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The Perceptions and Usage of the Interactive Video PlayPosit in a General Chemistry Course

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THE PERCEPTIONS AND USAGE OF THE INTERACTIVE VIDEO PLAYPOSIT IN A GENERAL CHEMISTRY COURSE

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Education
at the University of Kentucky

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ABSTRACT

THE PERCEPTIONS AND USAGE OF THE INTERACTIVE VIDEO PLAYPOSIT IN A GENERAL CHEMISTRY COURSE

Technology within science, technology, engineering, and mathematics (STEM) classrooms has been a topic of discussion for decades (Reiser, 2001, 2007). With the inclusion of more technologies or digital tools in the classroom has pushed classes towards a blended learning or flipped classroom approach (Atkins 2015; Tayebinik & Puteh, 2013; Williams et al., 2008). One such digital tool that has started gaining traction in the STEM classroom is the interactive video (M. K. Seery, 2013; Smith, 2013). Interactive videos allow students to watch the general lecture material outside of class and work through problems during normal class time (M. K. Seery, 2013; Smith, 2013; Stieff et al., 2018). Although flipped classrooms and interactive videos have been investigated before (Ratnaningtyas et al., 2020; M. K. Seery, 2013; Smith, 2013), most of these involve smaller lecture classes or laboratory classes. The current research investigating the perceptions of these tools mainly falls to the faculty and students who use it (Copeland, 2021; Keengwe et al., 2008; Mali & Lim, 2021). This research study attempted to investigate the gaps in the current literature.

This research used an embedded convergent mixed method to investigate the perceptions and usage of the interactive video platform PlayPosit in a undergraduate General Chemistry I course. An embedded convergent mixed methods approach allows for quantitative and qualitative data to collected and analyzed concurrently and one set of data (the quantitative data in this research) is embedded within the other data to help answer the research questions (Yu & Khazanchi, 2017). The qualitative in this research involved semi-structured interviews with faculty and teaching assistants (TAs) of the General Chemistry I (CHE 105) course about their perceptions and usage of the PlayPosit platform. The quantitative data involved student surveys utilizing the technology acceptance model (Davis, 1989; Lee et al., 2013; Park, 2009) and PlayPosit analytical information. Open-ended responses were also included in the student surveys to gain qualitative data from the students.

Analysis of the data followed the Activity Theory theoretical framework that was originally based on Vygotsky's activity theory (Mwanza, 2001; Vygotsky, 1978). In the original theoretical framework, Vygotsky posited that learnings are not isolated in their learning and that they are part of a larger activity in their learning journey (Vygotsky, 1978). This theory evolved to encompass many other areas that play a role in a learner's (also referred to as subject) journey; these include the subject, mediating tool, community, division of labor, rules, and object(ive) (Mwanza, 2001; Scanlon & Issroff, 2005). For both sets of interviews, there was an overall community among themselves, no larger set of rules that they had to follow, and faculty and TAs saw themselves as facilitators of knowledge. Some other themes emerged during the interviews and these included student buy-in, student engagement, and student learning. For a majority of the interviews, the responsibility of learning was put on the students and the faculty and TAs were to help facilitate that whether it actually occurred or not. Student responses saw the

general value of PlayPosit, but the time and energy they needed to do the PlayPosits had them generally disliking the platform.

Quantitative data in the form of student surveys saw that the perceptions of PlayPosit saw a general decrease over the semester independent of gender, major, or previous PlayPosit use. Utilizing the technology acceptance model showed that there was a positive correlation (albeit small one) between the different constructs (integration, ease of use, effect on learning, attitude, engagement, and perceived usefulness) and behavioral intention, which is a large indicator of actual usage. Looking at actual PlayPosit usage, the average number of videos watched and completed showed that students were not completing the videos. Correlations did show that there was a positive association between PlayPosit grade and final grade.

While new answers in the research were obtained through this research, no study is without its limitations. In this study, the student response rate especially in the post-semester survey was low, so paired data was not able to be investigated. Further studies could investigate more in-depth the role interactive videos have in the classroom, especially in larger classes like CHE 105. This study was able to give insight into how the perceptions of the interactive video platform PlayPosit by faculty, TAs, and students affect its usage.

KEYWORDS: [Interactive videos, college chemistry, activity theory]

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May 17, 2023

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THE PERCEPTIONS AND USAGE OF THE INTERACTIVE VIDEO PLAYPOSIT IN A GENERAL CHEMISTRY COURSE

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DEDICATION

To my husband, Matt, and my daughter, Parker. Your support and love let me know that I can do anything. I love you forever and always.

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CHAPTER 1. INTRODUCTION

1.1 Background

Technology within the classroom has been a topic of discussion, especially what is considered technology, for decades (Reiser, 2001, 2007). Everything from the use of film and print media in the early 20th century; audiovisual media in the 1960s; the internet and microcomputers in the 1990s; to now in the 21st century with smartphones, personal computers, and numerous software (Garrison & Akyol, 2009; Reiser, 2001, 2007), technology in all its many iterations and definitions have been a part of the educational landscape. With every different type of educational technology that has arisen, one question has been consistent, how does it affect student learning. Reiser (2001) stated that as new technology media has emerged in the educational scene, there is a great deal of enthusiasm about its effect on student learning, but that ultimately peters out and there is overall little impact on student learning. Despite the history of lack of educational change with earlier technology, Reiser (2001) does speculate that new digital media will bring about greater changes in instructional practices. This can be due to the awareness that educational technology should be more of a pedagogical tool and not the instructor itself (Garrison & Akyol, 2009; Imathiu, 2018; Kumar et al., 2021; Reiser, 2001).

In more recent years, technological trends have created a shift from the normal didactic face-to-face lecture to a more dynamic blended learning or distant learning approach (Atkins, 2015; Tayebinik & Puteh, 2013; Williams et al., 2008). There has been new research investigating these trends and how they not only affect student learning but also how to properly implement them (Al-Qahtani & Higgins, 2013; Atkins, 2015; López-Pérez et al., 2011; Tayebinik & Puteh, 2013).

1.2 Statement of the Problem

As technology has evolved, its implementation and role in education has increased. There have been many discussions about the effect of technology and student learning (Garrison & Akyol, 2009; Kumar et al., 2021; Oliveira et al., 2021). One of the major trends that has been discussed is blended learning, where there is a mixture of face-to-face instruction and online instruction and/or instructional material (Al-Qahtani & Higgins, 2013; Guàrdia et al., 2021; M. K. Seery, 2013). As will be discussed in the literature review, there is no set ratio of face-to-face versus online in blended learning. One of the most significant areas that has seen a large benefit of blended learning has been the science, technology, engineering, and mathematics (STEM) fields. One such benefit to including online learning tools is the flexibility for students (Atkins, 2015; M. K. Seery, 2013) which enables better interaction with the material. Even just the introduction of other educational technology tools, like simulations, have shown to have a positive impact on student learning (Dori & Barak, 2003; M. K. Seery, 2013). Studies have shown that technological tools lower students' cognitive load and allow for better understanding and learning (Johnstone, 1991; M. K. Seery, 2013; M. K. Seery & Donnelly, 2012). This is seen in several STEM fields but discussed quite often in fields like chemistry where a lot of the material is at the molecular or micromolecular level making it difficult for students to visualize and make connections (Johnstone, 1991, 1997). There has been a growing number of chemistry education research (and other STEM fields) looking at technology and blended learning and their impact on student learning (Johnstone, 1997; M. Seery, n.d.; M. K. Seery, 2013). This has led to many educators working towards implementing a blended learning environment.

A more specific focus of blended learning that has gained traction over the past few years, especially in the STEM fields, is the flipped classroom (Ratnaningtyas et al., 2020; M. K. Seery, 2013; Smith, 2013). In the flipped classroom, the normal lecture

material is given outside of class before hand and the in-class time is spent doing clarification and hands-on activities (Brame, 2016; Casselman et al., 2020; M. K. Seery, 2013). This switch allows students to get acquainted with the material, usually via videos like PlayPosit, before coming to class to get more familiar with it and be able to ask the professor questions (Casselman et al., 2020; Johnson, 2013; M. K. Seery, 2013; Smith, 2013). These before lecture activities have shown to help improve student understanding of the material and grades because the cognitive load of the material is reduced for the students (M. K. Seery, 2013).

Because blended learning has a higher reliance on technology compared to more traditional didactic lectures, the integration of technology and its effects on student learning has once again been brought to the forefront. This research has been around in some iteration for decades (Magalhães et al., 2020; Rossing et al., 2011; Sun, 2014; Zachos et al., 2018), and one of the ways that it has been researched is perceptions of the technology and its use by faculty and students (Fitzpatrick et al., 2011; Keengwe et al., 2008). The research involving perceptions has shown that when there is perceived buy in of the technology and its usefulness, there is a greater positive impact on student learning (Taylor, 2013; Zaza & Neiterman, 2019). Both faculty and students use the technology and interact with it and the course material more thoughtfully leading to better student learning. However, a major area has been lacking in this area of research, and that is the perceptions of teaching assistants (TAs) on technology usage. In a lot of large STEM classes, TAs take on the role of teacher, whether in recitations, laboratories, or even lectures themselves (Wan et al., 2020). However, these ‘instructors’ have not been researched when they play a large part in chemistry student education.

1.3 Purpose of the Study and Research Questions

Although there have been studies showing the benefits of a flipped classroom in K-12 and higher education (Bishop & Verleger, 2013; He et al., 2016; O'flaherty & Phillips, 2015) there have been some questions about creating a flipped classroom in larger courses (Bancroft et al., 2021; Hibbard et al., 2016)**.** One of the main components of a flipped classroom is that a majority of the lecture material is covered beforehand, and all practice problems (or student-centered active learning) are done during the normal lecture time. In order to implement this format, pre-recorded videos are used to give the lecture. Students watch the videos at home, and there are some pre-recorded videos that incorporate quizzes to help determine students' understanding. One of these interactive videos that is used in CHE 105 is PlayPosit. PlayPosit is an interactive video where questions are interspersed throughout the video (*PlayPosit*, 2022). The analytical information, I.e., views and answers, is given to the professors and teaching assistants so they can use that information in the classroom (*PlayPosit*, 2022). However, participation buy-in affects how well these interactive videos are utilized in student learning (Fisk, 2022; Hibbard et al., 2016). This study will investigate this concept of participation buy-in towards interactive videos, specifically PlayPosit, in a large general chemistry course at the University of Kentucky. Participation buy-in will be investigated by how teachers, teaching assistants, and students perceive the digital tool.

The purpose of this study is to investigate whether the perceptions of interactive videos, specifically PlayPosit, affect the usage of the digital platform by teachers, teaching assistants, and students in a large general chemistry I course. Although the main participants interacting with these videos are the professors who make the videos and the students who view them, the study will attempt to fill in the gap on teaching assistants. Teaching assistants play an important role in the active learning part of the flipped classroom equation. They incorporate content and active learning in recitation

sections. However, their actual roles in student learning are not portrayed as large compared to faculty. The study will attempt to answer the following research question:

1) How does the perceptions of PlayPosit affect the usage of it by the faculty, teaching assistants, and students of CHEM 105?

To answer this research questions an embedded convergent mixed methods (Creswell & Creswell, 2018; DeCuir-Gunby & Schutz, 2017) study will be used. An embedded convergent mixed methods approach is when both qualitative and quantitative data are collected and analyzed concurrently. The results of one set of data is “embedded” within the other data to help answer the other data (DeCuir-Gunby & Schutz, 2017). For the purposes of this study, the quantitative data will be embedded within the qualitative data to help answer the research question. The study will take place at the University of Kentucky utilizing the general chemistry I course (CHE 105) over two semesters (fall and spring). The quantitative data will be comprised of a student survey on perceptions of PlayPosit. The qualitative data will be comprised of interviews with faculty and TAs. There will also be some open-ended responses in the student surveys with the potential for follow-up interviews. Table 1-1 explains how each research question will be addressed in terms of data collection method.

Table 1-1. Research Questions and Data Collection Method

Research Questions	**Data Collection Method**
What are the perceptions of PlayPosit of faculty and how does that affect the use of it?	Faculty interviews
What are the perceptions of PlayPosit of teaching assistant and how does that affect the use of it?	Teaching assistant interviews
What are the perceptions of PlayPosit of students and how does that affect the use of it?	Student Surveys Student interviews

1.4 Theoretical Framework

The one main theoretical framework being used in this research study is Activity Theory (Scanlon & Issroff, 2005). It will be discussed in more depth in Chapter 2 but briefly will be mentioned here.

1.4.1 Activity Theory

Activity theory is rooted in Vygotsky's sociocultural approach to cognition (Tamayo, 2002; Vygotsky, 1978). In his theory, Vygotsky states that higher mental functioning and human action are mediated by tools and signs. There is some debate on what can be constituted as a tool, whether that is physical tools or even a teacher. In this research study, technology will be considered the tools. His original activity theory triangle relates the subject (generally the student), the object (knowledge), and mediating tools (Eun, 2010; Tamayo, 2002; Vygotsky, 1978). Although the original theory is a good foundation, others have expounded on Vygotsky's work and shown that individual students learn within a larger context, including the classroom environment. This original theory has evolved into something more complex that integrates the learner, object, mediating tools, and the dynamic nature of human activities (Tamayo, 2002). One of the adapted activity theory triangles that has become the new basis for activity theory in educational contexts can be seen in Figure 1.1. Further expansions of this triangle include the idea that all of these components come together to help learners create some sense-making leading to a particular outcome (Engeström, 2001).

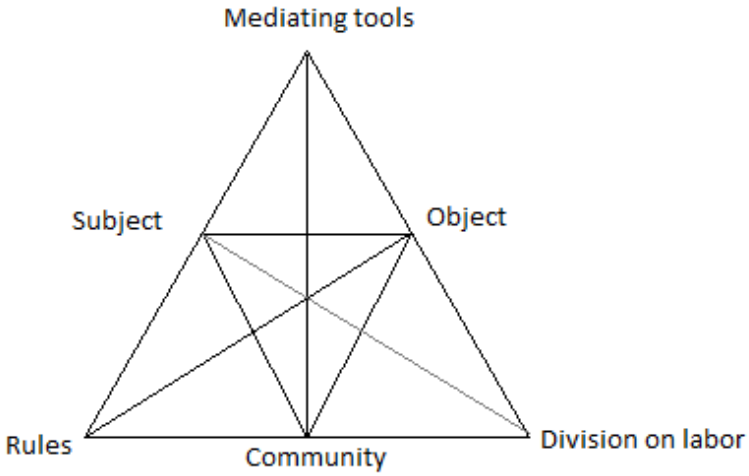

Figure 1-1. Expanded version of the classical mediational triangle. Recreated from Tamayo, 2002

1.5 Organization of Study

This dissertation will consist of five chapters. They will proceed as follows:

Chapter 2 will cover the literature review and theoretical framework in more detail. The literature review will cover interactive videos in the classroom and previous research on student, faculty, and TA perceptions about technology and/or interactive video usage.

Chapter 3 will discuss the methodology of the study including potential participants, data collection methods, and course structure and formats.

Chapter 4 will include all of the data that results from the study.

Chapter 5 will discuss the results of the study and make concluding remarks.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Literature Review

2.1.1 Technology and the Classroom

Technology use in the classroom has been around for decades. Everything from overhead projectors to compact discs to the emergence of the internet has become a part of the learning experience (Duhaney, 2000; Reiser, 2001). As technology has become a greater part of the educational experience, many educators and researchers have wondered, researched, and evaluated different technological tools and their effects on student learning (Bennett et al., 2012; Duhaney, 2000).

When considering technology as part of the classroom, whether K-12 or higher education, there have been many terms referenced and discussed to describe the different modalities. Some of these include but are not limited to, online learning, mobile learning (m-learning), e-learning, distant learning, and blended/hybrid learning (Ashraf et al., 2021; Basak et al., 2018; Dziuban et al., 2018; Tayebinik & Puteh, 2013). Within these terms, there has been overlap and many discussions about the boundaries of these terminologies. All of them include some technological tool component, whereas online or distant learning consistently means all instruction occurs online whether synchronous or asynchronous. Blended learning involves the integration of face-to-face instruction and online activities (Garrison, 2011; Garrison & Vaughn, 2008). Although there is no set proportion of face-to-face instruction and online activities, this description of blended learning is most consistent in the literature (Al-Qahtani & Higgins, 2013; Ashraf et al., 2021; Dziuban et al., 2018; Garrison, 2011).

2.1.2 Technology and Student Learning

Lastly, online video lectures, pre-recorded videos, or interactive videos have started to come to the forefront in educational technology discussions. This is because of the shift starting to happen towards flipped classrooms, where a majority of the lecture material is given in videos outside of class, and in-class time is spent on refining the information and problem solving (Bernard et al., 2017; Seery, 2013). This increase was also seen during COVID due to accessibility issues and other troubles students had while doing school at home (Kumar et al., 2021; Rapanta et al., 2021). Recorded videos do also refer to situations where professors record their lectures in real-time and post them afterward for students to come back and review. Most of the research, however, looks at pre-recorded videos, and based on where this study takes place interactive videos will mostly be discussed. In the current research, most students appreciate these videos because it allows them time to digest the information before going to class and allows them to go back and review the lecture material at a later date (C. S. Fichten et al., 2015; Moravec et al., 2010). There has also been an increase in student learning when students utilize the videos to their full extent (Agustian & Seery, 2017; C. S. Fichten et al., 2015; Moravec et al., 2010). Although they can be time-intensive up front, most professors like that these videos allow for more practice and discussion in class. It also allows for better clarification in the class after students watched the videos. Some platforms allow for embedded quizzes (graded or otherwise) to be embedded in the video to not only test the students' understanding but also allow the professors to see where students struggled the most and then clarify in class (Castro, 2019; C. S. Fichten et al., 2015). This allows for a more active-learning approach to the videos compared to just passively watching online videos of lectures. Although this study focused on the interactive video platform, PlayPosit, the discussion of flipped classrooms came up. Along with the research of Bernard et al. (2017) and Seery (2013), the researcher

defined flipped classroom as the traditional lecture content is done outside of class on the students' own time and the actual work (or what would be considered homework) is done in class.

