of Video Views to Submitted Concept Checks

Similar comparisons were made for the first four required lecture videos (*Figure 6*). I compared the number of times each video had been viewed to the number of students that submitted a concept check ($N=51$).

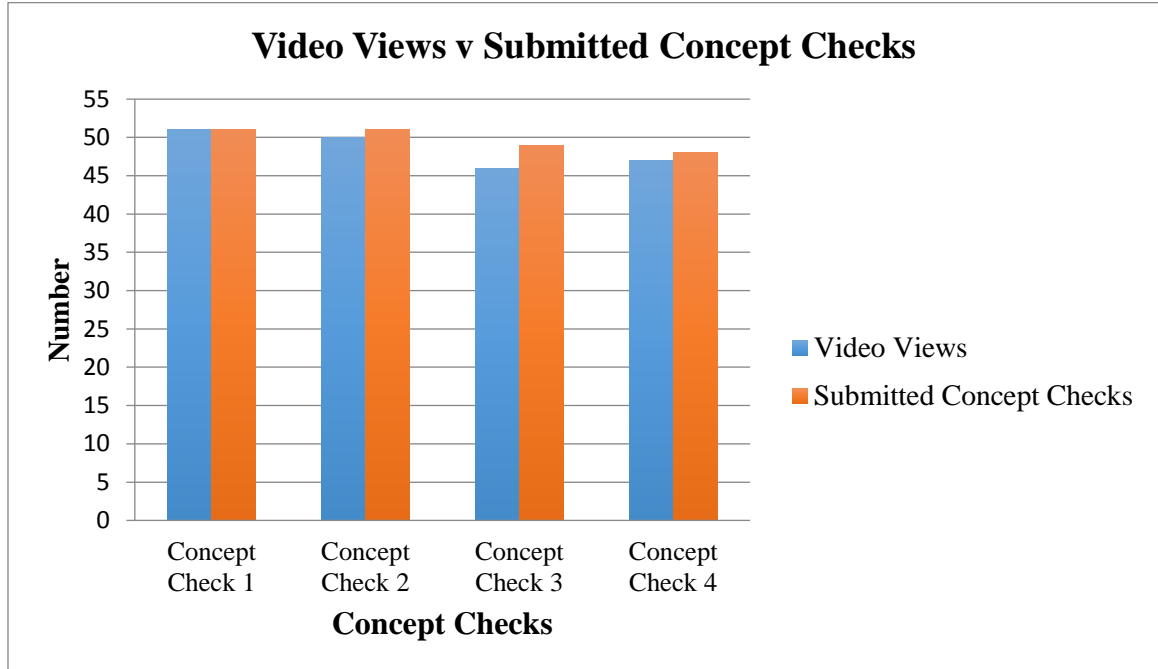


Figure 6. Video views v submitted concept checks, ($N=51$).

For the first concept check, the number of video views and submitted concept checks were the same. However, this was not the case on the second, third, and fourth concept checks since the number of submitted concept checks outweighed the number of video views each time. Students were either getting their information from sources other than the lecture videos or relying on prior knowledge to complete these concept checks. Additionally, there was a steady decrease in both the number of video views and submitted concept checks from the time of the first required concept check until the fourth.

Video Specific Questions on Concept Checks

In order to further determine if students were utilizing lecture videos for the completion of concept checks, video specific questions were embedded on concept checks. These were questions that could only be answered correctly (besides guessing) if

the students watched the intended lecture video. On the first four concept checks, I included one question, per concept check, that was specifically related to the corresponding lecture video. For the specific questions, within each of the four concept checks, I calculated the percentage of students whom answered the specific question correctly on submitted concept checks (Table 10).

Table 10

Video Specific Questions on Concept Checks, (N=51)

	Total Submissions	Total Correct Responses	Percentage of students whom answered correctly
First Concept Check	51	49	96.07%
Second Concept Check	51	47	92.16%
Third Concept Check	49	44	89.80%
Fourth Concept Check	48	45	93.75%
Average			92.94%

Note. Not all intervention students submitted a concept check each time, thus, the number of submitted concept checks varies.

