

THE EFFECTS OF INTERACTIVE TOOLS IN A  
FLIPPED CHEMISTRY CLASSROOM

by

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## ABSTRACT

The flipped classroom is becoming a common pedagogical approach in the classroom to increase active learning experiences in the classroom. In the flipped classroom, students receive direct instruction outside of class through videos, podcasts, or readings, and class time is freed up to design effective, engaging, and enjoyable activities and experiences. One concern with the flipped classroom is the student engagement and participation in the videos. For this project, two interactive technologies, PlayPosit and EdPuzzle, were evaluated to determine which technology would be the most effective on student achievement, student engagement, and student attitudes in the flipped classroom. Over the course of two units, Advanced Placement Chemistry students at Penn-Trafford High School watched the lecture videos in PlayPosit and EdPuzzle. The Comparison Unit using YouTube lasted two weeks. Treatment 1 using PlayPosit and Treatment 2 using EdPuzzle each lasted three weeks. Results from post-tests were analyzed and compared to determine the effect on student achievement. Student surveys and interviews were analyzed to determine the effect on student engagement and attitudes. Results revealed no significant difference in student achievement, but a significant difference in engagement when utilizing both PlayPosit and EdPuzzle. Student comments and interviews also showed that students preferred EdPuzzle to both PlayPosit and YouTube. Overall, EdPuzzle was the most effective platform for content videos in the flipped classroom.

## INTRODUCTION AND BACKGROUND

Today's students are not the same as the students who went through the educational system 30 years ago. The average millennial student was exposed to technology at a young age, so they think and process information differently from generations before. As students continue to change, the educational system must adapt to fit today's student. Teaching must incorporate technology and active learning strategies to ensure that students are engaged in the content. Educators must shift from a teaching centered classroom toward a learner-centered classroom. We want students to develop higher order thinking skills by engaging in authentic practice. However, in the traditional classroom, instructional minutes are limited. In order to implement more engaging activities, the flipped classroom was used in my high school classroom.

Penn-Trafford High School is a suburban high school located east of Pittsburgh in Harrison City, Pennsylvania. It serves several small cities in Penn Township, Pennsylvania. The Penn-Trafford High School demographics mirror those of the community with 97.13% Caucasian students. The high school is composed of grades 9 through 12 with 1,360 students and a 98.04% graduation rate. Five percent of students at Penn-Trafford are classified as gifted, with 29% of the students in my Advanced Placement (AP) chemistry course falling into this category ("School Performance Profile," 2015). Because 29% of my AP students are gifted, many of my students work at different paces. Differentiating instruction has been my primary focus for the last year, but our entire high school is now beginning to focus on how to best differentiate for our students as we begin to explore 21<sup>st</sup> century learning.

The high school recently underwent a \$30 million renovation, with a major focus on 21<sup>st</sup> century learning and student collaboration. New computer lab space is available for students to use for projects and group work. A video studio was added to the library for student projects and enrichment. Collaborative spaces with whiteboard desks are available for students and teachers to utilize during class. Due to this renovation and new spaces available, the high school administration encouraged teachers to implement collaboration activities in the classroom. Collaboration, creativity, and curiosity are now a focus of the teacher evaluation rubric. As teachers continue to implement collaboration, creativity, and curiosity, we are finding that not only are we implementing 21<sup>st</sup> century strategies, but we are also differentiating the learning for students.

In order to implement collaboration activities such as inquiries, demonstrations, and laboratories, I found that I needed more student interaction time during class. I struggled to increase implementation of inquiry activities due to the large amount of content that is required in AP chemistry. At the AP level, I am required to teach a set curriculum before the students take the AP chemistry exam in May. Because incorporating active learning strategies and inquiry activities require more time in class, I implemented a new approach for content delivery – the flipped classroom. The flipped classroom is a pedagogical model that moves the lecture delivery outside of the classroom and focuses on student application during class. In our AP Chemistry course, students watch short video lectures at home, and in-class time is devoted to active learning and discussions. The flipped classroom has also allowed my students to work at

their own pace as they learn new material, providing the differentiation that my students need.

As I have implemented the flipped classroom throughout this school year, the primary obstacle has been the engagement of students in the video content. In order for the flipped classroom to be successful, students are required to watch a 10 to 15 minute video at least 4 out of 5 nights a week. Most nights, students are simply watching a video for homework, but one night each week students might also be asked to complete a lab report. Many times students will enter my classroom saying that they did not watch the video the night before. When students do not watch the video before class, they are not prepared for the collaborative problem-solving and hands-on activities, which means they fall behind in class. This can produce a snowball effect with student understanding, so it is important that students watch the video when it is assigned to prevent falling behind in the class. My project focus is to investigate the interactive technology tools that can be used to increase student participation and engagement in the content videos. The focus question was, how do different interactive instructional tools affect student achievement, student engagement, and student attitudes in the flipped chemistry classroom?

#### CONCEPTUAL FRAMEWORK

Teaching students critical thinking and problem solving skills is a major challenge for chemical educators (Pienta, 2016). Very few students are able to demonstrate proficiency in critical thinking skills when material is presented in a lecture format due to passively learning the information (Worrell, 1992). Thus, in order to increase critical thinking and problem solving skills, students must engage in active learning which

promotes thinking, doing, and problem solving. In the chemistry classroom, active learning includes collaboration and inquiry, demonstrations, and laboratories. High school science teachers, specifically Advanced Placement (AP) and dual credit teachers, are encouraged to increase the use of inquiry in order to improve student learning (CollegeBoard, 2014). However, teachers struggle to increase implementation of inquiry activities when content coverage already requires a large portion of class time (Tomory & Watson, 2015). Because incorporating active learning strategies and inquiry activities require more time in class, some educators have started to investigate and implement a new approach for content delivery – the flipped classroom. The time gained by removing all or some of the lecture portion from class allows for more one-on-one engagement and active learning in the classroom (Roehl, Reddy, & Shannon, 2013).

In the traditional, lecture-based classroom, the teacher presents new information for up to two-thirds of the class time before beginning engaging, hands-on activities. The flipped classroom is a pedagogical approach in which students receive direct instruction outside of class through videos, podcasts, or readings, and the time in class is then freed up to design effective, engaging, and enjoyable activities and experiences (Kirch, 2016). Unlike the traditional classroom, time in the flipped classroom is restructured to allow more engaging and practical applications of the material (Bergmann & Sams, 2012). A report by McCammon and Parker (2014) showed that lecture time in a high school classroom was reduced from 37.8 minutes to 10.5 minutes per class period when the flipped classroom was implemented. In the flipped classroom, the teacher was able to act

more as a mentor for students as they continued their learning through hands-on, active learning tasks (Brunsell & Horejsi, 2011).

As the notable flipping pioneers Jon Bergmann and Aaron Sams (2012) point out, there is not one specific way to flip the classroom. Rather, the core idea is to simply flip the common instructional approach. New content that was once taught in class is now accessed at home via podcasts or screencasts, and class becomes “the place to work through problems, advance concepts, and engage in collaborative learning” (Tucker, 2012, p.82). However, it is important to remember that the flipped classroom is not about the content videos, but rather the different activities designed for class. Moving direct instruction outside of class provides more time in class for inquiry and discovery, discussion and problem-solving, collaboration and whole group discussion, and individualized and formative assessments (Kirch, 2016).

Each year, students enter the classroom with a range of abilities, motivations, and prior knowledge. Each student has his or her own set of needs, and it is the teacher’s responsibility to differentiate instruction in order to meet each student’s needs. The flipped classroom is a way to support students in their learning and better differentiate instruction and time with them (Kirch, 2016). Lecture tutorials are readily available, so review of the material is easy for students. Students are able to view the videos and work at their own pace, as well as interact with the videos multiple times if necessary, tailoring the learning experience to each student’s individual needs (Eichler & Peeples, 2016). Another study has also shown that the flipped classroom is especially beneficial for the

lower achieving students. The bottom 33% of students tend to post a higher grade in the flipped classroom than in the traditional lecture classroom (Ryan & Reid, 2016).

The flipped classroom has many other benefits as well. First, the flipped classroom is efficient with content delivery. Lecture content is delivered more efficiently through a video than in a live lecture. Studies have shown that high school teachers spend one-third the time teaching through a video than live in class (McCammon & Parker, 2014). When utilizing the flipped classroom, teachers are able to double the time that students are engaging in active learning and collaboration in the classroom (Brunsell & Horejsi, 2013a). Instructors who need more time in class to complete laboratory assignments, inquiry activities, and review and reinforce challenging concepts can utilize the flipped classroom to alleviate time constraints (Tomory & Watson, 2015).