2.1.2.1 Assessing Student Learning

There have been other indicators of student learning throughout the research, and these include student engagement and perceptions or attitudes (Fry et al., 2009; Schwab et al., 2018; Zaza & Neiterman, 2019). Studies have shown that students who are more engaged in the classroom tend to self-evaluate improved learning (Bernstein, 2021; Fry et al., 2009; Macarthur & Jones, 2008). There is also a positive correlation to student achievement with increased student engagement (Bernstein, 2021; Fry et al., 2009). Studies have shown that students can be quite reflective of their own learning and use perceptions to help bring forth those reflections (Bernstein, 2021; Fry et al., 2009; Keengwe et al., 2008). When students feel more engaged and the pedagogical practices of professors are more thoughtful and purposeful, they state that their perceived learning is improved (Fry et al., 2009; Keengwe et al., 2008). Although neither is a perfect indicator of student learning, student perceptions and achievement (i.e., grades) have to suffice until other forms of assessing student learning at a large scale can be used properly.

2.1.3 Perceptions of Interactive Videos in the Classroom

Many studies and developers have touted how well their particular technology or digital platform helps make teaching more effective or increases student learning (Akçay et al., 2006; Bond & Bedenlier, 2019; G. E. Kennedy et al., 2008; Venkatesh et al., 2014). One thing that has been noted throughout the literature on technology integration in the classroom is how effective the technology is depends on how it is used by all

those involved in the classroom. A major takeaway on how technology is used is due to perceptions of the technology. Some studies have shown that faculty will use technology if they perceive it to be beneficial to the students or helps them in administering the course (Copeland, 2021; Croteau et al., 2015; Georgina & Olson, 2008; Venkatesh et al., 2014). Students tend to find value in technology when it helps them feel more engaged and an active participant with the content in class (Diemer et al., 2012; Keengwe, 2007; Lennox & Aceti, 2012; Owston et al., 2013). Teaching assistants, despite having less research discussing their perspectives, have similar perceptions as faculty (Godlewska et al., 2019; Granić & Marangunić, 2019; Osterlund & Robson, 2009; Roehrig et al., 2003). Although the research mentioned covers technology broadly, similar general perceptions of interactive videos, like PlayPosit, occur in the literature and will be discussed more specifically in the next sections.

2.1.3.1 Faculty Perceptions

There have been a few studies that have looked at perceptions of technology usage among faculty (Fitzpatrick et al., 2011; Georgina & Olson, 2008; Ryan Fisk, 2022; Taylor, 2013). As technology has advanced, its integration within the classroom has been either impeded (Copeland, 2021; Rapanta et al., 2021; Valenti et al., 2019) or enhanced (Gaddis, 2020; Napier et al., 2011; Venkatesh et al., 2016) by faculty perceptions and self-efficacy toward that technology. Georgina & Olson (2008) looked at three main questions concerning technology integration, faculty skills, and their pedagogical practices. They found that the technology skills of faculty were strongly correlated to the potential of integrating technology into their course. As the technology got more advanced, e.g., smart classrooms versus projector screens, the awareness, proficiency level, and ultimately integration of the technology decreased (Georgina & Olson, 2008). This was also seen in the research on technology effectiveness by others

(Croteau et al., 2015; Venkatesh et al., 2014). Croteau et al. (2015) saw in their research that as instructors became more familiar with technology, they saw a significant contribution that the technology made to their students' learning. However, instructors found that learning strategies were more influential to student learning than the actual usage of technology (Croteau et al., 2015). The biggest takeaway from most of the research on faculty perceptions of technology usage was the more comfortable faculty felt about the technology themselves, the more likely they would integrate it within their classroom (Croteau et al., 2015; Georgina & Olson, 2008; Venkatesh et al., 2014). In Copeland (2021), she saw similar results that faculty integrated technology in their classroom where they were most comfortable with its use, like basic knowledge transmission, behind-the-scenes work, and communication purposes. Most faculty knew what would work to enhance the students' learning experience and stuck with that level of technology integration.

Although the previous paragraph discussed technology as a whole, similar sentiments have been made about recorded videos, especially those like PlayPosit, from faculty (Bakla & Mehdiyev, 2022; Carney, 2017; Kumar et al., 2021; Quan & Buikema, 2018). The major complaint from faculty when trying to implement interactive videos, pre-recorded videos, or even the flipped classroom is the heavy time commitment in the beginning (Beck, 2019; Bent et al., 2020; Haagsman et al., 2020; McLaughlin et al., 2014; O'flaherty & Phillips, 2015; Valenti et al., 2019; Weinert et al., 2020). However, once the videos are set up, the time commitment drops down (Bent et al., 2020; Henderson et al., 2017; McLaughlin et al., 2014; Weaver & Sturtevant, 2015). Despite the time commitment to get the videos up and running, faculty have noted the increase in student learning (Ashraf et al., 2021; Bernard et al., 2017; M. K. Seery, 2013; Smith, 2013). One of the main reasons for this is that the videos, especially with quizzes embedded, allow for students to become more active in their learning both with the pre-

lecture videos and the in-class activities (Lee & Kim, 2018; Shattuck, 2016; Weaver & Sturtevant, 2015). Student learning seems to be improved when the classroom takes on a student-centered active learning approach (Godlewska et al., 2019; Lee & Kim, 2018; Shah et al., 2013; Shattuck, 2016; Weaver & Sturtevant, 2015).

2.1.3.2 Student Perceptions

Although faculty have general control over what is done in their class, like the digital tools used, students and their learning have an impact on changes that can be made. Generally, faculty assess the effectiveness of a technology (or group of technologies) by student achievement (e.g., grades). Some literature has suggested that achievement should not be the impetus for technology usage on student learning (Fitzpatrick et al., 2011; Heflin et al., 2017; Henderson et al., 2017; Hornsby & Osman, 2014). Many of these studies and others have stated that student engagement is one of the strongest indicators of student learning (Henderson et al., 2017; Hornsby & Osman, 2014; Owston et al., 2013; Wan et al., 2021). Lennox & Aceti (2012) stated that while professors and their pedagogical choices/practices are the basis for the classroom experience, technology may offer a means to enhance student engagement. They also stated that student engagement is one of the bigger predictors of learning and personal development, academic success, and retention (Lennox & Aceti, 2012).

Student perceptions of technology use tend to fall into two main categories: how faculty use it and self-efficacy. A majority of studies that looked at students' perceptions of technology usage showed that the pedagogical integration (i.e., specifically how the professor integrated the technology) had a greater impact on their perceived effectiveness of the technology and their learning (Diemer et al., 2012; C. S. Fichten et al., 2015; Harrison, 2013; Henderson et al., 2017; Lennox & Aceti, 2012; Ramstedt et al., 2016). Therefore, even if the technology itself could be highly effective in increasing

student learning (e.g., student response systems), if the professor did not integrate it thoughtfully into the course, students are inclined to not favor the technology (Lennox & Aceti, 2012). Students most positively favored technology that helped them become more engaged in and out of the classroom, allowed different avenues to interact with the course material, and seemed to follow a more collaborative and active learning approach (Diemer et al., 2012; C. Fichten et al., 2018; Harrison, 2013; Lennox & Aceti, 2012; Ramstedt et al., 2016).

Although not as proportionately affecting student perceptions and learning, students' self-efficacy towards technology has shown to also have an impact. Some studies have indicated that when students are more comfortable with technology, they tend to report significantly greater levels of perceptions of learning and engagement (Diemer et al., 2012; C. S. Fichten et al., 2015; Keengwe, 2007; G. Kennedy et al., 2008). The potential disfavor of technology may be due to the time they have to spend learning how to navigate the technology instead of the course content. It can make it more difficult to be engaged in the material when they are working on learning how the technology works and how they are supposed to use it. In the C. S. Fichten et al. (2015) study, they found that students wanted not only technology-savvy professors, but also for their instructors to show them how to use the technology specifically for the course. Students then may feel more comfortable with the technology going forward and be able to be engaged with the material from the beginning. The technology acceptance model (TAM) and its many iterations have shown that when users of technology favorably view the technology (usually in terms of ease of use and usefulness), they have higher behavioral intentions of using the technology (Estriegana et al., 2019; Granić & Marangunić, 2019; Park, 2009; Venkatesh & Davis, 2000; Wong et al., 2013).

One of the most discussed pros with interactive videos from students is the flexibility that comes with viewing the videos (Fyfield et al., 2019; Shattuck, 2016; Wang

et al., 2019). This flexibility does not only pertain to viewing the content before class, but also the ability to return to the videos any time after class, like right before an exam to review (Alpert & Hodkinson, 2019; Lynne Nielsen et al., 2018; Reid, 2016; Shah et al., 2013). It also allows students to understand the material on their own time and use class time for resolving unanswered questions (Fyfield et al., 2019; Shah et al., 2013; Silverajah & Govindaraj, 2018). In a study done by Carney (2017), high school chemistry students were given different lecture videos, YouTube, EdPuzzle, and PlayPosit, and their achievement, engagement, and attitudes were evaluated. The author found that although student achievement was not statistically significant across the video types, student engagement and attitudes towards the interactive videos were more positive (Carney, 2017). The main reason that students preferred the interactive videos to YouTube videos, was the embedded teacher questions that made their learning experience more active and helping them be prepared for class (Carney, 2017).

Although students generally perceive PlayPosit and other interactive videos positively, there have been some negative comments about the videos. A common negative comment about interactive videos is the time commitment required for the videos especially when there is a time constraint on when it has to be completed (Alpert & Hodkinson, 2019; Reid, 2016; Shah et al., 2013). On a more technical side of student perceptions, the one study by Carney (2017) that compared EdPuzzle and PlayPosit, saw that a major drawback to PlayPosit was that students could not fast forward through the video. From an educational standpoint, keeping students on task within the videos makes sense, but if a student already knows the material, it can seem more like busy work to complete the video (Carney, 2017).

2.1.3.3 Teaching Assistant Perceptions

In larger universities, graduate TAs serve the role of the instructor in introductory classes, mostly recitation and laboratory in the STEM fields (Rivera, 2018; Wan et al., 2020, 2021). Therefore, teaching assistants should be included in research that involves student learning since they do play a role in undergraduate education. More research has begun to emerge on graduate teaching assistant training especially in terms of their roles as teachers (Godlewska et al., 2019; Osterlund & Robson, 2009; Rivera, 2018; Roehrig et al., 2003; Wan et al., 2020, 2021). However, there is limited research on teaching assistants' perceptions of technologies in the classroom. Some of the literature covers TAs roles in technology integration in a very limited capacity, and they are generally only mentioned in the methodology (Atkins, 2015; Fathema et al., 2015; Godlewska et al., 2019; Law, 2019; Samson, 2010). One study looked at the conversion of a chemistry course to a blended learning environment over several years (Godlewska et al., 2019), and as part of the study, TA perceptions were included. The TAs stated that the blended active learning environment was a powerful experience for the undergraduates and themselves (Godlewska et al., 2019).

Although most of the literature involving teaching assistants is based on their own training, there are some similarities when compared to comments made by professors. The main takeaway that was seen in some of these articles was that when TAs created a learning environment as a two-way street that was more learner-centered versus teacher-centered, student learning was positively affected (Godlewska et al., 2019; Rivera, 2018; Roehrig et al., 2003). Just as in faculty perceptions about technology integration, when the focus is more on the pedagogical use of the technology and it is used in a meaningful way, students tend to have a better understanding of the material. Most research that includes TAs with interactive videos or in a flipped classroom use the TAs as in-person instructors, and their perceptions are not

questioned as much as students or faculty (Barak, 2007; Godlewska et al., 2019; Nielsen et al., 2018; Rivera, 2018). This may be due to their role as more of a facilitator than professor/instructor. TAs generally do not have control over what is being taught for each class period but help facilitates student learning in the classroom by helping work problems and answer clarifying questions (Godlewska et al., 2019; Nielsen et al., 2018; Roehrig et al., 2003). However, Smith (2013) noted that one advantage of pre-recorded videos was that it allowed TAs to follow along with the lecture material at their convenience and allow them time to become prepared to help students in the course.

2.2 Theoretical Framework-Activity Theory

As mentioned earlier in the first chapter, Activity Theory is rooted in Vygotsky's sociocultural approach to cognition (Engeström, 2001; Tamayo, 2002; Vygotsky, 1978). In his theory, Vygotsky states that higher mental functioning and human action are mediated by tools and signs, and that learners are not isolated in their knowledge attainment but rather are a part of the sociocultural context in which they exist. There is some debate on what can be constituted as a tool, whether that is physical tools or even a teacher. In this research, interactive videos (PlayPosit) will be considered the mediating artifact. His original activity theory triangle relates the interplay between the subject (generally the student), the object (knowledge), and mediating tools (Figure 2.1) (Eun, 2010; Tamayo, 2002; Vygotsky, 1978).

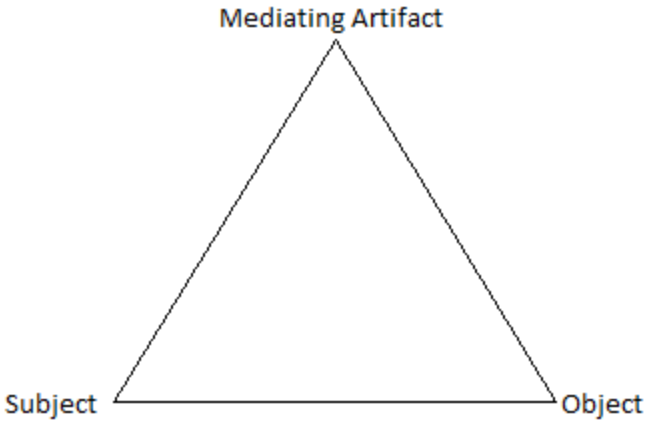

Figure 2-1. Vygotsky's mediated triangle. Recreated from Vygotsky, 1978

Although the original theory is a good foundation, others have expounded on Vygotsky's work and shown that individuals could not be understood without their cultural means (Engeström, 2001; Kahveci et al., 2008). This can be applied to students learning within a larger context, including the classroom environment. This original theory has evolved into something more complex that integrates the learner, object, mediating tools, and the dynamic nature of human activities (Engeström, 2001; Kahveci et al., 2008; Tamayo, 2002). One of the adapted activity theory triangles that has become the new basis for activity theory in educational contexts can be seen in Figure 2.2. Further expansions of this triangle include the idea that all of these components come together to help learners create some sense-making leading to a particular outcome (Engeström, 2001).

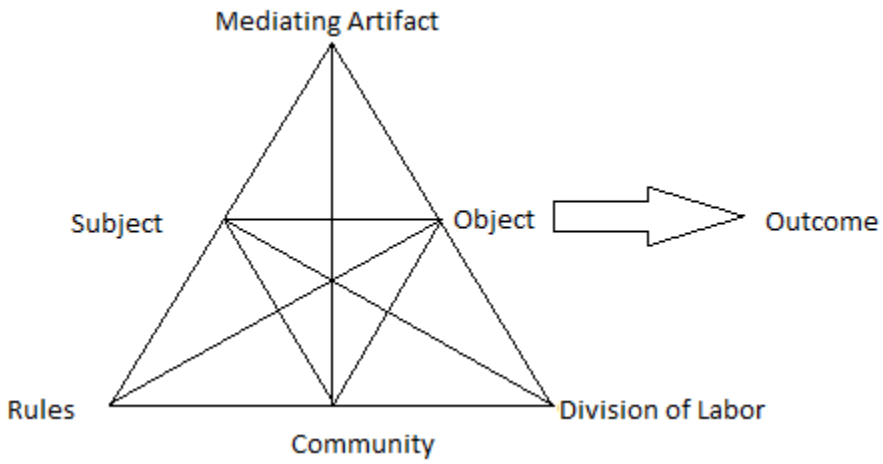

Figure 2-2. Expanded version of the classical mediational triangle. Recreated from Tamayo, 2002

Comparatively, this second iteration of the activity triangle allows for a more complete look at individuals and their roles within a larger context. However, this second generation of the model brings into question how these individuals and individual activity systems interact in even larger contexts. For example, in the discussion by (Engeström, 2001), patients within a hospital system fulfill different roles creating different contexts of those patients in the system. One role is as a person to be healed while the other is as a source of income. The contextual roles and thus object(ives) and outcomes are wholly different but for the same person. This idea can be transferred to higher education classrooms. Students can be seen as both a source of income and an individual learner to be developed (Scanlon & Issroff, 2005). Thus, the outcome of the student as income versus as a learner creates a different space and activity system that functions around them. This interchange of how the activity triangle is used to look at a situation has led to the third generation of activity theory. The third generation (Figure 2.3) allows for interacting systems to portray interconnectedness in larger contexts.