On each concept check, a small percentage of students (on average less than 10%) incorrectly answered the specific questions. This could be due to the students' use of additional resources *or* students' inaccurately answering the questions even after watching the lecture video. It is also important to note that comparison of the total number of video views to the number of students who answered the video specific question correctly is not an accurate comparison to make. Since I do not know specifically which students did or did not view the videos (I only know the total number of views received), I cannot compare this data.

INTERPRETATION AND CONCLUSION

Throughout my classroom research project, data collected from different methods and sources was valuable in providing me with insight on the effectiveness of concept checks. I could not have been more pleased with the overwhelming responses of “Yes” on the interviews and “Agree” on the surveys. These responses, comparison data (video views, concept check completion, etc.), and summative assessment grade data are clear indicators that concept checks *are* effective in my flipped Pre-AP Chemistry classroom. My research questions were answered in detail through an in depth analysis of student responses received from data collection tools.

Data analysis of student pre- and post-summative assessment interviews and student surveys showed that the completion of concept checks increased students’ understanding of the material prior to attending class the following day. On the pre-summative assessment student interviews, 84% of students indicated that completing concept checks helped him or her to better understand the content presented in the lecture video. Furthermore, responses from the student surveys indicate 80% of students agreed that concept checks provided them with an avenue for practice on recalling information, thus, aiding in their understanding of the new material before ever attending class. Students also claimed, in pre-summative assessment interviews, that they felt more prepared for class the next day due to interactions with the content simply beyond watching lecture videos. From the post-summative assessment interview data, 94% of students indicated increased confidence in their understanding of chemistry content on their exams due to previously completing concept checks.

Students' in-class content processing skills were also affected due to the completion of concept checks. In similar fashion to Pierce (2012), I witnessed higher summative assessment scores from students in my intervention group compared to the comparison group. The intervention group was provided with the opportunity to experience interactions with the material in a similar format to that of the summative assessments. On the nine-week completion interviews, 100% of students indicated there were similarities between questions asked on concept checks and summative assessments. The completion of concept checks made it so that were students able to practice recalling the information multiple times and in similar format to that of the summative assessment. Additionally, like Sams and Bergmann, since the students were receiving the information at home, more class time was available for students to ask specific questions. These questions might not have been thought of if they were not prompted with questions on concept checks. This led to more individualized lessons and directed conversation over the students' specific needs in relation to the content.

When determining if only lecture videos were used for concept check completion, video views and responses on specific question were considered. For the first concept check, 100% of the students in the intervention group viewed the video and submitted a concept check. Additionally, 96% of these students answered the video specific question correctly on the first concept check. This indicates that for the first concept check, questions were answered based on the information presented in the lecture video. It is important to note that the two students whom missed the video specific question also missed several other questions on their individual concept checks. The high percentages

observed on the first concept check slightly declined over the course of the intervention period. For the second concept check, one student did not view the lecture video and four students did not answer the video specific question correctly. At this time, I am unsure if the one particular student, who did not view the video, is also one of the four who answered the question incorrectly. This is a point for me to consider for future research and analysis of concept checks and their effectiveness. Overall, however, I can confidently state that students *did* use the lecture videos to complete concept checks since 93% of intervention students (on average) answered video specific questions correctly.

Flipped classrooms are effective based on the assumption that the students acquire content at home and that the teacher follows best practices for implementation as stated by Dr. Baker. I have herein proved an effective way to ensure students are completing required work, thus, acquiring (to some extent) the content at home. Knowing there was an increase in summative assessment scores for my students when concept checks were completed, I am confident in the flipped style of teaching. This provides me with the opportunity to cover more content within an 18-week period without risking a decrease in academic performance of my students. Referring back to my focus question, I can confidently state that the completion of concept checks *does* improve content mastery of out-of-class lecture. Furthermore, I will now be able to conduct a Pre-AP Chemistry course that is no longer watered-down.