The flipped classroom also improves the lives of both the teacher and the student. Creating video content allows teachers to disseminate the material once rather than repeating it class after class. A survey found that nearly 90% of teachers who tried flipping reported improved job satisfaction (Brunsell & Horejsi, 2013b). The flipped classroom also strengthens relationships among students and teachers. Teacher-student interactions increase in the flipped classroom, so the teacher can build trust with the students. Students also see the time and effort put in by the teacher, which can increase student investment in the classroom (McCammon & Parker, 2016). Because the roles in the flipped classroom are switched, class time is opened up for student collaboration with activities that require analysis, evaluation, and creation (Kirch, 2016).

In a high level course such as AP chemistry, content knowledge is of utmost importance, but students must practice before mastering the material. Although some studies, such as the one completed by Hotle and Garrow (2016), have shown no difference in exam scores, others have shown major differences between the traditional classroom and the flipped classroom. In a study examining the effects of flipping an AP Chemistry classroom, it was observed that students performed higher on unit assessments than in the traditional classroom. Overall, the flipped model allows a blended and self-paced classroom, more aligned to how today's student learns (Schultz, Duffield, Rasmussen, & Wageman, 2014).

Technology allows teachers a variety of ways to personalize the learning within the flipped classroom (Khan, 2012). Using his own method, McCammon introduced low technology options for creating lecture content when flipping the classroom. Teachers can create one-take videos with a smart phone or tablet by recording themselves presenting material already written on a whiteboard (Brunsell & Horejsi, 2013b). Another low technology option is the creation of paper slide videos by either teachers or students. A paper slide video is similar to a one-take video, except instead of using a whiteboard, teachers slide paper in and out of the frame as they present information (Brunsell & Horejsi, 2013c). More complicated technology options are also readily available for teachers. Podcasting and screencasting allows teachers to create more tailored learning experiences for students. Podcasts are audio recordings that can be utilized to provide hints or step-by-step solutions for students. Podcasts can be created using editing software such as Vocaroo or Audacity. The audio file can then be shared or uploaded for

student access (Smith & Mader, 2015a). Screencasts take podcasts to the next level. Screencasts are video recordings of a computer screen that includes audio. Software such as EduCreations, Screencast-O-Matic, or Camtasia allows the teacher to partner voice with a whiteboard or computer screen. This option helps both the auditory and visual learners in the flipped classroom (Luongo, 2015).

Although the results of the flipped classroom are generally positive, teachers struggle to engage students in the content videos. Whether students do not have internet or computer access or students simply do not watch the videos, some students do not watch the video. Teachers become frustrated when students do not read the book or watch the videos before class (Pienta, 2016). The students who do not watch the videos are not prepared for collaborative problem solving and hands-on activities, which results in frustration among the more prepared students (Brunsell & Horejsi, 2013a). Crystal Kirch, a teacher in California, was not satisfied with the level of accountability for her students actually watching the video, so she developed the Watch, Summarize, Question (WSQ) form. The WSQ form requires students to watch the video, summarize what they have learned, and ask a confusion, discussion, or example question about the content. The WSQ form is one way to hold students accountable for completing homework before class (Kirch, 2016). Hartman, Dahm and Nelson (2015) also recommend strategies for encouraging homework completion. Teacher should present new information in small amounts with frequent clicker questions to encourage reflection upon material. After learning new content, it is important to provide self-quizzing for students to encourage recall of material.

As technology continues to weave itself into the classroom, many teachers find themselves using online formative assessment tools such as Poll Everywhere, Kahoot, Socrative, NearPod, and Plickers to engage students with the material (Smith & Mader, 2015b). Additional technology tools are available to reinforce and assess student learning. In the flipped classroom, where videos are the basis for content delivery, student participation is the key. According to Smith and Mader (2015a), one possible solution is EdPuzzle, a free technology tool that allows a teacher to add questions and discussion prompts to a video. Students must answer the question before the video continues. EdPuzzle provides the teacher with data about participation, time spent on the video, and results of the questions. EdPuzzle is one of many online tools available to encourage or require students to watch and analyze the content video. The main focus of flipped classroom research must now revolve around which of the online tools is most effective in delivering online content videos.

## METHODOLOGY

The purpose of this study was to examine the effects of enhancing video lectures with interactive technology on student achievement, engagement, and motivation. This study was conducted over an 8-week period in 2 sections of Advanced Placement (AP) Chemistry with a total of 28 students. Eight students were male and 20 students were female. Two students were seniors and the remaining 26 students were juniors. The AP Chemistry students met for 82 minutes each day. Each classroom at Penn-Trafford High School was equipped with 30 Google Chromebooks, so students were able to utilize the school's server and network. The research methodology for this project received an

exemption from Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

### Comparison

The AP Chemistry courses at Penn-Trafford High School were already being taught using the flipped classroom method where instruction was delivered to students via teacher-created YouTube videos outside of class. After watching the videos, students completed the Watch, Summarize, Question (WSQ) form (Appendix B). Students were expected to come to class having watched the video, having completed the WSQ form, and having taken notes. An informal question and answer session was conducted at the beginning of each class to review any questions or misconceptions that arose during the video. The remaining class time focused on applying concepts through hands-on assignments, practice problems, and laboratory activities.

### Treatment

Because the AP Chemistry students were already exposed to the flipped classroom, the treatment phases focused on utilizing two different interactive platforms within the flipped environment. PlayPosit and EdPuzzle are two interactive, web-based platforms that contain interactive elements that an instructor can add to a video to enhance student learning. The two weeks prior to when the treatment began, a comparison phase was implemented for the gases unit. The comparison group consisted of all AP Chemistry students watching videos via YouTube on gases. Students watched the videos and then completed a WSQ form. There were two different treatment phases

of this project, one with the use of PlayPosit, and one with the use of EdPuzzle. All AP Chemistry students received each treatment (Table 1).

Table 1  
*Treatment Phases*

	Students Involved	Video Method	Content Covered	Length of Time
Comparison	All students	YouTube	Gases	Two weeks
Treatment 1	All students	PlayPosit	Kinetics	Three weeks
Treatment 2	All students	EdPuzzle	Equilibrium	Three weeks

*Note.* ( $N=28$ ).

The first treatment lasted three weeks and covered kinetics. The kinetics content was new to every student and included reaction rates, rate laws, and rate of appearance and disappearance. During this phase, students watched the teacher-created lecture videos through PlayPosit, an interactive platform that presents students with teacher-created questions during the videos, provides analytics for the teacher, and monitors student participation. These features provided necessary feedback for the student and the teacher, allowing misconceptions to be addressed and difficult material to be retaught. The teacher was able to see how long students spent on the video, as well as how well they performed on the questions. Students still completed the WSQ form after watching each video, and class time still focused on the application of concepts.

The second treatment lasted three weeks and covered general equilibrium. Equilibrium was also new to every student and covered equilibrium expressions, equilibrium constants, and Le Chatelier's principle. During this phase, students watched the content videos through EdPuzzle, another interactive platform that presents students with teacher-created questions during the videos. The embedded questions provided feedback for the student during the video, allowing them to rewind and re-watch

important sections of the video if they were not able to successfully answer the questions. EdPuzzle also allowed students to fast forward through content. Like PlayPosit, EdPuzzle provided analytics for each student like how many times they watched a section of the video and how long it took them to watch the entire video. Students still completed the WSQ form after watching the video, and class time still focused on the application of concepts.

Before treatment began, students were given the Interactive Video Tools Survey via Google Forms to establish the baseline of students' attitudes and engagement with the YouTube videos and WSQ forms (Appendix C). The Interactive Video Tools Survey included Likert-type statements about content delivery, participation, student preparedness, and WSQ forms with the choice to respond *strongly disagree*, *disagree*, *neutral*, *agree*, *strongly agree*. The Interactive Video Tools survey was administered again after each treatment phase, with Treatment 1 specific to PlayPosit and Treatment 2 specific to EdPuzzle. The results of the surveys were analyzed using a Wilcoxon Signed Rank test to determine if the median responses changed significantly during the treatment periods. Data was represented visually in bar graphs. The results of the Interactive Video Tools Survey were also analyzed qualitatively to determine trends in engagement and participation.