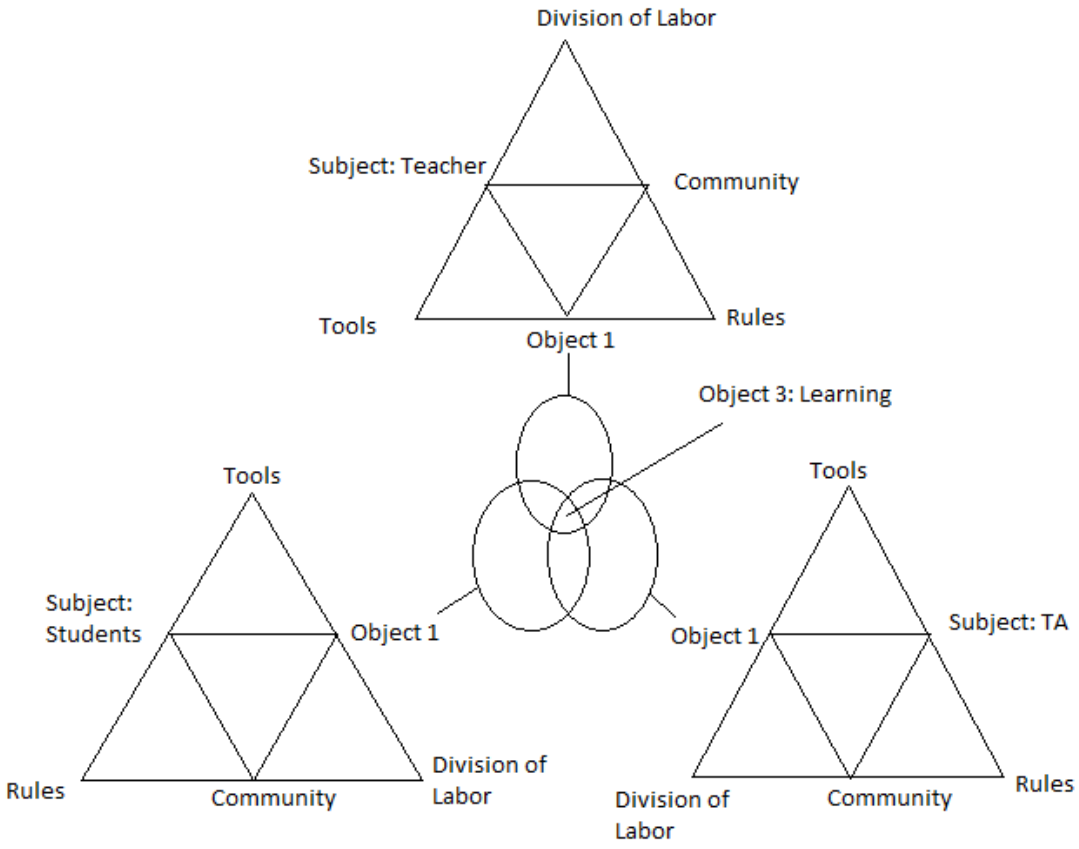

Figure 2-3. Third generation of the activity system. Recreated from Engeström, 2001

According to (Engeström, 2001), the object moves from an individual contextual state (object 1) to a collectively meaningful object (or outcome) created by the activity system (object 2), and eventually to a shared or jointly constructed object (object 3). This interaction can be seen in chemistry education. The main conceptualization of the interacting activity systems is students versus teaching assistants versus professors as the subject. Each of these individual subjects creates a different activity system among themselves, i.e., the roles they play and view others, the communities that are formed, division of labor, etc. The overall objective (object 3 in Figure 3) is chemistry learning.

2.2.1 Activity Theory as an Evaluation Lens

Generally, a theoretical framework is used as a lens to evaluate some type of research. Activity theory is no exception to its potential use. There have been quite a few studies using activity theory to critically look at e-learning and chemistry education (Benson et al., 2008; Kahveci et al., 2008; Scanlon & Issroff, 2005; Zheng et al., 2020). Benson et al. (2008) and Mwanza (2001) describe their use of the activity theory for analysis in the context of e-learning. They used a reduced version of the eight-step model set forth by (Mwanza, 2001) to guide their analysis. Mwanza (2001) developed eight questions to ask when trying to conceptualize an activity system. It is used to guide where items fall within the mediational triangle (specifically the second iteration, Figure 2.2). These eight questions are as follows:

1. What sort of activity am I interested in? = Activity
2. Why is this activity taking place? = Object(ive)
3. Who is involved in carrying out this activity? = Subjects
4. By what means are the subjects carrying out this activity? = Tools
5. Are there any cultural norms, rules, or regulations governing the performance of this activity? = Rules
6. Who is responsible for what, when carrying out this activity, and how are these roles organized? = Division of labor
7. What is the environment in which this activity is carried out? = Community
8. What is the desired outcome of the activity? = Outcome (Benson et al., 2008)

Benson et al. (2008) researched learning management systems (LMSs) and originally placed the item as the object of the activity system. However, after using the eight questions from Mwanza (2001), they changed their focus of the LMS to a part of the infrastructure that impacts on all three mediators (tools, rules, and divisions of labor) of activity at the same time. This helped showed that where the LMS was placed within

the activity system, it can go from responsive to directive in terms of student learning. Thus, the eight-step model for using activity theory as an evaluation lens will be used in this research study. The eight-step model appears to only pertain to an individual activity system, so it will be used differently for different subjects. Based on the eight questions, this proposal speculates the following for the activity systems:

1. Activity: CHE 105
2. Object(ive): to help students understand chemistry concepts
3. Subjects: teachers, students, and TAs
4. Tools: PlayPosit
5. Rules: using PlayPosit is part of the students' grade
6. Division of labor: who makes the videos, do TAs view the information from the videos, etc.
7. Community: CHEM 105
8. Outcome: utilizing all of PlayPosit's capabilities with the classroom content

CHAPTER 3. METHODS

3.1 Purpose and Research Questions

The purpose of this study was to investigate whether the perceptions of interactive videos, specifically PlayPosit, affect the usage of the digital platform by teachers, teaching assistants, and students in a large general chemistry I (CHE 105) course. The study will attempt to answer the following research question:

1) How does the perceptions of PlayPosit affect the usage of it by the faculty, teaching assistants, and students of CHEM 105?

The main research question was broken down into each group separately. Table 3-1 shows the individual questions and the associated data collection method. Each data collection method will be discussed below.

Table 3-1. Research Question and Data Collection Method

Research Question	Data Collection Method
What are the perceptions of PlayPosit of ***faculty*** and how does that affect the use of it?	Faculty Interviews
What are the perceptions of PlayPosit of ***teaching assistants*** and how does that affect the use of it?	Teaching Assistant Interviews
What are the perceptions of PlayPosit of ***students*** and how does that affect the use of it?	Student Surveys Student Interviews

3.2 Research Design

Because qualitative and quantitative approaches may not fully capture the entire picture individually, combining the two allows for more rich data and triangulation of that data. It allows the researcher to see all of the results of the data to get a clearer picture. Combined, this data can bring forth more rich data about CHE 105 and the usage of

PlayPosit. There are numerous ways that a mixed methods design could be implemented in a research study (Creswell & Creswell, 2018; Guetterman & Fetters, 2018), and it depends on what the researcher is trying to gain from the different quantitative and qualitative data. Because the qualitative and quantitative data in this study can be collected and analyzed at the same time, this study will follow a convergent style (Creswell & Creswell, 2018). Although each group of participants will be evaluated via their own data collection, a majority of the results relied on qualitative data. However, because the student population is large, the majority of their perceptions were analyzed via quantitative data in the form of surveys. This quantitative data was used to elevate the qualitative data, creating an embedded convergent mixed methods approach (DeCuir-Gunby & Schutz, 2017; Yu & Khazanchi, 2017). In an embedded convergent mixed methods approach, the quantitative data is collected and analyzed separately from but at the same time as the qualitative data collection and analysis (Figure 3-1). The results of one set of data (the quantitative in this research) are then embedded within the other set of data (the qualitative data) to answer or dispute the findings of the results (DeCuir-Gunby & Schutz, 2017; Yu & Khazanchi, 2017).

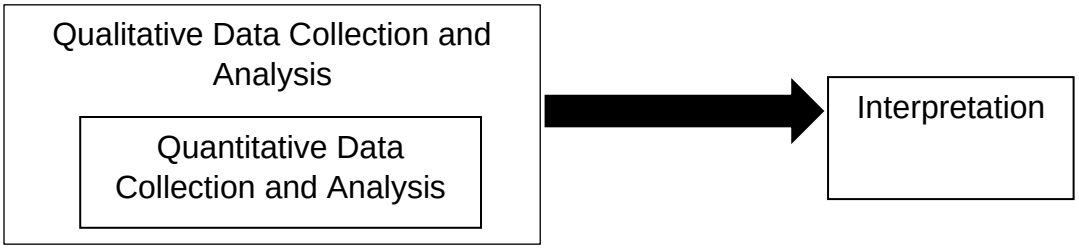

Figure 3-1. Embedded Convergent Mixed Methods. Adapted from DeCuir-Gundy and Schultz (2017)

Two main components were investigated in this research. The first being what are the perceptions of interactive videos, specifically PlayPosit, by faculty, teaching assistants, and students in General Chemistry I (CHE 105). The second component focused on the usage of PlayPosit, or how it was used. As mentioned earlier, an embedded convergent mixed methods approach was used because neither qualitative nor quantitative methods can fully answer those two main components that were investigated. Quantitatively, student surveys on their perceptions of PlayPosit were evaluated. To fulfill the qualitative aspect of this approach, open-ended responses within the survey were included. Students had the option to sign up for a follow-up interview, but there was a low number of respondents that did not warrant any follow-up interviews. To help investigate information on PlayPosit usage, analytical information was also collected. As part of the PlayPosit platform, analytics pertaining to the class can be linked to Canvas (for easier grade uploads) and given to the faculty. Some of these analytics include number of viewings and percentage of correct answers (go.playposit.com). The qualitative portion of data collection overall was from interviews with the faculty and TAs of CHE 105. The interviews covered general perceptions about PlayPosit, their teaching, and their usage or integration of PlayPosit in their class. With both the quantitative and qualitative data collected, a larger picture of PlayPosit perceptions and usage within CHE 105 were better understood (Figure 3-2).

Figure 3-2. Overview of Data Collection Methods

3.3 Setting and Courses Format

The setting of this research took place at the University of Kentucky, an R1 research institution. The class evaluated was the General Chemistry I course during the fall semester of 2022. At the University of Kentucky, General Chemistry I is designated as CHE 105 or CHE 109/110. CHE 105 is the General Chemistry I course covered over one semester, while CHE 109/110 is the course covered over two semesters. For the purposes of this study, only 105 was investigated. According to the UK Course Catalog (2022) for the Fall 2022 semester, there were 1680 available seats for CHE 105 over six different lecture sections.

As part of the CHE 105 course, there is a recitation section which is taught by a TA. Recitation meets for a 50-minute class session once a week and seats about 20-30 students. According to the Fall 2022 course catalog, there were eight recitation sections for each 105-lecture section. There was a total of eleven TAs over all the recitation sections. On average, each TA taught between one and five recitation sections.

Recitation in the chemistry department does not use PlayPosit to aid in the teaching of the course. However, the TAs do have a set plan of how they should run their recitation sections. Each week the recitation coordinator (Prof. D this semester) creates a worksheet based on the content that the students should be going over in their lectures. At their weekly TA meeting, the TAs go over the worksheet to make sure they have the content done. Then when they are in their recitation sections, they go over usually the first question (a scaffolding question) as a class, then they are to allow the students to work in groups to finish the worksheet together.

3.3.1 CHEM 105

CHEM 105 fulfills the requirement for UK Core, which is the university's general education requirements. All students have to attain 30 total credit hours across different colleges to fulfill their UK Core requirements. Under the Natural, Physical, and Mathematical Sciences, students are required to attain 3 credit hours to fulfill their core coursework (University of Kentucky, 2021). Although not part of this research, the General Chemistry I Laboratory (CHE 111) is a part of the UK Core requirements also. CHE 111 has to be taken either during or after 105 in order for students to move on to the next laboratory course (CHE 113), which is the laboratory for 107. According to the UK bulletin (University of Kentucky, 2021), 36 different degree programs require CHEM 105, and most of these degrees fall within the science, technology, engineering, and mathematics (STEM) fields. Six of the seven pre-professional programs (pre-medical, pre-pharmacy, pre-dental, etc.) also require CHEM 105 (University of Kentucky, 2021). Although most of the degrees that require CHEM 105 are within the STEM fields, since 105 applies to the UK Core requirements, non-STEM majors can take it. It is unclear, however, how many students on average take these courses in terms of STEM majors versus non-majors. As part of the demographic section of the surveys, area of

study/major was asked to see if there was a difference. The general topic overview for CHEM 105 are: properties of matter, dimensional analysis, the atom, chemical compounds, mole, dilution, chemical equations, types of reactions, basic thermodynamics, electromagnetic radiation, and gases.

3.4 Data Collection

Both the setting and participation selection was from convenient/purposive sampling (Acharya et al., 2013; Taherdoost, 2016). Purposive sampling is a non-random sampling where the research identifies the qualities that the participants need to possess to answer the research questions (Copeland, 2021; Taherdoost, 2016). Based on the research questions in this study, purposive sampling of the students, faculty, and teaching assistants of the General Chemistry I course at the University of Kentucky were able to help answer them. Instead of attempting to get a random sample of the participants, total population sampling was employed. This is when all of the potential participants are contacted and given the opportunity to choose whether to participate in the research study or not (Taherdoost, 2016). Although a major factor is convenience when choosing the University of Kentucky due to the researcher's location and previous relationship with the department, the fact that it is an R1 research institution lends to the potential of similarities to other universities. In the chemistry department, there are a few professors who teach the general chemistry courses every semester (they may switch between General Chemistry I and II), but there is also a rotation of other professors that occurs. This allows for variability among the professors and could lead to discrepant cases.

According to the UK Course Catalog (2022) for the fall semester, there were four (two males and two females) different professors teaching six different sections of CHE 105. The first professor, Prof. A (all names are pseudonyms), taught one online,

asynchronous section of 105. Because the section was online and asynchronous, Prof. A utilized PlayPosit videos for their lectures. The second professor, Prof. B, taught two sections of CHE 105. Both sections were taught in person using PlayPosit in a flipped classroom format. Prof. C also taught two sections of Che 105 in person utilizing PlayPosit in a flipped classroom format. Prof. D taught one section of CHE 105 in person using a didactic-lecture style and not utilizing PlayPosit.

For the recitations, there were eight recitation sections for each lecture section. Overall, there were eleven total TAs covering all the 105 recitations. Each TA taught between one and five recitation sections. In order to incentivize TAs to participate, a $50 Visa giftcard was given after the TAs participated. There were a total of five different TAs (three females and two males) that participated in the interviews, TA-1, TA-2, TA-3, TA-4, and TA-5. TA-1 was a seventh-year international student who previously taught an online asynchronous section of CHE 109 over the summer. TA-2, TA-3, and TA-5 were all first-year graduate students, so this was their first semester also teaching recitation. TA-2, however, graduated with their bachelor's from UK, so they had both a TA and student perspective. TA-4 was a second-year graduate student. This was also their second year doing recitation.

Because these classes are quite large (hundreds of students in one lecture section), students' perceptions were evaluated via survey at the beginning and end of the semester (Appendix C and D, respectively). Because CHE 105 is General Chemistry I, many majors and fields of studies require it as prerequisite for future classes. This leads to a high number of different backgrounds of students taking the class.

In the mixed methods approach, it is important to decide on the order that data will be collected. As mentioned earlier, the overall data collection approach will be an embedded convergent mixed methods approach (Creswell & Creswell, 2018; DeCuir-Gunby & Schutz, 2017; Yu & Khazanchi, 2017) where the qualitative and quantitative

data were collected and analyzed concurrently. The quantitative data was used to answer the qualitative data; the quantitative data was embedded within the qualitative data to answer the research question. This type of approach allows the quantitative data to elevate or deflate the qualitative data.

3.4.1 Faculty Data Collection

Since there were only four total professors (two males and two females) who taught CHE 105 in the fall 2022 semester, faculty perceptions were collected via semi-structured interviews (Appendix A). Semi-structured interviews are generally more flexible with a few topics or questions that help guide the interview process (Tracy, 2020). The topics covered in the interviews were general perceptions about PlayPosit, including if they had used the platform before, their role in making the videos, and how it affected their usage of it. As mentioned earlier, flipped classrooms utilize these digital tools quite often, so questions about flipped classrooms and how their classroom is structured were also asked. However, the structure and flow of the interview was based on what came up during the interview.

Each faculty member was emailed individually and asked to participate in the research. Each interview lasted about 30 minutes and occurred in person or via Zoom based on the faculty and the researcher's schedules. All interviews were audio recorded via the Otter.ai auto-transcription application. A backup audio recording was done via voice memos on the researcher's Ipad. This was to ensure that the audio was recorded and to allow for verification when it was difficult to hear some of the audio recordings. After the interviews, the transcripts were verified in conjunction with the recordings. Thematic analysis was initially done using the main components of activity theory. As the transcripts were being verified, and initial coding occurred, other themes emerged that were not part of activity theory.

3.4.2 Teaching Assistant Data Collection

Although the role of the TA in CHE 105 recitation is not as prominent as the professors, their role as instructor in recitation is an important component. The TAs do not make any of the PlayPosit videos, but they do have access to the information gleaned from the platform. These include how many students completed the videos, whether answers were correct or not, and other similar analytical information. Similar to faculty data collection, semi-structured interviews were conducted with the CHE 105 fall 2022 semester teaching assistants. The interview protocol was similar to that of the faculty, but since recitation TAs may not fully see themselves in the teacher role, the protocol was amended to reflect that (Appendix B). The topics covered in the interviews were similar to the faculty interviews and included general perceptions about PlayPosit, including if they had used the platform before, any interaction with the platform, and how it affected their usage of it. As mentioned earlier, flipped classrooms utilize these digital tools quite often, so questions about flipped classrooms and how their classroom is structured were also asked. However, the structure and flow of the interview was based on what came up during the interview.