VALUE

Completion of this classroom research project has brought to light many different aspects about students' attitudes towards learning, my teaching style, and the

effectiveness of concept checks in a flipped classroom. Throughout the intervention period and data analysis, I have further developed testable research questions that would provide an extension to this project. My main focus for furthering research would be to take a deeper look at how to create higher level thinking questions on concept checks that are specifically related to my lecture videos. I would like to be able to know *for sure* if students are answering concept checks based on the intended lecture videos or if other resources are being utilized.

In regards to students' attitudes towards learning, I experienced the biggest breakthrough in realizing the extent to which my students acquired knowledge at different rates and through different media sources. Prior to this classroom research project, I felt as if I had done a decent job of providing a variety of differentiation to my students. Although, around the fifth week of intervention period, I realized that my expectations for students to learn at home were too high. I was quick to assume that in a flipped learning classroom setting, students would automatically acquire new material at home and perform well on concept checks. Although most students put forth the effort in completing the concept checks, "learning" by all students did not occur. Further scaffolding and differentiation of content delivery will be need in the further to ensure more students' academic success.

Since processing rates and learning styles of students are different, some students needed to talk through and interact with the material before being questioned on the topic. As mentioned above, data showed a direct relationship between submitted concept checks and an increase in summative assessment scores. However, what the numbers do

not convey is students' feelings towards learning. Students mentioned in surveys and interviews that increased processing time between receiving the material and being questioned on the material would have been beneficial. They also suggested modifying the questions to be simpler, e.g. questions focused on "recalling" the recently acquired content rather than questions involving "application" of the content. In future semesters, I will consider revising the level and style of concept check questions. Perhaps questions that do not require as much processing or deep thought on the topic will allow more students to have an easier time with concept checks.

Data analysis from the comparison of video views to submitted concept checks showed a decline in the number of views per video as the nine-week intervention period progressed forward. This could have been due to lack of intriguing videos *or* the specific questions being asked. For this upcoming semester, I will work towards creating more intriguing videos to see if this helps to increase number of video views. If this does not increase the viewing rate, then I will focus on further modification of the questions in future semesters.

There were two main SMART (specific, measurable, attainable, relevant, time-bound) goals I had set for myself in relation to concept checks. First, is that students were to watch the lecture videos and complete concept checks when assigned; and second, that students were able to accurately recall the information presented from the lecture videos through concept check responses. My intention was not to test their knowledge of the topic, but to ensure they could *recall* the presented information. These two points alone provide the purpose for furthering my classroom research. Not only do

these research goals lead to further concept check investigation, but they also provide me with the opportunity to self reflect on my teaching style and communication with my students.

Through analysis of qualitative and quantitative student data, attention was brought to different aspects of my teaching style. The main thing I noticed was my ability to troubleshoot with students throughout this process. There were many struggles my students encountered at the beginning of this process. I was very pleased with the manner in which my students conducted themselves when reaching out to me for support. Students would actively seek my assistance at various times in the evening with different questions and I would provide them with the support they needed through email communication. This process helped me to become a more responsive teacher, which ultimately benefits my students. Frankly, answering numerous emails each night during the first few weeks was tiresome, however, it was well worth the effort as my students were able to catch on to the “new” teaching style and adapt their method of learning.

Upon self-reflection of my communication skills with my students, I am very confident in my ability to troubleshoot and communicate with students on a daily basis. An area for improvement is my ability to formulate specific, directed questions, thus, yielding the intended response I am seeking on concept checks. This was made apparent through students’ responses during interviews and surveys. Creating specific and concise questions is a skill I will be able to develop over time as my years of teaching experience increases. Advancement with this skill will impact my ability to be a more successful educator and further differentiate learning for my students. Overall, students’ attitude

toward completion of concept checks was positive in nature and encourages me to continue using concept checks in my flipped classroom. Concept checks will further be modified and improved for the next semester and I will continue this process for future semesters to come. As detailed in my analysis of this classroom research project, concept checks have proven to be effective in my flipped Pre-AP Chemistry course.