Student achievement was evaluated through the use of pre and posttests. During the comparison unit, the Gases Assessment was administered as a pretest (Appendix D). Students then watched the content videos via YouTube with no additional technology support, and the Gases Assessment was again given as a posttest. This two-week unit

established a baseline to be used as a comparison during both treatment phases. The Kinetics Assessment was given before and after Treatment 1 with PlayPosit, and the Equilibrium Assessment was given before and after Treatment 2 with EdPuzzle (Appendices E and F). These tests consisted of multiple-choice questions specific to the content covered. The results of each set of tests were represented using box and whisker plots to determine medians and ranges. Each set of the pre and post-test scores were analyzed for normalized gains. According to Hake (1998), a normalized gain less than 0.3 is a low gain, between 0.3 and 0.7 is considered a medium gain, and above 0.7 is a high gain. The normalized gains for the Gases Assessment were also compared to the normalized gains for each treatment phase to determine any trends in student achievement. Finally, the normalized gains for each treatment phase were compared to each other to compare the effectiveness. A randomization test was also used to determine if the median post-test scores were significantly different to the comparison phase.

A Daily Observation Report was logged at the end of each day by the teacher during the comparison phase and then again during each treatment phase (Appendix G). Each report documents student engagement during the videos, engagement in class, and completion of WSQ forms. Observations were also made based on the questions students asked during class, as well as their participation in class activities. The results of the Daily Observation Report were qualitatively analyzed for trends during each treatment phase.

Additional qualitative evidence was collected through the Student Interview Questions after each treatment phase, with the questions specific to each treatment

(Appendix H). Ten questions were asked to seven random students after each treatment phase. The interview results were analyzed for any trends in student engagement and participation during each treatment, as well as student attitudes toward the interactive tools. At the conclusion of the treatment period, students were asked to complete the Student Preference Survey (Appendix I). This survey asked students just one question about their preference for watching the videos. The data from all of these instruments were used to answer my focus question (Table 2).

Table 2  
*Data Triangulation Matrix*

Focus Question	Data Source 1	Data Source 2	Data Source 3
How do different instructional tools affect <i>student achievement</i> in the flipped chemistry classroom?	Pre-test and post-test scores	WSQ Forms	Daily Observation Report
How do different instructional tools affect <i>student engagement</i> in the flipped chemistry classroom?	Video Tools Survey	Student Interviews	Daily Observation Report
How do different instructional tools affect <i>student attitude</i> in the flipped chemistry classroom?	Video Tools Survey	Student Interviews	Student Preference Survey

## DATA AND ANALYSIS

### Student Achievement

The results of the Kinetics Assessment for Treatment 1 using PlayPosit showed a mean normalized gain of 0.57 from pre-test to post-test ( $N=28$ ). The results of the Equilibrium Assessment after Treatment 2 using EdPuzzle showed a mean normalized gain of 0.68. Treatment 2 showed the highest average normalized gain, but both Treatment 1 and Treatment 2 had higher average normalized gains than the Comparison Unit (Table 3).

Table 3  
Average Normalized Gains for Each Phase

Phase	Video Method	Normalized Gain
Comparison Unit	YouTube	0.45
Treatment 1	PlayPosit	0.57
Treatment 2	EdPuzzle	0.68

*Note.* According to Hake (1998), a normalized gain less than 0.3 is a low gain, between 0.3 and 0.7 is a medium gain, and above 0.7 is a high gain.

Ninety-six percent of students had a medium or high gain from the pre-test to the post-test during Treatment 2 compared to the 82% of students in Treatment 1 (Figure 1).

When asked about using EdPuzzle in class, one student stated, “EdPuzzle is a good site that helps me learn the material as the video pauses and questions appear. They keep my learning on track and help me review the material when it comes time for the test.”

Similar statements were made regarding PlayPosit. One student stated, “The questions in PlayPosit make me pause and think about what I’m learning instead of just watching the video passively.”

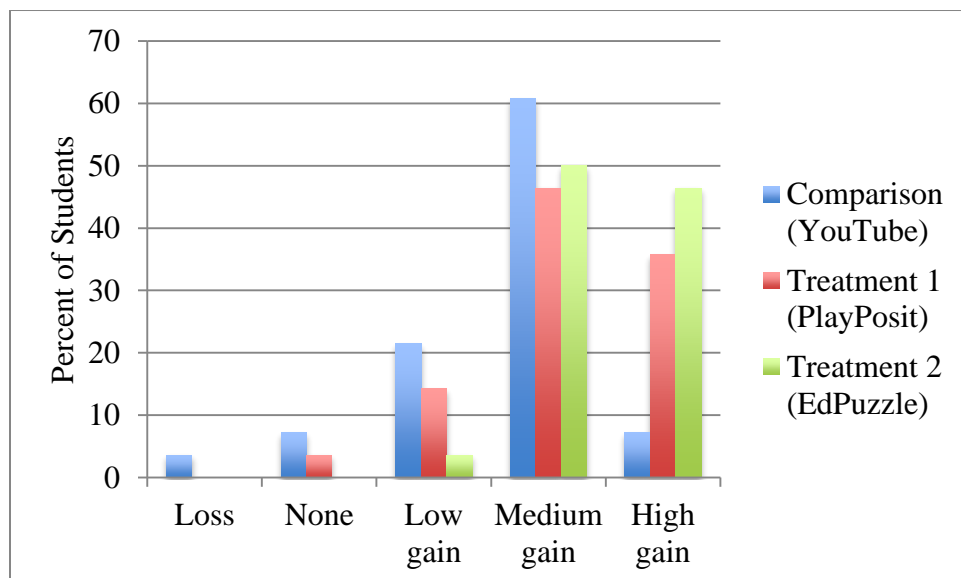
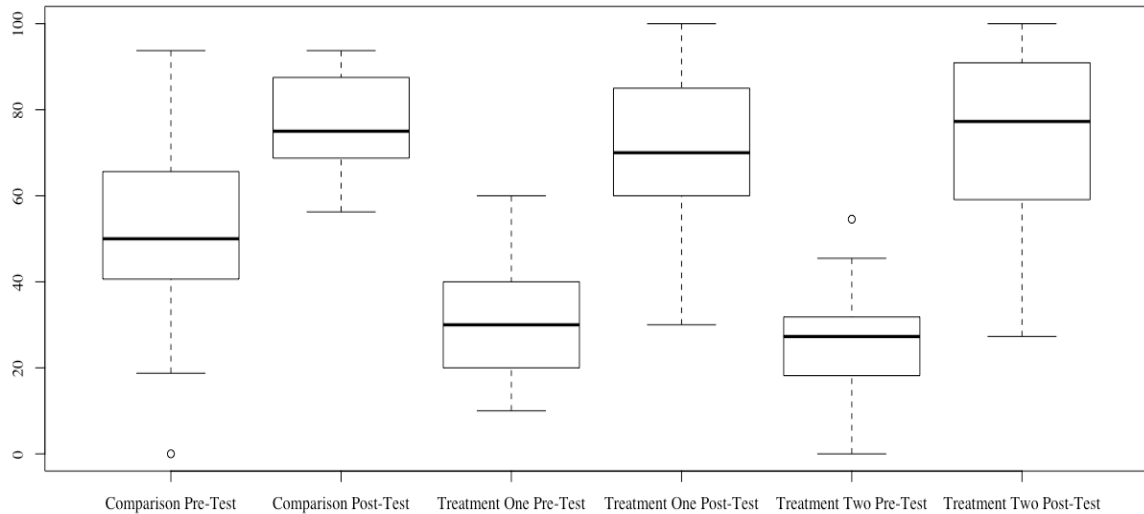


Figure 1. Normalized gains for each phase, (N=28).

There was an overall increase in scores during every phase of the research. The median score for the Comparison Unit increased from 50% to 75% (Figure 2). After Treatment 1 with PlayPosit, the median score on the Kinetics Assessment increased from 30% to 70%. Many of the lower scores were increased, increasing the median, but the distribution of scores remained similar. After Treatment 2 with EdPuzzle, the median score on the Equilibrium Assessment increased from 27% to 77%. The median scores and score distributions were similar for both Treatment 1 and Treatment 2.



*Figure 2.* Boxplots showing score distribution of the Comparison Gases assessment, Treatment 1 Kinetics Assessment, and Treatment 2 Equilibrium Assessment, ( $N=28$ ).