There were a total of eleven recitation TAs teaching in the fall 2022 semester. All CHE 105 recitation TAs were emailed and asked to participate in the research. Halfway through the semester, to increase participation, a $50 gift card was offered as an incentive. Eight TAs originally responded to the email, but only five ended up participating. Each interview lasted about 30 minutes and occurred in person or via Zoom due to the TA's and the researcher's schedules. All interviews were audio recorded via the Otter.ai auto-transcription application. A backup audio recording was done via voice memos on the researcher's Ipad. This was to ensure that the audio was recorded and to allow for verification when it was difficult to hear some of the audio

recordings. After the interviews, the transcripts were verified in conjunction with the recordings. Thematic analysis was initially done using the main components of activity theory. As the transcripts were being verified, and initial coding occurred, other themes emerged that were not part of activity theory.

3.4.3 Student Data Collection

It is generally viewed as students being the consumers in the classroom setting with the professors being the administers of information. This has been the focus of research indicating the difference between teacher-centered learning and student-centered learning (Trinidad & Ngo, 2019; Johnson, 2013). Although students are still the receivers of information, their perspectives and usage of classroom items, like PlayPosit, can potentially influence how it is used by the faculty and in the future (Switzer & Csapo, 2005; Cavanagh et al., 2016). This is why the perspectives of students on PlayPosit were collected. Because the student buy-in of certain tools in the classroom can change over a period of time (Lee & Kim, 2018), pre- and post-semester surveys were conducted via Qualtrics Survey Software. Both surveys contained general background and demographic information, questions about whether they have taken a chemistry class before, heard of or used PlayPosit before, and then Likert-style questions on their perceptions of PlayPosit.

The first 11 questions of the surveys asked students demographic questions, i.e., gender, age, major, and class standing. Along with these were questions on whether they have taken a chemistry course before and whether they have heard of or used PlayPosit or a similar platform before this class. The next section consisted of five-point Likert-style questions that were amended from the technology acceptance model questionnaires from Park (2009) and Lee et al (2013) and perception questions from Terrion & Aceti (2012). The last seven questions on the post-semester survey involved

further expansion on their perceptions and general usage questions. The questions were amended to cover PlayPosit and phrasing that indicated pre- and post-semester perceptions. For example, a question in the survey from Park (2009) states, “I find e-learning systems easy to use,” which had been phrased as “PlayPosit will be easy to use” in the pre-semester survey and “PlayPosit was easy to use” in the post-semester survey.

The technology acceptance model (TAM) survey options from Park (2009) and Lee et al. (2013) are based on the original TAM from Davis (1989) that looked at the perceived usefulness (PU), perceived ease of use (PEOU), and user acceptance of e-mail in the workplace. The technology acceptance model has been adapted in numerous studies (Al-Emran et al., 2018; Estriegana et al., 2019; Granić & Marangunić, 2019; Lee et al., 2013; Park, 2009; Venkatesh et al., 2003; Wong et al., 2013) evaluating the PU, PEOU, and user acceptance of technology. As the research has continued, the survey items have evolved to include other components that can be incorporated into technology users’ acceptance and use of technology. These include, but are not limited to, self-efficacy, computer anxiety, subjective norm, attitudes, and behavioral intention (Al-Emran et al., 2018; Estriegana et al., 2019; Granić & Marangunić, 2019; Lee et al., 2013; Park, 2009; Venkatesh et al., 2003; Wong et al., 2013). The TAM provides a basis for looking at how external variables influence belief, attitude, and intention to use of technologies (Park, 2009). Terrion & Aceti (2012), on the other hand, looked more specifically at the perception of student response systems and student learning and engagement. The items covered technical aspects of the clickers, student engagement, and effect on learning (Terrion & Aceti, 2012). All items were found to be reliable ($\alpha>0.75$) and the wording was amended from clickers to PlayPosit.

Both surveys can be seen in Appendices C (pre-semester survey) and D (post-semester survey). Because students could participate in however many surveys they

wanted, some of the introductory and demographic questions were repeated to ensure that whether they participated in one or the other, that information was evaluated along with the rest of the survey. Both surveys were included within the class and posted to the class Canvas site and extra credit was offered for those who completed at least one of the surveys. In order to potentially pair the data, the first question in both surveys involved a passcode that was specific to each individual student that should be easy to remember. The passcode involved the first three letters of their birth month (e.g., January=Jan), the two digits of their birthdate, and the last four digits of their phone number.

Because more information could be gained with qualitative information, open-ended responses at the end of the post-semester survey (Appendix D) were included. There was also a link to allow students to participate in a follow-up interview. The interviews were planned to be semi-structured and inquire of students more about their perceptions and usage of PlayPosit within their 105 class.

3.4.3.1 Other Quantitative Student Data

Although not explicitly linked to students and their perceptions, a secondary quantitative collection of data was collected. Since the PlayPosit platform accounts for 5% of their grade, viewing some of the analytics for the CHE 105 classes was evaluated. This information was not linked specifically to the students, but were helpful in triangulating earlier data, especially about student usage of PlayPosit. Some of the analytical information that can be viewed are answer choices (percentage of correct), number of views, time spent on interaction, and other similar information.

3.5 Data Analysis

3.5.1 Qualitative Data

For all qualitative data, the first round of thematic analysis was based on activity theory. Codes were developed based on activity theory and the components of the theory, i.e., community, division of labor, rules, etc. Subsequent rounds of coding followed inductive thematic analysis (Tracy, 2020; Ibrahim, 2012; Braun & Clarke, 2006) to evaluate the interviews and open-ended responses from participants. Thematic analysis, in short, is a method that the researcher uses to identify analyze, and report patterns, or themes, within the research data (Braun & Clarke, 2006; Tracy, 2020). There are two approaches to using thematic analysis, inductive and deductive. Researchers using deductive thematic analysis take previously established themes and apply them to their own research data (Braun & Clarke, 2006). This can be seen as a top-down way of evaluating qualitative data. Conversely, inductive thematic analysis is more of a bottom-up approach (bearing similarities to grounded theory). In inductive thematic analysis the themes are identified among participants individually then broadened to a larger context (Ibrahim, 2012). This approach involves coding and re-coding of themes as they emerge and are combined across the participants. Throughout the research process, memos were employed to capture other data and potentially help with data triangulation. For instance, memos were used after interviews to capture thoughts and actions that took place during the interview that were not seen on the transcripts.

3.5.2 Quantitative Data

Descriptive statistics were done for both the surveys and PlayPosit analytics via Microsoft Excel. Survey demographic questions included age, race, gender, and residency. Student educational background questions were also asked, and these

included major, previous chemistry experience, and previous CHE 105 experience. Questions were also included about whether students had heard about or used PlayPosit, or other similar interactive video platforms, before. All pre-semester and post-semester survey data underwent student's t-test assuming unequal variance. All the data and results will be discussed in the next chapter.

3.6 Validity and Ethical Considerations

The main ethical consideration for this study was participant anonymity. The surveys were anonymous, and in order to pair pre- and post-semester surveys, students entered a unique identifier. This identifier included the first three letters of their birth month (e.g., January=Jan), their two-digit birthdate, and the last four digits of their phone number. As part of the survey, students self-reported their grades for the class. To allow for anonymity, the post-semester survey had a separate link that students were able to follow to enter their email for follow-up interviews. For all interviews and correspondences, all identifying information was either not included in the final paper or pseudonyms were used. All identifying information in the final semester grades and PlayPosit analytic information were deidentified before being received by the researcher.

Because the research question included perceptions towards technology usage in higher education science classes, no other potential ethical violations appeared. Even though it should not have any impact on students' grades within the class, the anonymous open-ended responses to the surveys allowed students to express their true perceptions without repercussions. There were no treatments being undertaken in the research, so those ethical considerations did not apply to this project.

Because the research involved one particular department (chemistry) at one particular school (the University of Kentucky), any transferability of results that can be made would have to be with similar situations and schools. No real generalizations can

be made past this particular situation and time. However, thinking reflectively on the conclusions from this study could lead to other similar studies. For instance, how does this study at UK differ from other large universities or even small universities? Also, how does this study compare to other STEM classes, especially those that use similar technologies?

To test the validity of my actual conclusions, I used several strategies to avoid potential threats. The data collection strategy allowed for “rich data” (Creswell, 2007; Tracy, 2020). Employing interviews and writing memos afterward allowed for any emerging themes to be documented across different avenues. Also, sample triangulation allowed for a balance among the different methods and their flaws (Maxwell, 2012). The number of participants that took part (especially in the surveys) inherently allowed for sampling validity. With demographic information taken, and including teaching assistants in the sampling, the broad scope of perspectives helped create a diverse understanding of how technology impacts student learning.

CHAPTER 4. RESULTS

4.1 Qualitative Results

4.1.1 Faculty Interviews

The components of activity theory were used for the first round of coding of the interviews. Some of the questions employed asking about these particular components led to other themes to arise. Subsequent rounds of coding led to even more themes arising. The first round of inductive thematic analysis resulted in an average of nine different themes. These codes ranged from the faculty's reasoning to why they use or do not use PlayPosit to more specifically about student responsibility in their own learning. The next couple of rounds of thematic analysis broadened the codes. The number of themes was narrowed down to four general themes, and they were: student buy in, usefulness of PlayPosit, preferences to flip or not flip, and student engagement. The themes based around activity theory will first be discussed followed by those themes that emerged from the coding.

4.1.1.1 Activity Theory Themes

The original iteration of activity theory included only three components, subject, mediating artifact (or tool), and object (Verenikina, 2010). For this study, those three components were the professors, TAs, and students as subject; PlayPosit as the mediating tool; and learning/teaching general chemistry as the objective. The three other components of activity theory that have emerged are the rules, division of labor (or roles), and community (Engeström, 2001; Kahveci et al., 2008; Tamayo, 2002). These extended components of the initial activity theory take into account that educational aspects are not in a vacuum and that there are other areas that affect the outcome of the objective. The professors were also asked about each of these components and how they see themselves within these components.

4.1.1.1.1 RULES

The department of chemistry does not require their professors to use PlayPosit. Three of the four professors do use it, where two of them have flipped their classrooms, and the third uses it because their class is asynchronous online. Although Prof. D does not use PlayPosit for their CHE 105 class, they do use it in an upper-level analytical class. The main reason Prof. D likes PlayPosit for their analytical course is its functionality as a pre-laboratory resource so that the laboratory time is not taken up with pre-lecture.

When asked about being pushed to use PlayPosit, all four faculty shared a similar sentiment to Prof. D, “I haven’t [gotten pushback] from my colleagues so much.” Prof. D does mention that although there has not been significant pushback from the department to use PlayPosit, they think the department “would prefer that [the professors] all did the same thing.” The department’s desire to have the professors do all the same thing, or at least as similar as possible, is to keep the classes the same across the board so that students would not feel left out or different from other students.

Even though there has been this push to have CHE 105 as similar across the different professors as possible, the department does not require faculty to use PlayPosit. The department also allows faculty to create their own PlayPosit videos, allowing professor autonomy in how they make the videos. There are no set number of videos the professors have to make, no set way they have to do the videos, but most of the professors follow in a logical order with the textbook with a handful of embedded questions.

4.1.1.1.2 DIVISION OF LABOR

Because there are no set guidelines or rules about using PlayPosit, the division of labor for the faculty can be different depending on how they use or not use PlayPosit in their class section. This puts the onus of creating the PlayPosits on the faculty. Professors A, B, and C who use PlayPosit in their CHE 105 class discussed similar sentiments of creating the videos and how it can be laborious in the beginning. Prof. C discussed the effort it takes to embed thoughtful questions within their numerous videos

> *It takes a lot of time [at the beginning] and that's why I would be very sad to have it go away. The embedding of the questions, thoughtful questions... into the PlayPosit, it takes, you know, I have hundreds of videos, so it takes quite a bit of time to on the front end, [to] get all those created. If you're doing it as you're going it's not you know, it's not laborious, but if I had to redo everything because we no longer were using Playposit, it would be quite a challenge. And I know they've developed a whole lot of more intricate features, since I started using it that I am not going back and incorporating that often. But yeah, it does take quite a bit of time to watch your video and place those questions.*

The rest of the faculty addressed this responsibility about their role as the faculty, putting together the videos in an overall thoughtful manner that made sense to the students and followed a logical flow.

The faculty also discussed how the students had a responsibility too when participating in CHE 105. The division of labor among the students was referred to by the faculty as student responsibility. One of the features of using PlayPosit allows students to see the material before they get to lecture and the harder work (i.e., problems) is done in person. Prof. B discussed then when talking about the usefulness of PlayPosit

They are supposed to have the background information for what we are going to do that day in class. So I can sort of schedule the entire semester. They will know what we are going to cover each day of class. They will know why they have to read what they have to watch before coming to class, and with that information, maybe they can prepare well ahead of time if they want…. You're supposed to watch the video before coming to class and solve the problem because if not, then you're not getting as much out of the lecture time.

Even Prof. D who does not use PlayPosit discussed this student responsibility also with their reviews. Because PlayPosit is part of the students' grade for the class, Prof. D replaces that grade with review assignments. Prof. D does mention that doing the review assignment "forces them to review the material we've covered the previous week." All of the professors shared this sentiment that they're role is more of a facilitator of knowledge instead of the purveyor and keeper of the knowledge. Students play an important role as the learners in the classroom and that responsibility is put on them.

4.1.1.1.3 COMMUNITY

As mentioned earlier, since there is no requirement to use PlayPosit in CHE 105 and no set way to do the videos, most of the professors create their videos themselves. All four of the professors may teach other courses besides CHE 105 and other research faculty may do a semester teaching CHE 105. These faculty end up being part of the CHE 105 faculty community and are allowed the same autonomy as the lecturing faculty. However, some of these research faculty may not want to create videos at all or from the ground up, so the lecturing faculty are willing to share their notes and videos. Prof. C mentioned that one of these professors who do not teach general chemistry regularly "uses my lectures and my free PlayPosits in his class and hasn't gone and reinvented

the wheel for himself.” Creating the videos and being thoughtful in how they are put together can be “laborious in the beginning” according to Prof. C, so they are willing to share their PlayPosits so these professors can “put their energy into what they’re going to do in the classroom.” Prof. A also mentions sharing their notes with other faculty.

Besides the potential of sharing videos and notes among the faculty, there is communication among them about the course overall. Even though there is a decent amount of autonomy among the different faculty in how they can run their own sections, the overall course information that is covered has to be agreed upon by the faculty. Some of the discussions among the faculty are about the exams since general chemistry does common hour exams, where all of the sections of the course meet, usually in the evenings, to take the exams. All sections take the same exam, so despite having the freedom to run their sections how they choose, the CHE 105 faculty still have to produce and agree upon the exams. When specifically asked about community among the faculty, the discussion of class flow and exam information was mentioned by all four faculty members. Prof. A specifically said about communication among the faculty

> *there is a lot of communication, about what is offered and when and particularly on the examinations. The exam for next week, was written this week. I've been through it and checked it; the other instructors will all check it also. This of course means we hopefully don't have any errors on it, but that doesn't concern me as much as the fact that it's fair and sound. When you have several instructors agreeing that it's okay, I think it tends to be fair and sound.*

The mention of fair and sound exams refers to the idea that despite students having different faculty, the information they should gain from the course and learn will be the same across the board.

Despite this section focusing on activity theory around the faculty, recitation and the TAs play a role in whole CHE 105 sphere. When specifically asked about recitation and any interactions with the TAs, all four of the faculty said they try to be aware of recitation in terms of when students go to recitation and when they receive the information. Some students may not see any of the material before their recitation section because their actual lecture time is after recitation and the PlayPosits are not usually due until before class. The faculty do not directly interact with the TAs. Prof. D happened to be the recitation coordinator for all general chemistry courses (this includes CHE 109 and 110), so they were the go between person with the faculty and the TAs. As the course went on, Prof. D would keep track of where everyone was in the lecture and make up worksheets to do in recitation that helped reinforce what the students were learning.

4.1.1.2 Other Themes

There were four other themes that emerged throughout the interviews with the faculty. Although there was some connection to the themes from activity theory, these four emerged more as their own specific themes. These themes include student buy in, usefulness of PlayPosit, student engagement, and preference to flip.

4.1.1.2.1 Student Buy In

In the earlier section about division of labor, the conversation among the faculty about student responsibility in their own learning was discussed. Part of that discussion in terms of student learning, especially in conjunction with PlayPosit usage, was the theme of student buy in. The faculty who specifically discussed PlayPosit usage in terms of a flipped classroom brought up student buy in. Prof. C discussed how students felt towards PlayPosit in the beginning

In terms of comments that I've gotten in evaluations on PlayPosits…. when I first did it, I didn't know I have [to have] buy in from my students and I didn't try to sell it. And my evaluations just cut me to the core because they perceived it as me being lazy. I had never worked so hard in my entire life, then to create those. I would put good questions in them that were a good balance that they're not hard, they're just gauging are you paying attention. So they were like…. She's making us do all the work. She's being lazy and she shouldn't even be paid for this job. I was so taken aback by those evaluations.

Other professors had similar comments about student buy in. Prof. B even discussed when a student was honest with them, and the student did not buy in into the usage of PlayPosit. This student just hit play and went and did something else. The students seem to see it as mostly a grade requirement.

Prof. D discussed the student buy in as a reason why they do not use PlayPosit in their CHE 105 course. Prof. D mentioned that it is about the attitude of the students

Because it's also attitude, if they're hating the class, and they have so many other classes that a lot of them are taking biology, which is also flipped, so they're doing videos, and I feel like we're dumping a lot of video time on them.

Despite the appearance of all the students not getting the merits of PlayPosit, some seem to understand that they have to be active participants in the learning process and not just vessels to be taught at. Prof. C and Prof. A both mentioned that they see a better correlation between students who "engage in it well and do well on the PlayPosits" are the ones doing well on the exams. Again, there is no definitive causation that can be said about how well students do on PlayPosits and overall exams, but from the

professors' perspectives, the PlayPosits appear to be the better identifier of gainful knowledge when evaluating via the exams.