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APPENDICES

APPENDIX A

CONCEPT CHECK: INTRO TO STOICHIOMETRY

Intro to Stoichiometry

* Required

First Name *

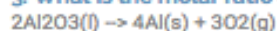
Last Name *

Student Email Address *

1. What is reaction stoichiometry? *

2. List two ways in which we can apply reaction stoichiometry in this class. *

3. What is the molar ratio of Al to O₂ in the following reaction? *



- 3:4
 2:3
 3:2
 4:3

4. The molar mass is determined using the _____ *

Fill in the blank below.

5. In your own words, summarize the "Tip" stated in the lecture video. *

Submit

Never submit passwords through Google Forms.

APPENDIX B
CONCEPT CHECK: MOLAR RATIOS

Molar Ratios

* Required

First Name *

Last Name *

School Email Address *

1. What is the definition of a "molar ratio"? *

2. How can we use molar ratios to perform stoichiometric calculations? *

3. From the lecture video, what is the molar ratio in Example 2 for sodium to chlorine gas? *

- 2/3
 1/2
 2/1

4. From the "Cookie Stoichiometry" Worksheet, what was the molar ratio in problem #3? *

5. From the "Cookie Stoichiometry" Worksheet, what were the molar ratios in problem #6? *

Submit

Never submit passwords through Google Forms.

APPENDIX C

STUDENT INTERVIEW: PRE-SUMMATIVE ASSESSMENT

Student Interview: Pre-Summative Assessment

Student Name: _____ Class average: _____

Disclaimer (read to student before conducting interview): This interview is completely voluntary and in no way will affect your grade or class average.

1. Did completing concept checks prior to class increase your understanding of the specific material? Please explain.
2. Did you feel more prepared for class the next day due to completing concept checks? Please explain.
3. If concept checks were not required, would you still have self-reflected on the material acquired from the lecture video/reference material? Please explain.

APPENDIX D
STUDENT INTERVIEW: POST-SUMMATIVE ASSESSMENT

Student Interview: Post-Summative Assessment

Student Name: _____

Class average: _____

Summative Assessment Score: _____

Disclaimer (read to student before conducting interview): This interview is completely voluntary and in no way will affect your grade or class average.

1. Did you feel confident in your academic performance on this past unit exam?
Please explain.
2. Did you witness similarities in concept check questions and test questions?
Please explain.
3. How did the completion of concept checks impact your testing and recollection of chemistry content?
4. For this upcoming unit and test, would you like to continue completing concept checks? Please explain.

APPENDIX E
STUDENT SURVEY: POST-SUMMATIVE ASSESSMENT

Student Survey: Post-Summative Assessment

Name: _____

Please note: Completion of this survey is completely voluntary and in no way will affect your grade or class average.

Please place a check mark (✓) in the box that most accurately describes your response.

Statement	Disagree	Neutral	Agree
Completion of concept checks enhanced my knowledge of the topic.			
Answering concept check questions provided myself with a way to practice recalling the information.			
In comparison to concept checks, similar style questions were asked on unit tests.			
If concept checks were not required, I would complete them.			
I furthered my academic knowledge of the content by completing concept checks.			
I am more confident in understanding the material due to completing concept checks.			
I would like to continue completing concept checks to enhance my learning.			

On average, how many minutes did you spend completing an individual concept check? Circle one.

0-5 minutes 6-10 minutes 11-15 minutes 16-20 minutes 21+ minutes

APPENDIX F
STUDENT INTERVIEW: NINE-WEEK COMPLETION

Student Interview: Nine-Week Completion

Student Name: _____ Class average: _____

Disclaimer (read to student before conducting interview): This interview is completely voluntary and in no way will affect your grade or class average.

1. How do you feel about your academic performance throughout this unit? Please explain.
2. Were there similarities between questions asked on concept checks and summative assessments? Please explain.
3. When asked a question on the summative assessment that was also covered in a concept check, could you answer those questions more confidently? Please explain.
4. We did not complete concept checks for the first two major topics in this course, would you have preferred to complete concept checks for those topics as well? Please explain.
5. For this upcoming unit, would you like to continue completing concept checks? Please explain.