The median post-test scores were not significantly different between the Comparison Unit and either Treatment 1 or Treatment 2 as shown from the randomization test. The calculated  $p$ -value was compared to an alpha level of 0.05 to determine if the result was significant (Table 4).

Table 4

*Randomization Test p-values Comparing Median Post-Test Scores*

Hypothesis	<i>p</i> -value	Significant Result?
No difference between median scores of the Comparison Unit versus Treatment 1	0.3482	No
No difference between median post-test scores of the Comparison Unit versus Treatment 2	0.8104	No
No difference between median post-test scores of Treatment 1 versus Treatment 2	0.2562	No

Student Engagement

The Interactive Video Tools Survey measured student attitudes and engagement for PlayPosit and EdPuzzle compared to the YouTube Comparison unit. The results were analyzed using the Wilcoxon Signed Rank test. The calculated *p*-value was compared to an alpha level of 0.05 to determine if the result was statistically significant. The responses after Treatment 1 with PlayPosit were measured against the Comparison Unit (Table 5). The responses after Treatment 2 with EdPuzzle were also measured against the Comparison Unit (Table 6). All four questions on the survey showed significant results when students compared EdPuzzle to YouTube, but the survey only showed significant results for two of the survey questions when students compared PlayPosit to YouTube.

Table 5

*Wilcoxon Signed Rank Test p-values for the Comparison Unit Versus Treatment 1 From the Interactive Video Tools Survey*

Question	<i>p</i> -value	Significant result?
Watching a video is an effective way to learn new material	0.1385	No
Felt more prepared for class after watching the videos	0.1151	No
Enhanced my learning of chemistry through videos	0.0005903	Yes
Felt more engaged during class after watching videos	$1.054 \times 10^{-5}$	Yes

*Note.* (N=28).

Table 6  
*Wilcoxon Signed Rank Test p-values for the Comparison Unit Versus Treatment 2 From the Interactive Video Tools Survey*

Question	<i>p</i> -value	Significant result?
Watching a video is an effective way to learn new material	0.01604	Yes
Felt more prepared for class after watching the videos	0.04811	Yes
Enhanced my learning of chemistry through videos	$3.48 \times 10^{-5}$	Yes
Felt more engaged during class after watching videos	$5.09 \times 10^{-9}$	Yes

*Note.* (N=28).

Students felt that watching videos was an effective way to learn chemistry when comparing YouTube to EdPuzzle ( $p=0.016$ ), but not when comparing YouTube to PlayPosit ( $p=0.14$ ). When using only YouTube during the Comparison Unit, 52% of students *agreed* or *strongly agreed* that videos were an effective way to learn chemistry in the classroom (Figure 3). After Treatment 2 using EdPuzzle, 89% either *agreed* or *strongly agreed* with the statement. When asked about their confidence with chemistry after watching the videos using PlayPosit during Treatment 1, one student stated, “The videos give me a basis for when I come into class, which I like. Although for some of the conceptual information, it can be hard for me to learn from a video.” When asked the same question about EdPuzzle after Treatment 2, another student said, “The videos give me the background information I need to make the examples in class easier. I like that I can rewind to re-learn material as needed and review the questions.”

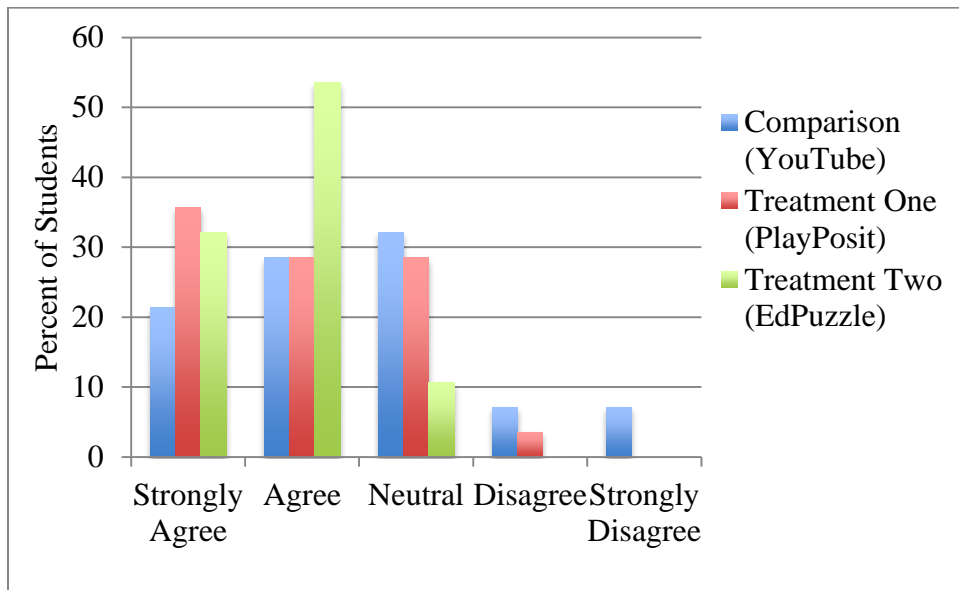


Figure 3. Interactive Video Tools Survey question: “I feel that watching a video is an effective way to learn new material,” ( $N=28$ ).

Students felt more prepared for class after watching videos with EdPuzzle compared to YouTube ( $p=0.048$ ), but not with PlayPosit ( $p=0.12$ ). Before any treatment, 70% of students either *agreed* or *strongly agreed* that they felt prepared for class after watching the videos via YouTube (Figure 4). After Treatment 1 using PlayPosit, the percentage of students agreeing or strongly agreeing increased to 78%. After Treatment 2 using EdPuzzle, the number of students increased even more to 93%. There was no significant difference in student perception of their preparation after Treatment 1, but Treatment 2 showed a significant difference ( $p=0.048$ ) when measured against the Comparison Unit.

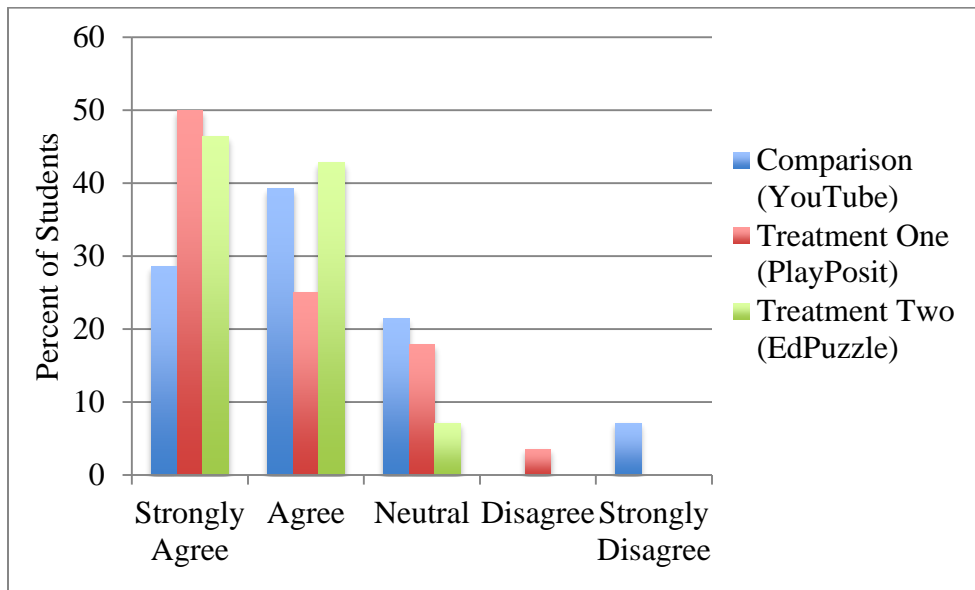


Figure 4. Interactive Video Tools Survey question: “I felt more prepared for class after watching the videos,” ( $N=28$ ).

After using both PlayPosit ( $p=0.00059$ ) and EdPuzzle ( $p=3.5 \times 10^{-5}$ ), students felt more engaged when compared to YouTube. When asked if they felt more engaged during class after watching the video, students answering *agree* or *strongly agree* increased from 11% to 70% after using PlayPost during Treatment 1 and 11% to 93% after using EdPuzzle during Treatment 2 (Figure 5). Students responded with statements such as, “The questions helped me focus and review my notes which made me more attentive during class.”