Because the faculty are aware of student buy in, they have learned to sell not only PlayPosits and the validity behind it, but also for the flipped classroom in general. Prof. B and C discussed flipping and having the students respond more to if they sold them on the idea of the flipped classroom and how it can help them. The biggest part that they work on selling is the fact that having the videos beforehand allows the hard part of the lesson, the stuff usually done at home, is done there in the classroom with the professor and student interns and TAs in recitation. As Prof. C stated, "I'm here to help you with the hard part" and the idea that with more time on task helps the students understand the material more.

4.1.1.2.2 USEFULNESS OF PLAYPOSIT

As part of selling the flipped classroom or PlayPosit, the usefulness of the video platform was discussed among the faculty. As mentioned earlier, one of the main useful features that all of the faculty use in their PlayPosits (even Prof. D when they use it for their analytical class) is the ability to embed questions. Prof. B said the following about usefulness of PlayPosit

> *I use the embedded questions. There is a little more that we can do like they can do a little reading or searching …. The questions can be multiple choice they can be fill in the blank they could be short essay. They could be made sort of matching questions. That's what I use. … One thing that I'm doing more frequently is adding feedback. You know, like, [previously] if they pick the wrong answer, then I would say they wouldn't get a comment saying why the answer is wrong*

The fact that there can be different types of questions allows the professors to ask thoughtful questions about the content. It is also a good measure to make sure they are watching the videos since PlayPosits can be made to not continue on until the questions have been answered. Prof. B was the only faculty to specifically mention about leaving feedback.

PlayPosit has a number of other features, like being able to search content or leave comments/ask questions in real time. Prof. C discussed this idea that it would be difficult for the faculty to answer those questions in real time, since most students most likely watch the videos late at night. Prof. C does use Piazza in their course, which is an anonymous discussion board in Canvas that the students can ask questions and even comment on other student's comments. Prof. C spoke about following Piazza more closely to see if students have questions throughout the day.

Another big feature of PlayPosits and recorded lectures in general is the ability of students to pause and rewind the videos. They can also watch the videos multiple times. Prof. C compared the ability to pause the PlayPosit videos versus not in a traditional lecture,

> *in terms of students getting the content is better also, because they can't pause me in the middle of my lecture, right? where they zoned out, which they inevitably will do, you've lost a bunch of material and you can't rewind me.*

As mentioned earlier, students can pause, rewind, and rewatch the PlayPosit videos as many times as they want to try to understand the material. Yes, students could ask questions during lecture, but all four faculty mentioned that rarely, if ever, do students in large lectures like CHE 105 ask questions in the middle of class.

4.1.1.2.3 STUDENT ENGAGEMENT

Understandably, one of the main indicators of student learning is student engagement, which all four faculty discussed during the interviews (Fyfield et al., 2019; Quan & Buikema, 2018). All four faculty discussed student engagement in the classroom whether or not they use PlayPosit. Prof. D mentioned it in terms of why they do not use PlayPosit in their class

> *And when I can get them to interact more with me and with each other and be more engaged and do some demonstrations, and I do demos for the big classes too, but when you can get them more engaged, I feel like it goes a lot better.*

Similar sentiments were shared between all the professors, even Prof. C who is the most dedicated to the flipped classroom model. They said about when they use to teach in a traditional lecture style

> *I loved lecturing. I absolutely adored going into the classroom. And then being on that stage and trying to come up with the best way to explain something to a live audience. I love lecturing, but I lost the ability to have them raptured at my command in the front of the classroom. I could not compete against social media in my classroom, and that is why I switched.*

Despite their loss of in person engagement in the traditional lecture style, the professors felt that student engagement can be shifted to the idea of time on task more. With the addition of recitation, the idea of “doing the doing” as Prof. C said or “spend more time on the content” as Prof. D said helps reinforce the material for the students.

Another aspect of student engagement is the actual interaction with the PlayPosit videos. All of the professors touched on this idea of taking full advantage of the PlayPosit videos. Some of these aspects were discussed in the earlier sections on

student buy in and responsibility in division of labor. Like when Prof. B discussed the usefulness of PlayPosit in that it provides background information before the student come to class.

4.1.1.2.4 PREFERENCE TO FLIP

All of the themes that have been discussed led to the conversation of a professor's preference to flip their classroom or not. As mentioned earlier, Prof. B and C both have flipped their classroom. As Prof. C specifically said about PlayPosits and a flipped classroom

> *I truly see it [flipped classroom] as a better delivery method in which we're working in the classroom on the hard part. Listening and taking notes is not the hard part. And so having the opportunity to be in the classroom and walk around and help students as they try to engage with the material is so much more important and it is very rewarding to get a chance to actually talk to students and interact with them. I missed the lecture, but I think this is better regardless.*

Prof. B mentioned similar ideas about why they also chose to flip. Prof. A and D both use PlayPosits; Prof. A because of the online asynchronous format of their class, and Prof. D uses PlayPosit in their upper-level course with a laboratory. However, when asked about flipping their classroom, both said something similar to Prof. A's opinion where they "can sense what the students are picking up" better in the classroom in a traditional lecture style.

The idea of student engagement, especially in the classroom, seems to be the main reason as to why the professors choose to flip their classroom or not. As mentioned earlier, "doing the doing" as Prof. C stated is the crux of student engagement

and student learning. With their choice of flipping their classroom, Prof. B and C discussed the ability to allow the students do the harder work in the classroom.

4.1.2 Teaching Assistant Interviews

Similar to the faculty interviews, the TA interview questions were originated around Activity theory (Appendix B). The first round of coding followed those themes also. As the interviews progressed, originally around seven other first level themes were coded. After subsequent rounds of coding, these themes were generalized to four other themes. These themes included student learning, usage and perspective of PlayPosit, format of recitation, and teacher style difference. Similar to the faculty interviews, the activity theory themes will be discussed first then the other themes that emerged will be discussed.

4.1.2.1 Activity Theory Themes

4.1.2.1.1 RULES

As mentioned earlier, the TAs do not actively use PlayPosit to aid in their teaching of the content. Some of the TAs may have looked at the PlayPosits in the beginning of their teaching career, but most of them did not look at them throughout the semester. For example, TA-2 stated

> *I kind of just look at what they're learning for the like, kind of what they're learning for the week on the worksheets, because we get them we have to do them a week before they do it. So, I kind of have an idea what they're doing in class from that. And also, I see that like, you know, from office hours, their Achieve homework, so that gives me an idea what they're doing too*

The other four TAs phrased their answers similarly. Each one referenced that they may have looked at the PlayPosits in their early teaching semesters. TA-1 said the following when asked if they looked at the PlayPosits

> *So that was what I was doing in the first semester to just refresh the concepts and also, since I've learned these things, back in [home country], it was in a different language and different method was very long time ago. So, I was trying to connect with students and see how they are learning them. So, I sort of follow the same way, the same approach I don't want to confuse them. So, I used to do that last year*

Especially as an international student, it was interesting that TA-1 wanted to make sure they were relaying the information to their students in a way that was congruent to how they were receiving it in their lecture or PlayPosit. Besides the worksheets and general flow of how the recitations should be ran, there were no other rules that the TAs had to follow. They had fairly free reign of how to run their individual courses.

4.1.2.1.2 DIVISION OF LABOR

Because the TAs did not have specific rules on how to run their recitation sections day to day, the division of labor for each TA was different. All of them implied or said that they knew their role was to be a facilitator in solidifying the content they learned in their lectures or PlayPosits. However, most of them phrased their roles similar to TA-5

> *I feel like my role is supposed to be I guess, facilitator where I kind of like cement the learning that they've seen before. But often I feel like I have to take more of an instructor role in other words because I've had a lot of comments from like,*

like my 105 and like, 109 classes that are like, you're the only like, you're the one that I've learned from the most, like, topics like you're the one that like, explains it in like, kind of like a lecture setting and, like, that's how I've learned. You've been able to explain it better. Or like they've just haven't been able to watch the PlayPosits, so they haven't seen it. So, they're learning it for the first time. So, I kind of feel like an instructor in that way.

Other TAs shared similar comments. Feeling like a facilitator versus instructor did seem to appear more prevalent depending on when their recitation section was compared to the students' lecture time. Some recitation sections would meet before they even went to lecture. Theoretically, the students should have seen the PlayPosits (for those courses that utilized PlayPosit), but in reality, most students may have not seen the content yet. TA-3 specifically mentioned how their students portrayed confidence in their content knowledge throughout the week

Mondays especially, they may be a little like, less confident and that can be just because it's a Monday. They just had it [the content] in class or they just haven't gotten to it. I know later in the week that confidence does build but there is a very, like there is still a difference I'd say between even my PlayPosits for say 105 I have two sections, one is on Wednesday, and one is on Thursday. There's a lot more confidence in the material between those two in my Thursday class than Wednesday class. Both taught at the same time like some of [the students], I think are like they have a lecture I believe after on Wednesday, so like they're a little maybe not as sharp with it. I haven't gone through like practice problems or whatever, but definitely like early in the week [there is less confidence in the material].

As other TAs also mentioned this gradual confidence in their students' content knowledge, it appears that as the students became more confident, the TAs could become more of a facilitator than an instructor.

4.1.2.1.3 COMMUNITY

Similar to the faculty interviews, the community between the TAs and faculty is not really existent. During the TA interviews, they mentioned that most of them do not interact with the faculty outside the recitation coordinator (Prof. D). A couple mentioned that they have reached out to some of the faculty to see what has been covered or more specifically what content is going to be on the exam. Other than that, most of their knowledge of what is going on in the lectures and the content being covered is through Prof. D and the problem worksheets that are worked on during recitation.

One of the big areas of community is with each other. Even outside of their position as TAs, there has been a community built around their individual cohorts. TA-2, TA-4, and TA-5, who are all first years, mentioned about a cohesive group between all of the first years because they are going through a similar shared experience. After the first level of community within the cohort, there is another level of community as recitation TAs. Many of the TAs mentioned this in their interviews. TA-2 specifically said about their cohort and recitation TAs

> *During the meetings, we kind of share what's going on in our classes and our opinion. And I would say that the first years are already kind of close. We all kind of like hang out with each other outside of like, school and a little bit so. But the TA meetings are like a way for us to kind of connect with the upper grads a little bit and share our frustrations what's going on with [being a] TA*

The two TAs (1 and 4) who are not first years also mentioned that there was a community among the recitation TAs.

Another group that the TAs interact with and are able to form somewhat of a community are their students. From having smaller classes to having to do office hours in the learning center, they have more one-on-one time with their students. Although the TAs do have a level of authority over the students, the fact that they are only TAs and most likely closer in age, the students may feel more comfortable with the TAs. Some of the TAs mentioned that their students felt more comfortable airing their frustrations to the TAs. As TA-4 stated, “I think it is more comfortable [for the students] and having like the TAs and that interaction.”

4.1.2.2 Other Themes

Comparable themes that arose during the faculty interview coding also emerged in the TA interview coding. General perceptions of PlayPosit, student learning (which encompasses types of students and student engagement), and teacher style difference were the other themes that emerged in the coding.

4.1.2.2.1 General Perceptions of PlayPosit

Since four of the five TAs were first or second years, questions about any previous use of PlayPosit or similar interactive videos was asked. All four of the TAs mentioned most interaction with PlayPosit was during COVID when learning went online. Only TA-2 had previous experience specifically with PlayPosit because they went to UK for their undergraduate degree. TA-2 thought fondly of PlayPosit because “you can pause them; you can make them faster, slower, or whatever, and it like helps you review over information.”

As mentioned earlier most of the TAs did not interact with PlayPosits in a large capacity; mainly to check what content was covered or how it was covered. All of the TAs saw the value in PlayPosits for a tool, but not necessarily for all of the material that was covered. TA-3 specifically said about PlayPosits

> *I can see a benefit in it. But I also see that especially for some concepts that are harder to understand, it's more beneficial to be relaying that information to them in person. So, they can have like a direct sort of reaction if they have questions or need any clarification, stuff like that.*

Most of the TA's interactions with PlayPosit was through the discussions about it from their students. TA-1, who taught CHE 109 over the summer in an online asynchronous format, had more experience with PlayPosits compared to the other TAs. Their experience based off of their time teaching an asynchronous course led them to have similar thoughts to Prof. A's in that they would prefer to be in person because it is easier to see the students' reaction. "Sometimes something just pops up, so I just take this route or that route, and I try to explain different ways," they said about teaching in person versus via PlayPosit. Since this was in an asynchronous format, their opinion may be slightly different if PlayPosit was used in a different, more flipped classroom format.

Because the use of PlayPosit lends towards a flipped classroom style, some mentions of flipped classroom arose in the TA interviews. Most of the TAs who mentioned flipped classroom said their students who have that format tend to like it. When discussing the benefits of a flipped classroom and the department's general trend towards flipped classroom, TA-4 said the following about recitations

I don't know if like for a lot of people recitation is really needed... This semester, we've done more like hands on, like group work stuff versus like having like lecturing for the entire class. So, I don't know. I guess they want us to be like more hands on everything. So yeah, I think if everyone goes to flipped classrooms at some point, yeah. Like, it'll just be done, like doing more application base. But you could also be doing that in lecture. So, I don't know if you'd really need recitation at that point. I think the whole idea is like you have a smaller classroom that's more comfortable to ask questions. So, they may not entirely get rid of recitation

A couple other TAs thought the same thing, that if there is a push for the department to go fully flipped, there may not be a need for recitation since the idea of recitation is to have those smaller classes and more hands-on work. However, if the students are getting that from their lectures in the flipped classroom style, they may not need the extra class.

4.1.2.2.2 STUDENT LEARNING

One of the advantages of being a TA is that students tend to feel more comfortable interacting with them. Usually being close in age and students themselves, undergraduate students do not necessarily see TAs similar to how they see professors. This gives the TAs an advantage or disadvantage to usually be on the receiving end of student complaints and how they are doing in the class. This can be evident especially since UK chemistry TAs have to spend about three hours per week in the chemistry learning centers for their office hours. A few of the TAs during the interviews alluded to these interactions with students in the learning center. It should be noted that although the TAs generally teach one course, e.g., general chemistry I recitations, they are

expected to be able to answer any and all questions from students who enter the general chemistry learning center. There is a separate learning center for organic chemistry, so most students who enter the general chemistry learning center are taking one of the many general chemistry courses, including lab.

A few of the TAs mentioned throughout their interview that how well someone does, and even utilizes the PlayPosits, depends on the type of student they are in general. TA-2 specifically said that some of their students said they would prefer to do the PlayPosits (or be in a flipped classroom setting), but “it just depends on the student.” TA-5 discussed more explicitly that there are essentially two types of students in terms of utilizing PlayPosits

> *And so I feel like there's kind of a couple of groups of students, right. There's going to be like, your students who want to do really well like your premeds or maybe some other majors. And so, they'll watch the PlayPosits like it's intended to be like, one time speed, watch it, take notes, answer the questions. But I would say for the other like 60-75% a lot of times, they figured out that they could put it on like 16 times speed, and just like, go through it, and answer the questions and then that saves them time.*

Other TAs had similar comments about the students, that one type of student will watch and interact with the PlayPosits in an intentional way, while others will just try to get through it.

Somewhat tied into the student type and using the PlayPosits with intention was the idea of student engagement. TA-3 mentioned that no matter what type of student or how well the PlayPosits are put together, “there will be students who see it as extra work because you know, you can’t always make every student super engaged and excited with everything.” As mentioned previously, there are some students who actively engage

with the PlayPosits, and then there are other students who just get through the videos without any extra effort.

Each of the TAs mentioned that part of the problem with engaging the students is the amount of extra work that it adds on to their plates. TA-1 discussed during the interview how much work the students have and how that can decrease their intentional use of PlayPosits

> *There are things that in theory, you think it helps, because if you think about it, yes, they look at it, they watch the PlayPosit, and then they come to the class. They have multiple examples. But in reality, you're just adding more and more and more homework for them. At some point, they don't they just don't care. They just want the point…. but adding the PlayPosit, Achieve, lecture, recitation. Now all these things that just add too much. And at some point, they just don't care. It's going to get a B or C and just be done with it. So, I don't know if it helps the students.*

This was another reason that TA-1 preferred to teach in person because even if they are not fully engaged, “at least you have them [in class].”

Overall, the TAs could see the value in PlayPosits, but since students had difficulty being engaged with the material and/or were just the type of students that did not care to put in any effort, the TAs had difficulty getting fully behind the use of PlayPosits. Most of the TAs, despite the student engagement issue, thought that PlayPosits did aid in student learning. TA-2 spoke about the use of PlayPosit and student learning

> *Yeah, I would say that they aid in it. Like just, I would say it aids but I don't think it should be the only form of like, lecture or review for the class though.*

4.1.2.2.3 TEACHING STYLE DIFFERENCE

Just like the type of student a person could be, the TAs referenced that the type of professor also may have an impact on the students' interactions and perceptions of PlayPosit and their actual learning. TA-2, in their discussion about student learning said the following about type of teachers,

> *some students have said that they like the flipped classroom. Some have said, told me, they don't. So, it just depends on the students and also I think it also depends on the actual professor that that is doing the PlayPosit, because I know for example, some students are in [Prof. C's] class… they said they're very helpful. [Prof. C] explains everything well, and then [the professor] does like a quick review in class. And then [Prof. C] has like student helpers. Like [Prof. C] has some go be in groups in class and has like student helpers, like working on worksheets and stuff together. And a lot people like that*

All of the TAs at one point mentioned something positive about Prof. C in terms of their students and whether or not their students were learning the material. TA-3 mentioned that out of all their recitation sections, the ones with Prof. C were the one class that "were more confident in the material coming in," so potentially there can be some correlation to who the students have as a professor.

However, without extra data that would be needed to completely compare the individual professors, the student and TA perceptions about the professors have to be taken with a grain of salt. A couple of the other professors were discussed in comparison to Prof. C. TA-4 did mention that their recitation students from Prof. C and Prof. D's lectures "had a better grasp of the material." None of the five TAs interviewed taught a recitation section for each professor, so besides secondhand accounts from the

students, they cannot even in their capacity as TAs compare on student learning across all the professors.

4.1.3 Student Qualitative Data

Because there were potentially 1680 students in CHE 105, the student surveys included a few open-ended responses to allow students to voice their opinion about their class and PlayPosits. Follow-up interviews were made available but due to lack of responses no actual interviews were done with any of the students. However, there were 46 students of the 72 who did the post-semester survey who left comments in the open-ended responses.

4.1.3.1 Effect of Professor on Perceptions

As mentioned in some of the TA interviews, students seem to be responsive, whether positively or negatively, to which professor they have and their PlayPosit videos. As Prof. C mentioned, some other faculty have used their videos before, so students may not be seeing the same professor in their lectures as the PlayPosit videos they see. One of the first questions in the post-semester survey asked about this. All of the students who responded answered yes to the question “were the PlayPosit videos done by your professor?” To follow up, the students were asked if that played a factor in their perceptions of PlayPosit. Twenty-two of the students responded that no, it did not affect their perceptions of PlayPosit.

The other 37 students answered yes that their perceptions were affected by their professor doing the videos. Most of the responses were positive in nature. One student said about their professor doing the PlayPosit videos

I would feel more confident in the content if it was my professor. Plus, [the professor] would use the same language from the PlayPosits in class, making it easier to understand.

The other positive comments were similar in nature. Having that congruence of the same professor between the PlayPosit videos and their lecture helped them "understand the material more," "better understand calculations," and "not hate chemistry entirely." The students also found the value in PlayPosits. Some commented that it helped them take "notes more efficiently," or as one student said

PlayPosits helped me control what I was learning and when I was learning. I was more comfortable learning on my own than having to be hyper focused in lecture, trying to take notes, do homework, and learn new material all at the same time.

There were, however, some negative comments on whether their perceptions were affected by their professors. One student commented that they have difficulty learning online but that was the section they were in, so using learning via PlayPosits was difficult for their learning style. Another student stated about their professor

I feel as if my professor did not do a good job at explaining anything or making sure the students understand what is actually going on in the class.

Other comments were more focused on either the questions used in the PlayPosits or the amount of time spent on the videos. One student specifically said

The amount of time spent watching the videos outside of scheduled class time ranged from 1.5 to 3 hours depending on how many 20+ minute videos were assigned. It came to a point in the semester that I simply played the videos at 2x speed just to ensure my grade wasn't affected.

Similar to what the professors were saying in their interviews, there are going to be some students who dislike PlayPosits and some who like it, there is no pleasing everyone. With all of the professors using their own videos, it is difficult to comment on the actual effect of professors in the videos on students' perceptions, but from the comments from the students, they appreciated that it was their professor doing the videos.

4.1.3.2 Advantages of PlayPosit

The students were also asked if they thought there were any advantages or things in particular about PlayPosits that they liked. There were three general categories of reasonings that the students liked about PlayPosits or what they found advantageous of the educational platform. These were the viewing and review, ease of use, and interaction.

4.1.3.2.1 Viewing and Review

The first advantage mentioned most by students was the ability to go back. This is in reference to both during the initial viewing of the video, i.e., rewinding, and after the initial viewing, i.e., reviewing. Most of the students said similar phrasing to "the student can pause and rewind any sections that were unclear." Being able to rewind and replay videos seems to be a big benefit for students so that they can clarify a concept that is difficult. In comparison, students are unable to pause and rewind normal didactic lectures, unless they stop the professor and ask questions. Most of the misunderstandings that students have about the material usually comes up after lecture, and unless they have some type of recording of the lecture, students usually have to rely

on their notes or their classmates. The ability to rewind the interactive videos allows students that extra time to try to comprehend the information.

Besides being able to rewind during the viewing of the videos, students also commented that they liked that they could return and rewatch the videos multiple times after first viewing them. They liked that it was an extra source of review. As one student wrote, “an advantage of PlayPosit is that you are able to go back and watch the videos for review if needed.” Other similar comments were left. Although students can review their notes and possible other recordings, PlayPosits automatically are set up as a built-in review for them, especially since they cover all the lecture materials outside of lecture time.

Along the lines of being able to rewind and review whenever, students were appreciative that within the confines of the original deadline, they could watch the videos at their own pace. Some students did mention the ability to do it 2 times the normal speed. It is unclear whether this faster pace was just intended for the first viewing, and the student would return without the confines of the deadline; or if they just did the faster time and never returned to review the videos. It could be argued that students would watch originally at a faster pace, especially for content that they understand, and would return when reviewing for the exam, but most students may not take full advantage of that feature.

Being able to receive the content outside of normal lecture time seems to be a positive feature of PlayPosits. One student wrote that the advantages of PlayPosit, “include allowing a significant amount of lecture material to be taught to the viewer outside of the classroom when the learner is not limited to 1 hour 15 min of class time.” Other comments said simpler versions of this, like “able to work at my own pace,” or “PlayPosits were lecture that you could watch on your own time, in your own setting, and

your own speed." The ability to view content outside of normal lecture time seemed to be one of the more important features for students.

4.1.3.2.2 Ease of Use

In a somewhat related manner, students found that PlayPosit was easy to use. Many students specifically said that an advantage was the ease of use of the platform. As part of the ability to rewind and review, students mentioned that the ability to pause and fast forward was also an appreciated feature of the interactive videos. One student's comment stated, "I liked getting to be able to stop the videos whenever I needed to write more notes and being able to go back to things if I maybe heard something wrong."

When students find that some technological tool is easy to use, they are more likely to use it. This ties into the student buy-in that the professors and teaching assistants mentioned. If student find something easy to use, they tend to find the value in using it. Although not explicitly stated, some of the students' comments lent to this notion.

4.1.3.2.3 Interaction

One of the other features of PlayPosit is the interaction with the videos. This is two-fold in that some students specifically mentioned the embedded questions and others appreciated how the professors worked through the problems. Multiple students liked how their professor worked through problems in the videos. One student wrote, "the video would walk through the calculation with you with each problem instead of going over the first question and then leaving you to figure out the rest of the questions on your own." Another student mentioned that doing some practice problems in the videos was helpful compared to trying to focus in class.

Other students appreciated the flip side of this, where the content material was presented in the videos and the practice problems were done in class. Like some of the professors spoke about, it appears that the students appreciate “doing the doing” in their normal lecture time instead of at home without any real help.

The students who mentioned the embedded questions spoke about them more to keep engaged with the material and videos. One student commented about the interactive videos that they, “refresh [my] mind with interactive questions.” Another student wrote, “it made me engaged with my lecture videos.” Having the embedded questions can help the students not only stay more engaged with the material, but also help clue them in to what they may need more clarification or practice on.

4.1.3.3 Disadvantages of PlayPosit

Students were also asked if there were any disadvantages or particular aspects of PlayPosit that they did not like. There were three general themes that arose after coding. They were time, focus, and engagement. These three themes can be broken down a little further and will be discussed in the following section.

4.1.3.3.1 TIME

One of the comments that multiple students stated was in relation to how much time the videos take up. Some comments were similar to one student’s where they said, “sometimes the videos were incredibly long.” Other students also mentioned how many videos there were. One student specifically said about the time commitment required in watching the videos,

Per week, the amount of time spent outside of the classroom watching videos often ranged between 3 to 7 total hours. That isn't including the 1h 15m classroom time.

Although there were not any more comments as specific as this student's, there were other similar sentiments. One aspect of PlayPosit is requiring students to answer questions before they can move on through the videos. However, students are not able to fast forward through content. Having to completely play the video can add to the time commitment students need to watch the videos. This aspect, the inability to fast forward, was another comment that came up multiple times. At first glance, the inability to fast forward complaint seems to be just a complaint. However, a couple students commented on their displeasure with this because they already knew some of the content. One student specifically said, "I found it really frustrating when I already understood something and wanted to skip to the next part but couldn't."

Other students commented on general functionality of the platform that caused the time to do the videos longer than intended. One student wrote that the platform, "could be buggy sometimes, not loading or taking some time to process and buffer during the videos." Although this can be a constraint on the students' time, this is a disadvantage that has more to do with internet and computer issues.

4.1.3.3.2 Focus

When a few students discussed the time commitment the PlayPosit videos required, they either explicitly or implicitly stated this made it difficult to focus. One student wrote the videos were "long and sometimes hard to focus [on]." Another student explicitly stated

The amount of assigned videos twice a week and the grading system for the PlayPosit videos led to a decrease in focus and more annoyance than effective learning.

Although the other students' comments were not as straightforward as this student's, there were similar frustrations with the length and amount of videos causing loss of focus.

Other students discussed that it was hard to focus in terms of keeping up with the content in the videos. One student wrote that "only online work can become hard to keep up with and actually learn from." Other students made similar comments. Similarly, students knew going in that the videos could be long and tedious, so many of them stated comments like one student

It's very easy to get distracted, put them off, or play them in the background just to get them over with. I don't feel like I'm fully learning with them.

It appears that many of the students had difficulty focusing on the content when the videos were numerous and long. As mentioned in the faculty interviews, though, there is a trade-off. If all the content for one chapter is in one video, that video would be quite longer than the average 20-minute videos of most of the professors. Alternatively, less content in one video may shorten the time of the video, but that would increase the total number of videos.

In line with students' issues with focusing on the videos, a few commented that this was due in large part to their ability to learn better in a normal lecture style. One student said, "It's hard to focus and fully pay attention when only learning from videos," and another said, "if you learn better in-person, it can sometimes be difficult to learn through the videos." While students may have difficulty staying focused on the videos,

they may feel that this means that they only learn when in-person. However, there were some comments in other sections of the survey where the students stated they saw the potential in learning via interactive videos. The in-person learning comments may be just that the students are used to that style and have not yet bought in to PlayPosits.

4.1.3.3.3 ENGAGEMENT

The last major theme that arose in the students' comments was engagement. While engagement and focus can be related, the students' comments warranted a separate theme. One of the positive aspects of PlayPosit interactive videos is the embedded questions. Although there were earlier comments about the embedded questions and the benefits of having them, some students found them to be a disadvantage.

A common complaint was that these embedded questions were appearing, and the students had barely learned the content. One student specifically said

> *it seems like a bad idea to use these PlayPosits for a grade because it unmotivated me since it was for a grade. I also felt more pressured to know it and understand the content immediately, personally, I need time and practice to understand concepts, so this gave me negative vibes of PlayPosits.*

Tying into focusing, other students claimed that they would just play the videos in the background until a question came up to answer it. One student discussed that they would play the "videos at 2x speed just to get to the questions that would pop up. I would then return [to] the videos after the due date to actually learn the material discussed." Other students made it appear that having the underlying pressure of the grades made it difficult to completely engage with the videos.

As mentioned by Professor B, some of their embedded questions allowed students to try multiple times if they got the answer wrong. It appears from the students' perspective that they generally like this idea, however, the fact that that was not the case for all the questions, was a feature they did not like. This made it seem like it was difficult for the students to stay engaged with the content. This displeasure was amplified with the fact that the questions were graded for accuracy and not completion. As mentioned above, some students found it difficult to answer the questions correctly when they just learned the content and may not fully understand it. Another student wrote that grading the PlayPosits for correctness "unmotivated me since it was for a grade. I also felt more pressured to know it and understand the content immediately." This could have been a detriment to many students who tried to utilize the PlayPosit videos to their full potential but were unable to fully grasp the content in that short amount of time before being graded on it.

Another comment that came up multiple times was about the inability to ask questions in real-time with their professors during the videos. Prof. C mentioned this feature and spoke about how much time consumption on their end it would take up especially when the students most likely watch the videos at all hours of the day. One student specifically wrote

> *If I have questions I cannot ask my professor right away, I have to wait till lecture which by then I mostly forget about it.*

While there are other avenues for the students to ask questions outside of class time, this does seem to be a feature of the platform that many students may be willing to use. It potentially could help increase engagement with the video and the content if they have questions answered in real-time. Unfortunately, as stated by Prof. C, this would

mean that the professors would have to have some notification system or be on the platform all throughout the day which is not feasible.

4.1.3.4 Student Comments Based on Professor

As part of the post-semester survey, students were asked which section they were in, so that any comments could be looked at comparing the different professors. Out of the 55 student responses, two were in Prof. A's asynchronous course, 22 were in Prof. B's course, and 28 were in Prof. C's course. Although the previous comments could be seen throughout all of the responses, there were a few that were specific to the students' specific professor.

For Prof. A, only one student specifically mentioned the format of the course or PlayPosit. The student commented that if a student learns better in person "which is something I do, it can sometimes be difficult to learn through the videos." Similar comments were made by students in other sections but more in terms with viewing the content through the PlayPosit videos.

Most of the student comments from Prof. B's students were about PlayPosit in general. The only few comments that specifically mentioned Prof. B were generally positive. One student wrote,

> *[Prof. B]'s very helpful and explains all concepts well. Makes me not hate chemistry entirely*

As mentioned earlier, most of the students responded positively to doing the practice problems during the lecture time and having the capability of viewing the PlayPosits on their own time.

Prof. C's students had a few more comments specific to how they did the PlayPosit videos. Most of the students liked that the videos were done by Prof. C, but a

few commented that Prof. C did not explain some of the concepts well. Prof. C mentioned in their interview that they were incorporating feedback with some of the embedded questions in the videos. One student commented that they did not like that you could redo some of the questions and not others. All other comments from Prof. C's students were similar to Prof. A and Prof. B's students about PlayPosit.

4.1.3.5 Other Student Comments

There was another section in the student survey to allow students to leave any other comments they had about CHE 105 or PlayPosit in general. Most of the comments fell into the advantages or disadvantages previously mentioned, but there were a few students who brought up ways to improve CHE 105 and PlayPosits. A few other STEM departments also use PlayPosit, and one that was mentioned from a few students was the biology department. It appears that the biology department (one course that was specifically mentioned was BIO 148) utilizes all the same material, e.g., same videos, same lecture material, same exams, etc. and just the professors vary. While the chemistry department does share most of the material, e.g., homework, exams, etc. the different professors are given a fair amount of free reign to run their classes as they see fit. One student believed that "CHE 105 would see better grades if all of its students could study the material the same way." This may not be the case since "the students who are there to learn will watch the videos and learn," as another student stated.

4.2 Quantitative Results

4.2.1 Survey Results

Surveys were administered via Qualtrics Survey Software and open to CHE 105 students for two weeks at the beginning and end of the Fall 2022 semester. Students were incentivized to do the surveys by the addition of five bonus points. As mentioned

earlier, the surveys were anonymous, but for potential pairing of data, students entered a code consisting of the first three letters of their birth month, their two-digit birthdate, and the last four digits of their phone number.

For both surveys, the Likert-scale questions were converted to dummy variables: Strongly Agree=5, Somewhat Agree=4, Neither/Neutral=3, Somewhat Disagree=2, and Strongly Disagree=1. Any question that had negative phrasing was recoded so that similar worded questions could be properly averaged. The dummy variables for the reverse codes then became: Strongly Agree=1, Somewhat Agree=2, Neither/Neutral=3, Somewhat Disagree=4, and Strongly Disagree=5. Any question where a student did not respond, a "N/A" was given so as to not throw off any statistics.

The Qualtrics survey registered 271 participants who started the pre-semester survey. Survey participants were eliminated from the data set if they were under the age of 18, completed the survey outside the two-week window, or did not finish the survey. This left a total of 207 participants. Demographic information for both pre- and post-semester surveys is shown in Table 4-1 below. The post-semester survey returned only 72 participants. After removing those who were under 18, outside the two-week window, or did not finish the survey, a total of 55 surveys were included in the results. Because there were not a lot of post-semester surveys, all statistical data was done unpaired. For both the pre-semester and post-semester survey, most of the respondents were female, age 18-22, first year (or freshmen), white, and a Kentucky resident.

Other information about the students' background was also taken. This included their major, whether they have taken a chemistry course before, and if they have heard of or used PlayPosit or a similar interactive video before. Those results can be seen in Table 4-2 below. Because of the open-response and mixture of responses, majors were separated into larger categories. This included science, which encompasses majors like biology and chemistry; engineering; social sciences, which encompasses psychology

and sociology; mathematics; non-STEM majors; technology; pre-professional tracks; and undecided. The majority of respondents were science majors, followed closely by engineering students. At least 50% of both pre- and post-semester respondents have taken a standalone chemistry course before, used an interactive video platform like PlayPosit before, and were taking CHE 105 for the first time (Table 4-2).