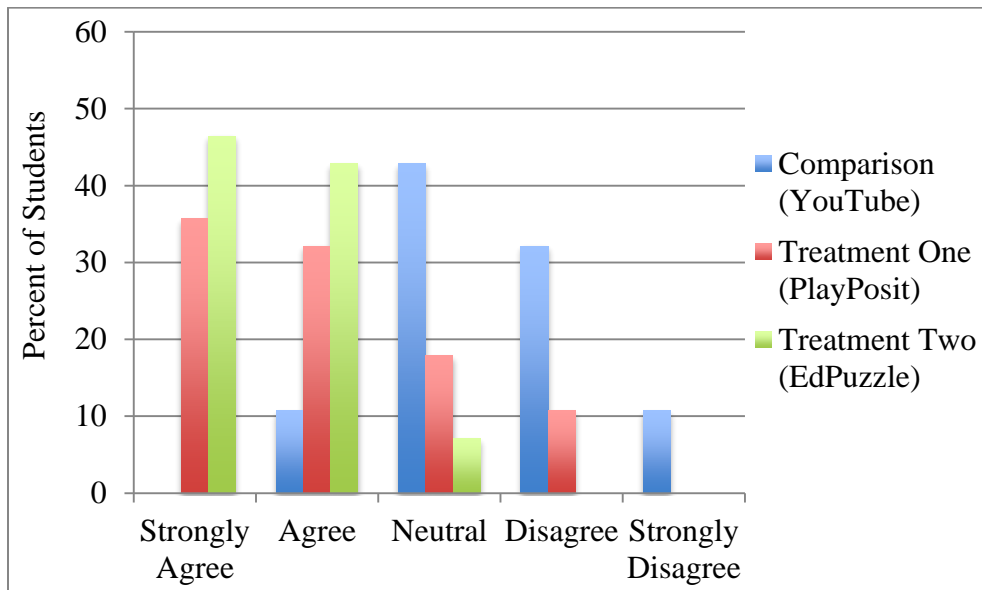


Figure 5. Interactive Video Tools Survey question: “I feel more engaged during class after watching the videos,” (N=28).

While utilizing different interactive technologies, students responded that they felt more engaged, and the observation data agreed with survey data. Observations were made during each class period to determine if students were on task and engaged. On average, 85% of students remained on task during the Comparison Unit (Table 7). However, when utilizing PlayPosit during Treatment 1, engagement increased to 88%. Treatment 2 with EdPuzzle showed even higher engagement with 94%.

During the treatment periods, students were more engaged during class as well as more engaged during the videos. When using only YouTube during the Comparison Unit, 74% of students watched the video and completed the WSQ form. After Treatment 1 using PlayPosit, the percentage of students watching the videos increased to 90%, and after Treatment 2 with EdPuzzle, it increased to 91%. When asked about their engagement during the video and during class, a student said, “The questions kept me

engaged in the video when I would normally have gotten bored, and then I was able to focus more in class because I had the background information needed.”

Table 7  
*Daily Observation Report*

	Watched the videos	Completed the WSQ form	Asked a confusion question on WSQ	Asked a discussion question on WSQ	Asked an example question on WSQ	Remained on task during class
Comparison	20.75	21	78.9%	17.4%	3.8%	23.75
Treatment 1	25.17	23	85.5%	10.9%	3.6%	24.5
Treatment 2	25.50	23.25	75.5%	8.17%	16.3%	26.25

*Note.* The table shows the average number of students or percentage of students completing an activity, ( $N=28$ ).

#### Student Attitude

After both treatments, students responded to the Student Preference Survey with their preference of video tool. Seventy-one percent of students preferred EdPuzzle for watching the content videos. When asked why they preferred EdPuzzle, one student stated, “I like the ability to fast forward, and I feel like it is more up to date.” Another student said, “It is the easiest to navigate while still keeping me interested. I just want to wander when I’m on YouTube.”

### INTERPRETATION AND CONCLUSION

#### Student Achievement

The first research question revolved around student achievement on post-tests after utilizing YouTube, PlayPosit, and EdPuzzle. The results showed an overall positive shift in student post-test scores from the Comparison Unit to Treatment 2 but not Treatment 1. The median post-test score during the Comparison Unit using YouTube was 75%. After Treatment 1, the median score was only 70%, but after Treatment 2 with

EdPuzzle, the median score was 77%. Median scores increased 40% from pre-test to post-test during Treatment 1 and 50% after Treatment 2, but the median scores were not statistically significantly different from the Comparison Unit. This is somewhat surprising because it would be expected that with more active participation in the videos, students would perform at a higher level on the exams.

Although the median post-test scores were not significantly different, the average normalized gains from pre-test to post-test signify an increase in scores after the use of YouTube, PlayPosit, and EdPuzzle in the classroom. The Comparison Unit with YouTube showed the smallest gain, with EdPuzzle showing the highest gain. These differences in normalized gains during both treatments could be a result of the material becoming more difficult. The content covered during the Comparison Unit is typically a unit that is a review of a first-year chemistry course. The median pre-test scores were significantly higher during the Comparison Unit when compared to both treatments. The median pre-test score for the Comparison Unit was 50% compared to 30% for Treatment 1 and 27% for Treatment 2. Because many students were already familiar with gases as seen from the 50% median pre-test score, the students did not have as much room to grow on the post-test resulting in a smaller normalized gain.

Both treatments covered new content. Treatment 1 covered kinetics and Treatment 2 covered equilibrium, which are both new topics to all students during AP Chemistry. Learning new content during both treatments could explain why the median pre-test scores were so much lower and the average normalized gains were higher. Perhaps if all of the material were new, the difference in test scores would have been

significant. Because the median post-test scores were not significantly different, the different interactive instructional tools did not affect student achievement. However, based on normalized gains, EdPuzzle was the most effective tool regarding student achievement in the flipped classroom.

### Student Engagement

The Interactive Video Tools Survey assisted in answering the second focus question about student engagement in the flipped classroom. The results of the survey revealed that after both treatments students felt more engaged during the videos and class. Based on student responses during interviews, the embedded teacher-generated questions in both PlayPosit and EdPuzzle required students to remain focused rather than just passively taking notes. The questions were randomly placed in the video, and students were required to answer the questions before moving on in the video. When students answered questions during the video, they were able more likely to participate in class. This increase in participation was most likely due to the confidence gained from the videos. When students answered a question incorrectly, they received feedback and were able to replay any specific section of the video. The students who replayed parts of the video remained on task for the entire duration of class.

Students also had the opportunity to ask questions at the conclusion of the video, which were the springboard for discussion at the beginning of each class. The increase in both student generated and teacher generated questions resulted in more engagement and participation from the students. If students asked *Confusion* questions on the WSQ form, I would make them part of the Do Now Exercises at the beginning of class. Students

would then answer the questions and discuss them as groups. I would also pose some of the *Discussion* and *Example* questions to students and ask the to discuss as a class. When students recognized their question being asked, they immediately took more interest and were more likely to add to the discussion. During these brief class discussions, students were also answering their peers' questions, which increased collaboration.

The embedded questions in both PlayPosit and EdPuzzle had a positive impact on student engagement in the flipped classroom, but EdPuzzle also helped students feel more prepared for class after watching the videos, making it the more effective platform for student engagement.

#### Student Attitude

In response to the focus question about student attitude in the flipped classroom, it was found that students preferred EdPuzzle to both PlayPosit and YouTube. Both PlayPosit and EdPuzzle enhanced the student learning through the embedded questions, but after using EdPuzzle, students responded that videos were an effective way to learn chemistry. Students seemed to prefer EdPuzzle to PlayPosit because in EdPuzzle they had the ability to rewind and fast-forward, as well as receive feedback after answering each question. During the videos, students wanted to fast forward if they already understood the material, but PlayPosit did not allow skipping during the video.

Both EdPuzzle and PlayPosit were preferred over YouTube. This is most likely because both EdPuzzle and PlayPosit integrated teacher-generated questions throughout the videos. The questions required students to take an active role in their learning. Students commented about the questions requiring more critical thinking, which

increased their engagement in the videos. In conclusion, both EdPuzzle and PlayPosit enhanced student learning when compared to YouTube, but EdPuzzle was the more effective platform that most students preferred.