Table 4-1. Demographic Results of Pre- and Post-Semester Survey

	Pre-Count	Pre-Percentage	Post-Count	Post-Percentage
Gender				
Male	75	36.23	19	34.55
Female	127	61.35	34	61.82
Non-binary	3	1.45	1	1.82
Prefer not to say	2	0.97	1	1.82
Age				
18-22	204	98.55	54	98.18
22-25	3	1.45	0	0.00
25-30	0	0.00	1	0.48
Year				
First year	196	94.69	50	90.91
Second year	5	2.42	3	5.45
Third year	6	2.90	1	1.82
Fourth year	0	0.00	1	1.82
Fifth or more	0	0.00	0	0.00
Race				
White	178	72.36	49	73.13
Asian	17	6.91	7	10.45
Black	10	4.07	1	1.49
Latin	14	5.69	2	2.99
Native Hawaiian or Pacific Islander	3	1.22	1	1.49
American Indian or Alaska Native	5	2.03	0	0.00
Other	0	0.00	0	0.00
No response	0	0.00	1	1.49
2 or more	19	7.72	6	8.96
Residency				
Kentucky Resident	130	62.80	50	90.91
Non-resident	77	37.20	5	9.09
International Student	14	6.76	0	0.00

Table 4-2. Pre- and Post-Semester Survey Results of Student Background

	Pre-Count	Pre-Percentage	Post-Count	Post-Percentage
Major				
Science	86	41.55	20	36.36
Social Science	36	17.39	14	25.45
Engineering	54	26.09	18	32.73
Math	4	1.93	1	1.82
Technology	15	7.25	2	3.64
Pre-Professional	5	2.42	0	0.00
Non-Stem	4	1.93	0	0.00
Undecided	3	1.45	0	0.00
Previous Chemistry Experience				
Taken Chem	120	57.97	34	61.82
Chem as science	23	11.11	10	18.18
Not Taken Chem	63	30.43	11	20.00
Previous PlayPosit Experience				
Used before	93	44.93	28	52.83
Heard about it	56	27.05	6	11.32
Never heard about it	58	28.02	19	35.85
Previous CHE 105 Experience				
First Time	202	97.58	50	90.91
Repeating	5	2.42	5	9.09

During the data analysis, only 21 questions from the pre-semester survey and post-semester survey were included. The 21 questions analyzed included TAM-based questions about ease of use, engagement, perceived usefulness, and behavioral intentions. As mentioned earlier, the questions were amended from Park (2009) and Lee et al. (2013) to ask specifically about PlayPosit. The full list of questions can be found in Appendix E. The average pre-semester and post-semester scores are shown in Figure 4-1. Unless noted, all pre- and post-semester survey data underwent student's t-test assuming unequal variance. The average scores showed a slight increase in the pre- to post-semester surveys, but it was not statistically significant at the 95% confidence level (t-stat = -1.5875, p-value = 0.121). The associated average numbers and standard

deviations are shown in Table 4-3. The mode and median were also included to show that despite the slight decrease between pre- and post-semester, the most often response and median values were around the 4 (Somewhat Agree) mark.

As seen in Table 4-3, most of the questions show a decrease between the beginning of the semester and the end of the semester. The questions where an increase occurred are number 4 (PlayPosit will be easy to use/PlayPosit was easy to use), number 5 (PlayPosit will contribute to my interest in the course material/ PlayPosit did contribute to my interest in the course material), number 12 (Learning how to use digital tools is easy for me/ Learning how to use PlayPosit was easy for me), and number 13 (It is easy to become skillful at using digital tools/ It was easy to become skillful at using PlayPosit). As a reminder, question 3 (PlayPosit will be frustrating to use/ PlayPosit was frustrating to use) and question 10 (PlayPosit will not contribute to my learning experience/ PlayPosit did not contribute to my learning experience) were recoded because of their negative wording. This indicates that the increase between the pre- and post-semester survey results is due to more agreement in how frustrating it is to use PlayPosit and that it did not contribute to students' learning experience.

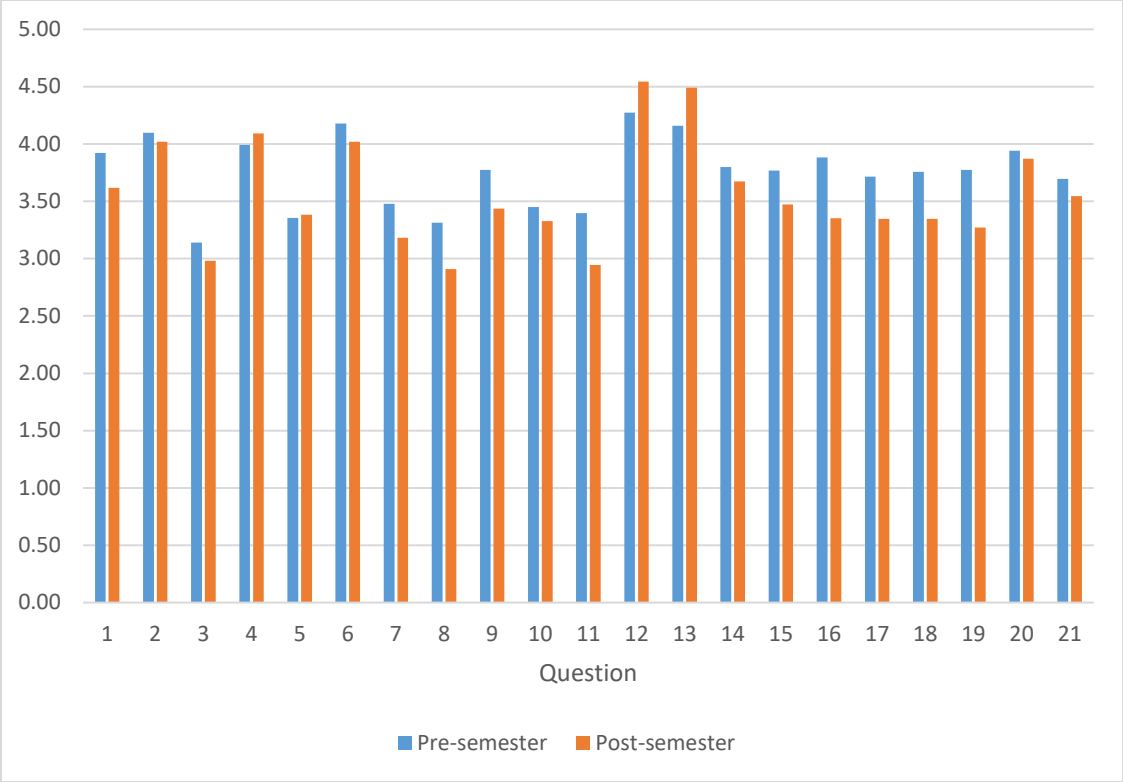

Figure 4-1. Average Scores of Pre- and Post-Semester Surveys

Table 4-3. Average, Standard Deviation, Mode, and Median of Pre- and Post-Semester Survey Results

	Pre-Semester			Post-Semester			
Question	**Average ± SD**	**Mode**	**Median**	**Average ± SD**	**Mode**	**Median**	**Difference**
1	3.92 ± 0.92	4	4	3.62 ± 1.39	4	4	-0.30
2	4.10 ± 0.85	4	4	4.02 ± 1.16	5	4	-0.08
3	3.14 ± 1.13	3	3	2.98 ± 1.21	4	3	-0.16
4	3.99 ± 0.90	4	4	4.09 ± 0.84	4	4	0.10
5	3.35 ± 1.08	4	3	3.38 ± 1.35	4	4	0.03
6	4.18 ± 0.75	4	4	4.02 ± 1.16	5	4	-0.16
7	3.48 ± 1.14	4	4	3.18 ± 1.52	4	4	-0.30
8	3.31 ± 1.08	3	3	2.91 ± 1.39	3	3	-0.40
9	3.77 ± 0.98	4	4	3.44 ± 1.52	5	4	-0.34
10	3.45 ± 1.15	4	4	3.33 ± 1.40	4	4	-0.12
11	3.40 ± 0.91	3	3	2.95 ± 1.01	3	3	-0.45
12	4.27 ± 0.83	5	4	4.55 ± 0.88	5	5	0.27
13	4.16 ± 0.83	4	4	4.49 ± 0.81	5	5	0.33
14	3.80 ± 0.96	4	4	3.67 ± 1.41	5	4	-0.13
15	3.77 ± 1.04	4	4	3.47 ± 1.53	5	4	-0.30
16	3.88 ± 1.11	4	4	3.35 ± 1.52	5	4	-0.53
17	3.72 ± 1.08	4	4	3.35 ± 1.48	5	3	-0.37
18	3.76 ± 1.02	4	4	3.35 ± 1.47	5	4	-0.41
19	3.77 ± 1.02	4	4	3.27 ± 1.59	4	4	-0.50
20	3.94 ± 0.98	4	4	3.87 ± 1.19	5	4	-0.07
21	3.69 ± 1.05	4	4	3.55 ± 1.29	4	4	-0.15

Because the survey was based off of the technology acceptance model (TAM) (Davis, 1989; Park, 2009; Terrion & Aceti, 2012), the survey results were grouped according to the TAM constructs (Appendix F). (The acronyms are as follows: I = Implementation, EU = Ease of Use, E = Engagement, EL = Effect on Learning, PU = Perceived Usefulness, A = Attitude, and BI = Behavioral Intention). According to Table 4-4, which shows the differences for the entire survey results, only the construct ease of

use increased over the semester. Although there was a decrease for most of the constructs, they all were fairly small with the averages staying in the neutral range.

Table 4-4. Pre- to Post-Semester Difference Based on TAM Construct

	I	EU	E	EL	PU	A	BI
Pre-Semester	3.576	3.855	3.383	3.611	3.834	3.749	3.818
Post-Semester	3.321	4.032	3.158	3.382	3.533	3.321	3.709
Difference	-0.255	0.177	-0.226	-0.229	-0.300	-0.428	-0.109

According to the technology acceptance model, BI is the best indicator of actual technology usage, and the other constructs can affect it (Davis, 1989; Lee et al., 2013; Park, 2009). In order to see how each specific construct affected the behavioral intention construct in this study, correlation data analysis was done on the pre- and post-semester surveys. The post-semester survey correlations can be seen in Table 4-5. As can be seen in the table, all of the constructs have a positive correlation on behavioral intention, but none of them are higher than 0.455 (see last row of Table 4-5). This indicates that while all of the constructs have a positive correlation, none of them have a particularly strong correlation with behavioral intention.

Table 4-5. Correlation of TAM Constructs

	I	EU	E	EL	PU	A	BI
I	1.000						
EU	0.711	1.000					
E	0.769	0.600	1.000				
EL	0.707	0.525	0.834	1.000			
PU	0.748	0.580	0.895	0.895	1.000		
A	0.762	0.625	0.876	0.809	0.905	1.000	
BI	0.246	0.291	0.432	0.330	0.455	0.361	1.000

4.2.1.1 Gender

The gender differences for the average scores were evaluated for both the pre-semester survey and post-semester survey individually. To determine if there was a difference in average score based on gender, an Analysis of Variance (ANOVA) was done first. For the pre-semester survey, the ANOVA returned an F-value of 4.158 and a p-value of 0.009, indicating that there was a statistical difference among the genders. Table 4-6 shows the t-statistic for each combination of genders. As seen in the table, the main statistically significant difference was the students who were non-binary.

Males had a lower average compared to all of the other genders. Only non-binary had an average response of 4 (Somewhat Agree), while the other genders had an average response of 3 (Neither/Neutral). This indicates that the other three genders did not have much expectations at the start of the semester, but non-binary students did have slightly positive expectations at the beginning of the semester.

The sample size of non-binary and students who preferred not to state their gender was too small (n=1 for both), so post-semester statistical analysis was only done comparing males and females. Post-semester survey results showed no statistically significant difference between the two genders (t-statistic = -1.128, p-value = 0.266). The t-statistic shows that males had a lower average than females at the end of the semester. However, both genders still only had an average response of 3 (Neither/Neutral).

Table 4-6. T-statistics of Pre-Semester Average Score Based on Gender

	Male	Female	Non-binary
Female	-1.701		
Non-binary	-3.133*	-2.072*	
Prefer not to say	-0.656	0.566	2.171*

*p-value=0.05, **p-value<0.001

Table 4-7. Pre- to Post-Semester Difference Based on Gender

	Male			Female		
Question	**Average Pre- ± SD**	**Average Post- ± SD**	**Difference**	**Average Pre- ± SD**	**Average Post- ± SD**	**Difference**
1	3.71 ±1.10	3.63 ±1.50	-0.08	4.03 ±0.79	3.65 ±1.39	-0.38
2	3.89 ±0.88	3.84 ±1.38	-0.05	4.22 ±0.82	4.12 ±1.07	-0.10
3	3.00 ±1.20	2.72 ±1.32	-0.28	3.21 ±1.11	3.06 ±1.15	-0.15
4	3.99 ±0.86	3.89 ±0.88	-0.09	3.98 ±0.93	4.18 ±0.83	0.20
5	3.27 ±1.08	3.32 ±1.20	0.05	3.42 ±1.07	3.38 ±1.48	-0.04
6	4.13 ±0.64	3.74 ±1.45	-0.40	4.21 ±0.81	4.18 ±1.00	-0.03
7	3.46 ±1.19	2.95 ±1.51	-0.51	3.48 ±1.12	3.29 ±1.57	-0.18
8	3.34 ±1.13	2.95 ±1.35	-0.39	3.30 ±1.08	2.85 ±1.46	-0.45
9	3.58 ±1.11	3.21 ±1.58	-0.37	3.88 ±0.89	3.56 ±1.54	-0.32
10	3.14 ±1.24	3.26 ±1.37	0.12	3.62 ±1.06	3.32 ±1.47	-0.30
11	3.38 ±0.91	3.16 ±1.01	-0.22	3.40 ±0.97	2.79 ±1.01	-0.60
12	4.28 ±0.83	4.53 ±0.96	0.25	4.25 ±0.85	4.53 ±0.86	0.27
13	4.13 ±0.84	4.37 ±1.01	0.24	4.15 ±0.84	4.56 ±0.70	0.40
14	3.60 ±1.04	3.68 ±1.45	0.08	3.93 ±0.90	3.65 ±1.43	-0.28
15	3.65 ±1.08	3.42 ±1.50	-0.23	3.83 ±1.01	3.47 ±1.58	-0.36
16	3.83 ±1.10	3.21 ±1.55	-0.62	3.89 ±1.14	3.39 ±1.56	-0.49
17	3.55 ±1.03	3.32 ±1.60	-0.23	3.82 ±1.12	3.35 ±1.47	-0.47
18	3.69 ±0.97	3.26 ±1.56	-0.43	3.79 ±1.07	3.38 ±1.48	-0.41
19	3.57 ±1.09	3.00 ±1.73	-0.57	3.88 ±0.96	3.35 ±1.54	-0.53
20	3.84 ±0.99	3.84 ±0.96	0.00	4.01 ±0.98	3.94 ±1.32	-0.07
21	3.56 ±1.09	3.05 ±1.22	-0.51	3.82 ±1.01	3.85 ±1.26	0.03

To see if there was any change over the semester, pre- to post-semester differences were done for the genders. Again, since the sample size was too small, only males and females were compared. There was no statistical difference between the two

genders (t-statistic = -0.0017, p-value = 0.999). Both genders actually had an average decrease of 0.20. When actually comparing the average responses per question and gender (Table 4-7), the average response was a 3 (Neither/Neutral).

When comparing the different TAM constructs based on gender, as seen in table 4-8, both males and females had a decrease across all constructs with most being at least a 1.0 difference. Looking at the pre-semester data (Table 4-7), all genders started out around the neutral level and by the end of the semester, their responses decreased to somewhat disagree. This indicates that the students came in with fairly neutral expectations about PlayPosit, but then their perceptions decreased by the end of the semester. Also, since all of the TAM constructs had a positive correlation with behavioral intention (Table 4-5), it is not surprising that with all of the constructs being negative, BI is also negative.

Table 4-8. Pre- to Post-Semester Difference of TAM Constructs-Gender

	I	**EU**	**E**	**EL**	**PU**	**A**	**BI**
Female	-0.254	0.244	-0.228	-0.319	-0.350	-0.468	-0.017
Male	-0.217	0.039	-0.281	-0.103	-0.209	-0.411	-0.253

4.2.1.2 Major

As stated earlier, the majors were categorized into general areas of study: science, social sciences, engineering, technology, math, pre-professional, and undecided. An ANOVA was done on both pre-semester and post-semester survey results based on general area of study. Both pre-semester and post-semester survey responses showed a statistical difference based on area of study. The pre-semester survey response F-value was 19.767 with a p-value of <0.001, and the post-semester survey response F-value was 15.414 with a p-value of <0.001. Table 4-9 and 4-10 show the t-statistics for the majors' t-test for the pre-semester and post-semester responses,

respectively. Because there were less responses in the post-semester survey, only those that had responses were compared.

Looking at Table 4-9, mathematics, non-STEM, and undecided majors were for the most part statistically significant compared to the other majors. Mathematics and non-STEM majors had higher expectations (average response was 4) going into the semester compared to the other majors. Undecided had statistically lower expectations (average response was 2) compared to the other majors at the beginning of the semester. Comparatively, in the post-semester survey results, technology majors were statistically different from the other majors, with more positive responses (average response was 4) compared to the other majors.

Table 4-9. T-statistics of Pre-Semester Survey Results Based on Major

	Science	**Social Science**	**Engineer**	**Math**	**Tech**	**Pre-Prof**	**Non-Stem**
Social Science	0.752						
Engineer	1.318	0.445					
Math	-2.939*	-3.318*	-3.763**				
Tech	0.960	0.323	-0.025	3.262*			
Pre-Prof	2.578*	1.777	1.493	4.498**	1.233		
Non-Stem	-3.465*	-3.853**	-4.440**	0.024	-3.672**	-5.143**	
Undecided	7.357**	6.372**	6.353**	7.993**	5.340**	4.439**	9.020**

*p-value=0.05 **p-value<0.001

Table 4-10. T-statistics of Post-Semester Survey Results Based on Major

	Science	**Social Science**	**Engineer**	**Math**
Social Science	-2.068*			
Engineer	-1.199	0.997		
Math	-2.748*	-1.272	-1.987	
Technology	-7.490**	-6.013**	-7.033**	-3.244*

*p-value=0.05 **p-value<0.001

Because only five of the areas (science, social science, engineering, math, and technology) had responses in both the pre- and post-semester surveys, only those five were investigated for the pre-/post-semester differences. The average differences based on major are listed in Table 4-11. Most questions had an decrease in average responses over the semester. Technology majors were the only major that had a increase over almost all of the questions. The ANOVA returned a statistical difference (F-value = 6.303, p-value <0.001) based on area of study. Table 4-12 shows the t-statistics of the difference comparisons. As mentioned, technology majors had an average increase over all the questions, which was statistically significant when comparing to the other majors. Science majors also were statistically different compared to the other majors (except for mathematics). Science majors had a larger decrease over the semester compared to the other majors even though they also decreased in their perceptions over the semester (excluding technology majors).