#### VALUE

At the end of this project, I found that using EdPuzzle in the flipped classroom was the most effective interactive technology for the flipped classroom. Although it did not significantly change student test scores, EdPuzzle increased student engagement both during videos and during class, as well as provided students the opportunity to rewind and fast forward, which they greatly desired. EdPuzzle also allowed me to monitor student progress for each video. I could see which the questions that students missed, as well as how many times they watched each section of the video. EdPuzzle inspired me to reflect on each lesson and how to improve.

Reflection has been one of the most essential skills throughout this process, and reflection has helped me develop, grow, and change as an educator. As I worked through this project, I was able to reflect on my teaching and my students' progress. I wrote down what worked, what did not, and key comments from students. As students used both PlayPosit and EdPuzzle, I listened to their feedback and was more responsive to the individual needs of each student. Students wanted more opportunities to ask questions, so I was sure to add more question and answer time at the beginning of each class. Students wanted more feedback on the embedded questions, so I added more explanations to each question as well as more student feedback throughout the entire class. This process reminded me how reflection and feedback should play a key role in every classroom.

As I worked through this project, other teachers in my school were also affected. Teachers became interested in the flipped classroom and how technology could be implemented in the classroom, and they began asking questions. Many teachers have now begun to explore the flipped classroom and utilize it in their own classes. Teachers have started to implement more video or technology based lessons. Whenever teachers have questions, they come to me, and we work together to find a solution. This has allowed me to become a technology mentor for other teachers in my building and grow my own skills as both a coach and educator.

In terms of the results of this project, there are definitely future implications of my work. Next year I will utilize both PlayPosit and EdPuzzle again, but instead of each technology only lasting for one unit, I want to use each over multiple units. I also will be sure to use them as I am teaching all new material. This will allow me to better compare the test scores to see if there were significant differences. If the material is completely new to students when using YouTube, PlayPosit, and EdPuzzle, I can make better comparisons regarding test scores. When using EdPuzzle and PlayPosit again next year, I need to determine the best way to encourage students to watch the videos. Most of my frustration during this project came from the same three students not watching the videos. These students then struggled through the concepts and did not perform well on quizzes and tests. Perhaps I will need to assign points randomly for video participation. Either way, interactive platforms will continue to be used in my classroom to increase student engagement and encourage a more active learning approach within the flipped classroom.

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APPENDICES

APPENDIX A  
INSTITUTIONAL REVIEW BOARD EXEMPTION



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**

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 c/o Microbiology & Immunology  
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*Chair:* Mark Quinn  
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*Administrator:*  
 Cheryl Johnson  
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**MEMORANDUM**

**TO:** Samantha Carney and John Graves  
**FROM:** Mark Quinn *Mark Quinn*  
**DATE:** November 29, 2016  
**SUBJECT:** "The Effect of Interactive Tools in a Flipped Chemistry Classroom" [SC112916-EX]

The above research, described in your submission of November 9, 2016, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

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

APPENDIX B

WSQ FORM

## WSQ - Watch, Summarize, Question

Please answer the following questions regarding the video you watched last night.

\* Required

### WATCH

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The first part of the WSQ is to "Watch". Make sure you have taken good notes and used the "rewind" and "pause" buttons whenever you needed to slow down or hear something again.

**1. What did you use to help take notes and clarify information? \***

Please select all that apply.  
*Check all that apply.*

- Video on YouTube
- Textbook
- Other internet resources
- Other: \_\_\_\_\_

### SUMMARIZE

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The second part of the WSQ is to "Summarize" what you learned. This will be an "open summary" where I do not give you any guiding questions and just ask you to summarize what you learned. Sometimes I will ask specific questions in place of the open summary.

**2. Please summarize the key parts of what you watched or read. \***

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### QUESTION

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The last part of the WSQ is to ask a "Question" what you read or watched.

Please label your question as a:

- 1) CONFUSION - What is something you would like me to explain or answer during my session that you aren't sure about right now?  
or
- 2) DISCUSSION - What is something that you know/understand but would be a good question to explain or answer during my session? After you ask the question, please answer it to the best of your ability  
or
- 3) EXAMPLE - Make up your own example problem similar to this concept and solve it verbally.

**3. Confusion, Discussion, or Example? \***

Please select whether your type of question.  
*Mark only one oval.*

- Confusion
- Discussion
- Example

**4. Please ask your question. (You must ask a question!) \***

If you selected discussion or example, you must also give an answer to your question here.

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APPENDIX C

INTERACTIVE VIDEO TOOLS SURVEY

## Video Tools Survey

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

Directions: Read each statement and choose what best reflects your feelings about each statement.

\* Required

1. **Email address \***

\_\_\_\_\_

2. **I am interested in chemistry. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

3. **I watched the video lectures using this tool when they were assigned. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

4. **I felt more prepared for class after watching the videos. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

5. **I felt more engaged during class after watching the videos using this tool. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

6. **I controlled the pace of my learning when I watched the videos. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree



15. **During video lectures, it is easy for me to listen and take notes at the same time. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

16. **I completed the WSQ forms after the videos. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

17. **I completed the WSQ forms even when they are not graded. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

18. **I feel that completing the WSQ form helps me learn chemistry. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

19. **I feel that overall EdPuzzle enhanced my learning of chemistry through videos. \***

*Mark only one oval.*

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

20. **Would you like to add any other comments about using EdPuzzle to watch the class videos? \***

I do read these, so I would love feedback to make the next unit better!

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APPENDIX D  
GASES ASSESSMENT

## Gases Test

Please answer the following questions regarding gases.

\* Required

1. **Email address \***

\_\_\_\_\_

2. **Which set of values represents standard pressure and standard temperature (STP)? \***

Mark only one oval.

- 1 atm and 101.3 kPa  
 1 kPa and 273 K  
 101.3 kPa and 0 degrees C  
 101.3 atm and 273 degrees C

3. **A sample of helium gas is in a sealed, rigid container. What occurs as the temperature of the sample is increased? \***

Mark only one oval.

- The mass of the sample decrease.  
 The number of moles of gas increases.  
 The volume of each atom decreases.  
 The frequency of collisions between atoms increases.

4. **A sealed, rigid 1.0-liter cylinder contains He gas at STP. An identical sealed cylinder contains Ne gas at STP. These two cylinders contain the same number of \***

Mark only one oval.

- atoms  
 electrons  
 ions  
 protons

5. **Which statement describes the particles of an ideal gas according to the kinetic molecular theory? \***

Mark only one oval.

- The gas particles are arranged in a regular geometric pattern.  
 The gas particles are in random, constant, straight-line motion.  
 The gas particles are separated by very small distances, relative to their sizes.  
 The gas particles are strongly attracted to each other.

6. **At 25 degrees Celsius, gas in a rigid cylinder with a movable piston has a volume of 145 mL and a pressure of 125 kPa. Then the gas is compressed to a volume of 80. mL. What is the new pressure of the gas if the temperature is held constant? \***

Mark only one oval.

- 69 kPa  
 93 kPa  
 160 kPa  
 230 kPa

7. **The phase of a sample of a molecular substance at STP is not determined by its \***

*Mark only one oval.*

- arrangement of molecules  
 intermolecular forces  
 number of molecules  
 molecular structure

8. **A 220.0 mL sample of helium gas is in a cylinder with a movable piston at 105 kPa and 275 K. The piston is pushed in until the sample has a volume of 95.0 mL. The new temperature of the gas is 310. K. What is the new pressure of the sample? \***

*Mark only one oval.*

- 51.1 kPa  
 216 kPa  
 243 kPa  
 274 kPa

9. **When a sample of a gas is heated in a sealed, rigid container from 200. K to 400. K, the pressure exerted by the gas is \***

*Mark only one oval.*

- decreased by a factor of 2  
 increased by a factor of 2  
 decreased by a factor of 200  
 increased by a factor of 200

10. **Which gas sample at STP has the same number of molecules as a 2.0 L sample of  $\text{Cl}_2(\text{g})$  at STP? \***

*Mark only one oval.*

- 1.0 L of  $\text{NH}_3$   
 2.0 L of  $\text{CH}_4$   
 3.0 L of  $\text{CO}_2$   
 4.0 L of NO

11. **According to the kinetic molecular theory, which statement helps to describe an ideal gas? \***

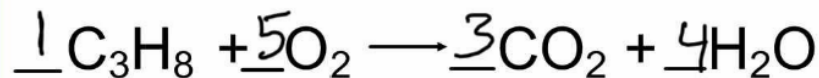
*Mark only one oval.*

- The gas particles are diatomic.  
 Energy is created when the gas particles collide.  
 There are no attractive forces between the gas particles.  
 The distance between the gas particles is small, compared to their size.

12. **When a sample a gas is cooled in a sealed, rigid container, the pressure the gas exerts on the walls of the container will decrease because the gas particles hit the walls of the container \***

*Mark only one oval.*

- less often and with less force  
 less often and with more force  
 more often and with less force  
 more often and with more force

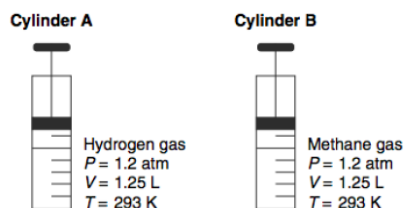


13. Propane burns in air to form carbon dioxide and liquid water, as shown above. When 4.0 moles of propane is combusted, how many liters of carbon dioxide are formed at STP? \*

Mark only one oval.

- 4.0 liters  
 12 liters  
 90. liters  
 270 liters

Cylinder A has a movable piston and contains hydrogen gas. An identical cylinder, B, contains methane gas. The diagram below represents these cylinders and the conditions of pressure, volume, and temperature of the gas in each cylinder.



14. How does the total number of gas molecules in cylinder A compare to the total number of gas molecules in cylinder B? \*

Mark only one oval.

- Cylinder A is greater than cylinder B.  
 Cylinder A is less than cylinder B.  
 The cylinders have the same number of gas molecules.

A sample of helium gas is placed in a rigid cylinder that has a movable piston. The volume of the gas is varied by moving the piston, while the temperature is held constant at 273 K. The volumes and corresponding pressures for three trials are measured and recorded in the data table below. For each of these trials, the product of pressure and volume is also calculated and recorded. For a fourth trial, only the volume is recorded.

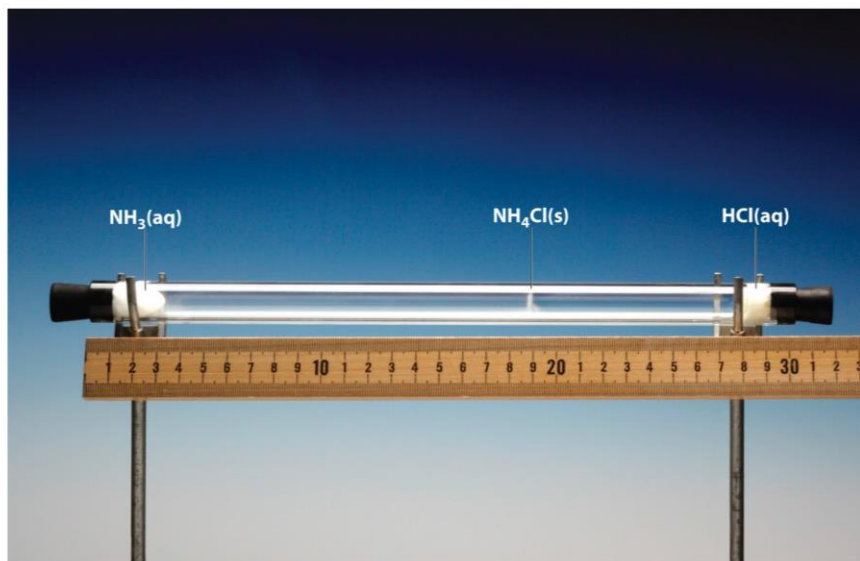
Pressure and Volume Data for  
a Sample of Helium Gas at 273 K

Trial Number	Pressure (atm)	Volume (L)	P × V (L·atm)
1	1.000	0.412	0.412
2	0.750	0.549	0.412
3	0.600	0.687	0.412
4	?	1.373	?

15. Determine the pressure of the helium gas in trial 4. \*

Mark only one oval.

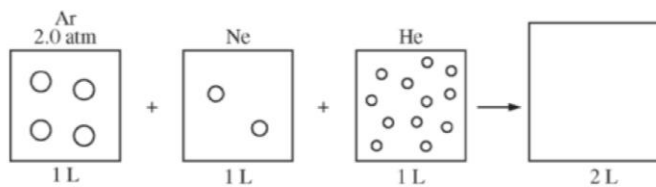
- 1.373 atm  
 0.412 atm  
 0.300 atm  
 0.566 atm



16. Why does the ammonium chloride not form in the center of the tube? \*

Mark only one oval.

- Chloride ions travel at a faster rate than ammonium ions at the same temperature.
- Ammonium ions travel at a faster rate than chloride ions at the same temperature.
- Ammonium ions and chloride ions travel at the same rate at the same temperature.
- Chloride ions travel slower because they are diatomic.



17. The figure above represents three sealed 1.0 L vessels, each containing a different inert gas at 298K. The pressure of Ar in the first vessel is 2.0 atm. The ratio of the numbers of Ar, Ne, and He atoms in the vessels is 2:1:6, respectively. After all the gases are combined in a previously evacuated 2.0 L vessel, what is the total pressure of the gases at 298K? \*

Mark only one oval.

- 3.0 atm
- 4.5 atm
- 9.0 atm
- 18 atm

APPENDIX E  
KINETICS ASSESSMENT

## Kinetics Test

1. Name

\_\_\_\_\_

2. Under certain conditions, the average rate of appearance of oxygen gas in the reaction:  $2 \text{O}_3 \rightarrow 3 \text{O}_2$  is 6.0 torr/s. What is the average rate expressed in units of torr/s for the disappearance of  $\text{O}_3$ ?

Mark only one oval.

- 9.0  
 6.0  
 4.0  
 3.0  
 1.2

3. For irreversible chemical reactions, the rate will be affected by changes in all of these factors except:

Mark only one oval.

- temperature  
 concentration of reactants  
 concentrations of products  
 catalyst  
 surface area of solid reactant

4. The rate law of a certain reaction is  $\text{rate} = k[\text{X}][\text{Y}]$ . The units of  $k$ , with time measured in seconds, is

Mark only one oval.

- $\text{s}^{-1}$   
  $\text{M}^{-1} \text{s}^{-2}$   
  $\text{M}^{-2} \text{s}^{-1}$   
  $\text{M}^{-1}$   
  $\text{M}^{-1} \text{s}^{-1}$

5. The rate expression for a third order reaction could be

Mark only one oval.

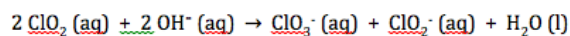
- rate= $k[X]$   
 rate= $k[X][Y]$   
 rate= $k[X]^2$   
 rate= $k[X]^2[Y]$   
 rate= $k[X]^2[Y]^2$

6. The rate law for a reaction is  $\text{rate}=k[A][B]^2$ . Which one of the following statements is false?

Mark only one oval.

- The reaction is first order in A.  
 The reaction is second order in B.  
 The reaction is second order overall.  
 k is the reaction rate constant.  
 If [B] is doubled, the reaction rate will increase by a factor of 4.

Use the following for the next two questions.



Experiment Number	[ClO <sub>2</sub> ] (M)	[OH <sup>-</sup> ] (M)	Initial Rate (M/s)
1	0.060	0.030	0.0248
2	0.020	0.030	0.00276
3	0.020	0.090	0.00828

7. What order is this reaction with respect to ClO<sub>2</sub>?

Mark only one oval.

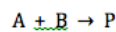
- 1st  
 2nd  
 3rd  
 zero  
 Cannot be determined

8. What order is this reaction with respect to OH<sup>-</sup>?

Mark only one oval.

- 1st  
 2nd  
 3rd  
 zero  
 Cannot be determined

Use the following data for the next three questions.



Experiment Number	[A] (M)	[B] (M)	Initial Rate (M/s)
1	0.273	0.763	2.83
2	0.273	1.526	2.83
3	0.819	0.763	25.47

9. What order is this reaction with respect to A?

Mark only one oval.

- 1st  
 2nd  
 3rd  
 zero  
 Cannot be determined

10. What order is this reaction with respect to B?

Mark only one oval.

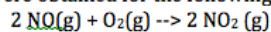
- 1st  
 2nd  
 3rd  
 zero  
 Cannot be determined

11. The magnitude of the rate constant is

Mark only one oval.

- 38.0  
 0.278  
 13.2  
 42.0  
 2.21

The initial-rate data in the table were obtained for the following reaction...



Experiment	Initial [NO] (mol/L)	Initial [O <sub>2</sub> ] (mol/L)	Initial Rate of Formation of NO <sub>2</sub> (mol/L s)
1	0.10	0.10	$2.5 \times 10^{-4}$
2	0.20	0.10	$5.0 \times 10^{-4}$
3	0.20	0.40	$8.0 \times 10^{-3}$

12. What is the experimental rate law for the reaction?

Mark only one oval.

- rate =  $k[\text{NO}][\text{O}_2]$   
 rate =  $k[\text{NO}][\text{O}_2]^2$   
 rate =  $k[\text{NO}]^2[\text{O}_2]$   
 rate =  $k[\text{NO}]^2[\text{O}_2]^2$

13. If temperature is increased, the reaction rate

Mark only one oval.

- decreases  
 increases

14. Which of these changes with time for a first order reaction?

Check all that apply.

- Rate of reaction  
 Rate constant  
 Half life  
 Concentration of reactant

15. For a first order reaction of half-life 75 minutes, what is the rate constant in /min?

Mark only one oval.

- $(.693)/75$   
  $(.693)/1.25$   
  $(.693)(75)$   
  $75/(.693)$   
  $.693$

16. Which of the following would show the correct relationship between concentration and time for a reaction that is second order in [A]?

Mark only one oval.

- $\ln[A]$  vs time  
  $1/[A]$  vs time  
  $[A]$  vs time

APPENDIX F  
EQUILIBRIUM ASSESSMENT

## Equilibrium Test

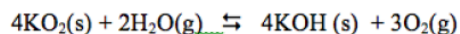
Answer the following questions to the best of your ability!

1. **True or false: Chemical reactions stop occurring at equilibrium.**

Mark only one oval.

- True  
 False

Write the equilibrium constant expression for the following reaction:



A)  $K_{eq} = \frac{[\text{KOH}]^4[\text{O}_2]^3}{[\text{KO}_2]^4[\text{H}_2\text{O}]^2}$

B)  $K_{eq} = \frac{[\text{KO}_2]^4[\text{H}_2\text{O}]^2}{[\text{KOH}]^4[\text{O}_2]^3}$

C)  $K_{eq} = \frac{[\text{O}_2]^3}{[\text{H}_2\text{O}]^2}$

D)  $K_{eq} = \frac{[\text{H}_2\text{O}]^2}{[\text{O}_2]^3}$

2.

Mark only one oval.

- A  
 B  
 C  
 D

Consider a reaction  $3\text{A}(\text{g}) + \text{B}(\text{s}) \rightleftharpoons 2\text{C}(\text{g})$ . If 2.0 mol A, 3.0 mol B, and 2.0 mol C are present in a 1.0 L flask at equilibrium, what is the value of  $K_c$ ?

3. A) 4.0    B) 1.0    C) 2.0    D) 0.25    E) 0.50

Mark only one oval.

- A  
 B  
 C  
 D  
 E

4. For the reaction given, how do the equilibrium concentrations of the reactants compare to the equilibrium concentration of the products?

Consider the chemical system  $\text{CO} + \text{Cl}_2 \rightleftharpoons \text{COCl}_2$ ;  $K = 4.6 \times 10^3 \text{ L/mol}$ .

Mark only one oval.

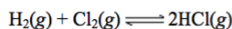
- They are much smaller.  
 They are much larger.  
 They are about the same.  
 They are exactly equal.

The value of  $K_{\text{eq}}$  for the equilibrium  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \leftrightarrow 2 \text{HI}(\text{g})$  is 794 at 25 °C. At this temperature, what is the value of  $K_{\text{eq}}$  for this equilibrium?  $\text{HI}(\text{g}) \leftrightarrow \frac{1}{2} \text{H}_2(\text{g}) + \frac{1}{2} \text{I}_2(\text{g})$

5. A) 1588 B) 28 C) 397 D) 0.035 E) 0.0013

Mark only one oval.

- A  
 B  
 C  
 D  
 E



The chemical equation for the formation of hydrogen chloride gas from its elements is shown above. Given that the equilibrium constant for the reaction above is  $K_p$ , Which of the following best represents the equilibrium constant for the reaction  $\text{HCl}(\text{g}) \rightleftharpoons \frac{1}{2} \text{H}_2(\text{g}) + \frac{1}{2} \text{Cl}_2(\text{g})$  ?

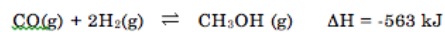
- A)  $\frac{1}{K_p^2}$   
 B)  $K_p^2$   
 C)  $\frac{1}{\sqrt{K_p}}$   
 D)  $\sqrt{K_p}$

6. Mark only one oval.

- A  
 B  
 C  
 D

Use the information below for the next three questions.

Consider the following reaction:



Which direction would each of the following changes cause the reaction to shift to regain equilibrium?

7. **Decreasing the volume in the container.**

*Mark only one oval.*

- Left  
 Right  
 Neither

8. **Adding hydrogen gas.**

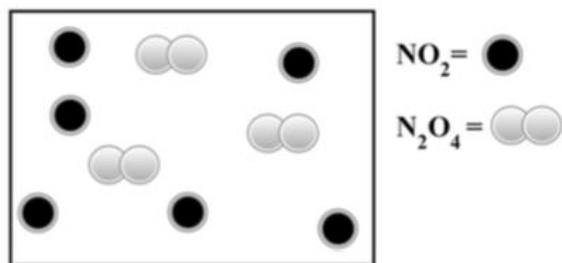
*Mark only one oval.*

- Left  
 Right  
 Neither

9. **Lowering the temperature.**

*Mark only one oval.*

- Left  
 Right  
 Neither



The diagram above represents a mixture of  $\text{NO}_2(g)$  and  $\text{N}_2\text{O}_4(g)$  in a 1.0 L container at a given temperature. The two gases are in equilibrium according to the equation  $2 \text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g)$ .

Which of the following must be true about the value of the equilibrium constant for the reaction at this temperature?

- A)  $K = 0$
- B)  $0 < K < 1$
- C)  $K = 1$
- D)  $K > 1$

10. *Mark only one oval.*

- A
- B
- C
- D

Which of the following best describes the conditions of a chemical reaction that indicate equilibrium has been reached?

- A) The rates of the forward and reverse reactions become equal.
- B) The concentrations of reactants and products become equal.
- C) The temperature shows a sharp rise.
- D) All chemical reactions cease.

11. *Mark only one oval.*

- A
- B
- C
- D

APPENDIX G  
DAILY OBSERVATION REPORT

## Daily Observation Report

Teacher observations of each section.

### Video and WSQ Participation

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1. What video were students watching?

---

2. Number of students who watched the video

---

3. Number of students who completed the WSQ form

---

4. Number of students who asked a confusion question

---

5. Number of students who asked a discussion question

---

6. Number of students who asked an example question

---

### Class Participation

---

7. Number of students who completed the do now exercise before reviewing as a class

---

8. Number of students who remained on-task during the class activity or lab

---

## Classroom Reflection

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9. Describe the engagement of students today

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10. Memorable thoughts or questions asked by students today

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APPENDIX H  
STUDENT INTERVIEWS

## Student Questions

This is a Google form for students' responses regarding the different technology tools used in class. Participation in this survey is voluntary and participation or non-participation will not affect your grade or class standing in any way.

1. **Name**

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2. **How much time did you spend watching the videos? How did you feel about the length?**

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3. **If you do not complete the WSQ form regularly, what would you prefer instead to create an incentive to watch each video?**

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4. **What did you like best about EdPuzzle?**

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5. **What would you like to change about EdPuzzle?**

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6. What was most and least beneficial to you about the videos?

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7. Did you feel like you stayed engaged during the entire video? Explain your response.

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8. Do you think this helped you more than simply watching the video on YouTube? Why?

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9. Did you only watch the videos when they were assigned? If not, when and for what purpose did you re-watch them?

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10. How do you think watching the videos affected your engagement (participation, interest, confidence) during class?

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11. Is there anything else that you want me to know about EdPuzzle?

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APPENDIX I  
STUDENT PREFERENCE SURVEY

## What is your preference?

Please answer the questions below about your preference on the videos!

\* Required

1. Email address \*

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2. What is your preference for watching the videos? \*

*Mark only one oval.*

- YouTube
- PlayPosit
- EdPuzzle

3. Why do you like that option the most? (Regarding the question above) \*

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