Table 4-11. Pre-/Post-Semester Survey Differences Based on Major

Question	Science	Social Science	Engineering	Math	Technology
1	-0.62	0.01	-0.35	-0.67	1.13
2	-0.36	0.12	-0.06	-1.00	1.20
3	-0.13	-0.25	-0.34	1.00	0.83
4	0.13	-0.20	0.11	0.67	0.77
5	-0.19	-0.10	0.17	0.00	1.50
6	-0.48	0.17	-0.17	0.00	0.60
7	-0.49	-0.13	-0.56	0.50	1.17
8	-0.90	0.26	-0.31	-1.50	0.40
9	-0.80	0.11	-0.30	-0.25	0.63
10	-0.47	0.19	-0.15	-0.25	1.10
11	-0.90	-0.32	0.00	-1.00	-0.33
12	0.16	0.50	0.38	0.00	0.21
13	0.31	0.40	0.40	0.00	0.43
14	-0.54	0.26	-0.14	0.00	1.29
15	-0.82	-0.09	-0.13	0.00	1.43
16	-0.97	-0.33	-0.38	-0.75	1.21
17	-0.63	-0.35	-0.28	-0.75	1.50
18	-0.53	-0.35	-0.49	-0.50	1.29
19	-0.82	-0.52	-0.36	0.00	1.00
20	0.01	-0.52	-0.03	0.75	1.14
21	-0.35	0.01	-0.16	-2.25	1.36

Table 4-12. T-statistics of Pre-/Post-Semester Difference Based on Major

	Science	Social Science	Engineering	Math
Social Science	-3.788**			
Engineering	-2.996**	1.129		
Math	-0.869	1.293	0.770	
Technology	-10.518**	-8.197**	-9.275**	-6.244**

*p-value = 0.05 **p-value<0.001

Table 4-13 shows the difference of the TAM constructs across all of the majors. Only ease of use increased over the semester over all of the majors. Despite this, most of the areas of study had a decrease in all constructs, except for technology majors who had an increase in all constructs over the semester. It still is not surprising that BI also decreased when most of the constructs also decreased. When looking at the correlation between the constructs (Table 4-5), the correlation between ease of use and behavioral intention (0.291) is not a strong correlation, meaning that it does not outweigh the correlations of the other constructs on behavioral intention.

Table 4-13. Pre- to Post-Semester Differences of TAM Constructs-Major

	I	**EU**	**E**	**EL**	**PU**	**A**	**BI**
Science	-0.582	0.129	-0.526	-0.636	-0.796	-0.664	-0.168
Social Science	0.005	0.088	-0.006	0.120	-0.037	-0.356	-0.143
Engineering	-0.074	0.161	-0.235	-0.222	-0.252	-0.377	-0.094
Math	-0.600	0.321	-0.303	-0.250	-0.333	-0.417	-0.825
Technology	0.489	0.586	1.022	0.867	1.263	1.262	1.250

4.2.1.3 Previous PlayPosit Usage

Comparisons of the survey results based on whether the students have used PlayPosit before were done. An ANOVA was done on both pre-semester and post-semester surveys and came back statistically different (pre: F-value = 4.064, p-value <0.001; post: F-value = 5.974, p-value <0.001). After t-tests were done to compare the difference between the knowledge and usage of PlayPosit, the t-statistics indicated that in the pre-semester results students who had not heard of PlayPosit had slightly higher perceptions of PlayPosit than those who have heard of it and were going to use it the first time during the semester. The students who had not heard of it also had a slightly

lower perception of PlayPosit compared to those who had used it before. For the post-semester results, there was a statistical difference between those students who had used PlayPosit before compared to those who were using it for the first time during the semester. The t-statistics indicate that those who had used PlayPosit before the semester had slightly lower results than those who were using it for the first time. The t-statistics for both the pre- and post-semester results are shown in Table 4-14. The ANOVA returned a statistical difference on pre- to post-semester change based on previous PlayPosit use and knowledge (F-value = 11.558, p-value <0.001). The semester difference based on previous PlayPosit usage is shown in Table 4-15. The t-statistics of semester differences comparing previous usage of PlayPosit is shown in Table 4-16. The students who had never heard of PlayPosit before had a slightly more positive change over the semester compared to those who had used it before. However, it was not statistically significant. The students who had heard of PlayPosit and were using it for the first time during the semester had a more positive change in perceptions over the semester compared to those who had used PlayPosit before and it was statistically significant. Alternatively, these same students had a lower positive change over the semester compared to those who had not heard of PlayPosit before, and this difference was statistically significant.

Table 4-14. T-statistics of Pre-/Post-Semester Survey Results

Pre-Semester		
	Used Before	**Never Heard of it**
Never Heard of it	2.465*	
First Time Using	-1.825	-4.610**
Post-Semester		
	Used Before	**Never Heard of it**
Never Heard of it	2.880	
First Time Using	2.282*	-0.057

*p-value=0.05 **p-value<0.001

Table 4-15. Semester Difference Based on Previous PlayPosit Use

Question	I have heard of and used it before	I have never heard of it	I have heard of it before and will use it the first time this semester
1	-0.09	-0.47	-0.79
2	0.08	-0.32	-0.07
3	-0.15	0.02	-0.77
4	-0.04	0.46	-0.54
5	0.18	0.00	-0.40
6	-0.16	-0.32	0.23
7	0.14	-0.61	-1.10
8	-0.18	-0.37	-1.53
9	-0.10	-0.52	-0.96
10	-0.08	0.04	-0.22
11	-0.40	-0.36	-0.82
12	0.24	0.50	-0.23
13	0.21	0.44	0.60
14	0.03	-0.11	-0.87
15	0.01	-0.48	-1.17
16	-0.24	-0.74	-1.22
17	-0.16	-0.47	-1.24
18	-0.06	-0.68	-1.31
19	-0.44	-0.38	-1.31
20	-0.05	-0.15	-0.06
21	0.00	-0.39	0.02

Table 4-16. T-statistics of Pre- to Post-Semester Difference Based on Previous PlayPosit Use

	Used Before	**Never Heard of it**
Never Heard of it	1.971	
First Time Using	4.433**	2.790*

*p-value=0.05 **p-value<0.001

When looking at the technology acceptance model constructs based on previous PlayPosit knowledge and usage, almost all of the constructs had a decrease from the beginning of the semester to the end of the semester. Only ease of use for those who have used PlayPosit before and never have heard of it showed an increase over the semester, as seen in Table 4-17. Although there was a decrease over most of the constructs, the results stayed in the neutral region for most of the constructs. Engagement, perceived usefulness, and attitude among the students who have heard of PlayPosit and used it for the first time this semester had a decrease into a new answer range. The average for these constructs were approximately in the somewhat agree or neutral area in the beginning and ended in the somewhat disagree range, so these constructs were more positive in the beginning and more negative or neutral at the end of the semester.

Table 4-17. Pre- to Post-Semester Difference of TAM Constructs-Previous PlayPosit Use

	I	**EU**	**E**	**EL**	**PU**	**A**	**BI**
Used Before	-0.162	0.105	0.048	-0.094	-0.065	-0.221	-0.026
Never Heard of It	-0.344	0.380	-0.330	-0.241	-0.410	-0.508	-0.269
First Time Using It	-0.216	-0.177	-1.008	-0.592	-1.006	-1.288	-0.020

4.2.2 CHE 105 Statistics

At the beginning of the Fall 2022 semester, there were 1,318 total students enrolled across all six sections of CHE 105. Prof. A's section had a total of 23 students by the end of the semester. Profs. B and C had 423 and 429 students at the end of the semester, respectively. Prof. D had 223 students remaining at the end of the semester. The total number of students, then, who completed the semester over all six sections

was 1,098. Based on these numbers, there was a drop of 220, or about 16.69% students from the beginning to the end of the semester.

Table 4-18. Percentages of Grades for the Faculty of CHE 105

	Percentage			
Grade	**Prof. A**	**Prof. B**	**Prof. C**	**Prof. D**
A	13.04	22.46	22.61	30.49
B	21.74	33.33	29.14	30.04
C	30.43	26.95	25.17	26.01
D	8.70	12.06	13.29	7.62
E	26.09	4.96	9.79	4.93
I	0.00	0.24	0.00	0.90

Although the grades of CHE 105 were not investigated as part of the overall study, final grade distributions for each professor were graciously given to the researcher and approved with a modification to the IRB. The percentages of the grades for each professor are given in Table 4-18. Profs. B and C had similar distribution and percentages with most of their grades being in the B range. Prof. D had a similar tailing with very similar percentages for their A and B grades (30.49 and 30.04%, respectively). Prof. A had a distribution resembling a normal distribution, with the apex of the curve being in the C range. An Analysis of Variance (ANOVA) was done using Excel to see if there was significant difference among the grade distributions for each professor. The p-value returned in the ANOVA was 0.046, which is less than the α of 0.05, so the null hypothesis that the grade distributions are the same is rejected. A student's t-test assuming unequal variance was used to see which professor's grades caused the null hypothesis to be rejected. The t-statistics for each comparison can be seen in Table 4-19.

Table 4-19. T-statistics of Professors' Grade Distribution

	Prof. B	**Prof. C**	**Prof. D**
Prof. A	2.966*	3.522*	2.681*
Prof. B		0.034	-1.300
Prof. C			-1.504

*p-value=0.05, **p-value<0.001

Based on the t-statistics, Prof. A's grade distribution is the statistically different distribution. Although grades were not a major component of this study, it is interesting that Prof. A's course was the only course that was taught asynchronously online, and his grades were statistically different than the other professors. Further discussion will be done in the last chapter. Another interesting point was that Prof. D was not statistically different even though the format of her class was the traditional didactic-lecture style.

4.2.3 PlayPosit Data

While the perceptions of the PlayPosit videos can give an indication of student usage, the actual usage data can add another level of information into PlayPosit perceptions and usage in the classroom. In order to glean some more information, data about the PlayPosit videos and grades within each section was evaluated. Some complaints mentioned in the interviews was the number and length of videos. A majority of the videos across all three professors who utilized PlayPosit had a length of 10-20 minutes (see Figure 4-2). Prof. C did not have any videos under 10 minutes, but he did have two videos between 40 and 50 minutes and two videos more than 50 minutes. Professors A and B both had videos less than 10 minutes and did not have any videos

longer than 40 minutes. As can be seen in Table 4-20, the average video length for Profs. A and B were 17.75 and 15.00 minutes, respectively. Prof. C's average video length was almost 10 minutes more at 23.75 minutes. The median video lengths were not too different compared to the average lengths. While the average and median video lengths tell an interesting story, in combination with the total number of videos, there is an extra level to the conversation added. Although Prof. C has the longest video times (his shortest at 10.90 minutes and longest at 53.40 minutes), he had the least number of videos at 55 videos. Prof. C even mentioned this trade off in his interview, stating that based on the topic, the video might be quite long; however, with longer videos comes less of them total. Prof. B referenced this trade off in her interview as well. Alternatively, students may not be aware of the differences in video count and length among the different sections, so their comments were only based on their class. Their comments were not unwarranted, but if they saw the length and count across the different sections, they may have made different comments.

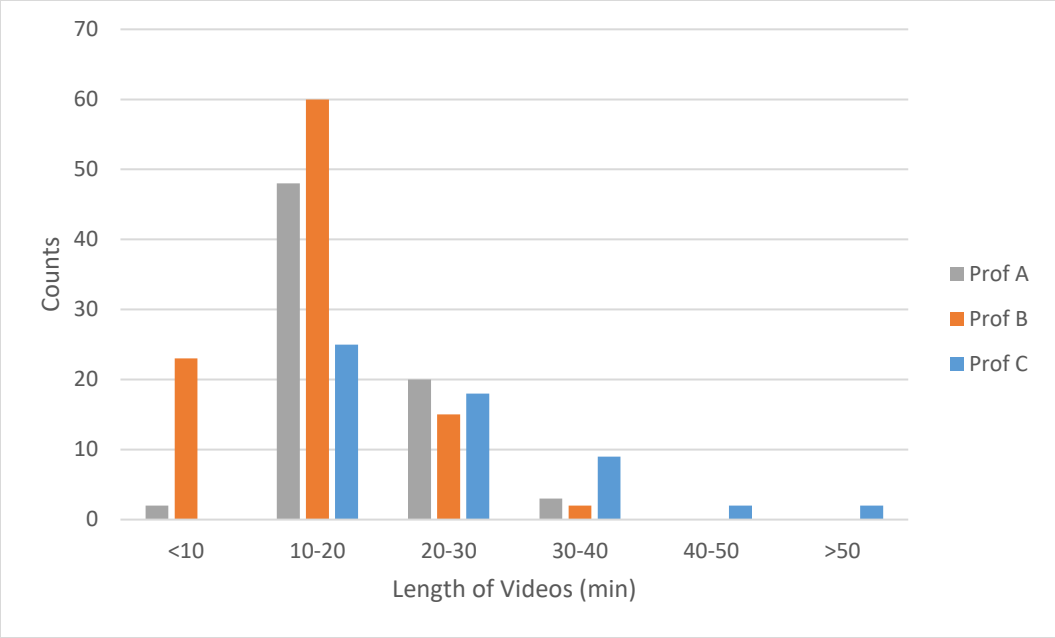

Figure 4-2. Number of Videos Based on Length

Table 4-20. Information on Video Length per Professor

	Prof. A	**Prof. B**	**Prof. C**
Average Length ± Std Dev (min)	17.75 ± 5.46	15.00 ± 6.27	23.75 ± 9.13
Median Length (min)	17.82	14.12	20.63
Shortest (min)	8.48	4.52	10.90
Longest (min)	35.02	33.22	53.40
Total Count	73	99	55

It appeared that the actual length of the videos was not what made the students comment about how long it took to do the PlayPosit videos. Rather, the time it took to do the videos could generally be longer since students mentioned stopping the videos to take notes, rewind the videos, or to take their time with the embedded questions. All of these can increase the time it takes to watch the videos. There have also been comments from the professors and teaching assistants where students have admitted to putting the videos on in the background and only returning to do the questions. In order

to investigate this area, the average and median watch times were analyzed for each professor. These can be seen in Table 4-21 along with the minimum and maximum average and median watch times. One step further was taken to see how much longer than the actual length of the videos it took the students to watch the videos. The difference between the median time and length of video and between the mean time and length of video can also be seen in Table 4-21. Most of the times to watch the videos were longer than the actual length of the videos. This makes sense if students are pausing, rewinding, or taking their time with questions. All three professors did have a median watch time that was less than the actual length. Another feature of PlayPosit is the ability to rewatch the videos. While the first time through is what is graded, students are allowed to return to the videos as many times as they want. Looking at the proportion of rewatches, Prof. B did not have any students rewatch videos, while Prof. A and C had some videos that were rewatched. Prof. C had a total of 33 out of their 55 videos rewatched, with the average proportion of rewatches being 0.02 (Table 4-21).

Table 4-21. Mean and Median Watch Times for Each Professor

Prof. A				
	Average	**Std Dev**	**Min**	**Max**
Median Watch Time (min)	22.51	10.89	8.40	104.20
Difference between Median Time and Length (min)	4.75	8.42	-5.97	70.60
Mean Watch Time (min)	48.58	25.61	12.30	117.20
Difference between Mean Time and Length (min)	30.83	23.77	2.65	95.62
Rewatch Proportion	0.00	0.01	0.00	0.05
Prof. B				
	Average	**Std Dev**	**Min**	**Max**
Median Watch Time (min)	20.42	11.20	6.30	75.60
Difference between Median Time and Length (min)	5.32	8.66	-5.92	55.67
Mean Watch Time (min)	53.90	18.60	22.10	113.00
Difference between Mean Time and Length (min)	38.79	13.51	15.88	91.80
Rewatch Proportion	0.00	0.00	0.00	0.00
Prof. C				
	Average	**Std Dev**	**Min**	**Max**
Median Watch Time (min)	30.42	17.43	13.30	98.30
Difference between Median Time and Length (min)	6.67	0.09	-0.37	54.58
Mean Watch Time (min)	60.18	24.77	30.30	137.30
Difference between Mean Time and Length (min)	36.42	17.07	14.37	93.58
Rewatch Proportion	0.03	0.05	0.00	0.22

When comparing the grades of the PlayPosit videos between professors, one has to be cognizant that the grades could be an indication about student learning. However, this information is a small amount of the total learning experience in CHE 105. Table 4-22 breaks down the number of videos watched per professor and the spread of

grades. All three professors had about 70-80% of the videos watched over the semester. Although not a direct correlation, it is interesting that average grades for the PlayPosit videos is within about 10% of the percentage of videos watched. This indicates that the effort students put in to actually watching the videos will correlate to their grades.

Table 4-22. PlayPosit Videos Watched and Grades Based on Professor

	Prof. A	**Prof. B**	**Prof. C**
Total Videos	73	99	55
Average ± SD Videos Watched	52.00 ± 24.01	78.31 ± 29.08	44.89 ± 14.89
Percentage ± SD of Videos Watched	71.23 ± 13.91	79.10 ± 12.00	81.62 ± 9.48
Median Number Videos Watched	66	97	53
Average ± SD Grade	78.65 ± 20.44	80.65 ± 8.24	85.36 ± 12.37
Median Grade	83.12	81.45	87.55
Minimum Grade	0.00	46.83	0.00
Maximum Grade	96.00	100.00	100.00

Because students commented on the length of videos as one of the disadvantages, we compared the shortest and longest videos for each professor. The comparisons can be seen in Table 4-23. Only Profs. A and C had similar topics for their shortest videos, covalent compounds. All of the other videos independent of length was a different topic. Some of the more interesting information attained from the table is that the average grades ended up being completely different than what is expected. One would think the shorter videos would have slightly better grades than the longest videos. That, however, is not the case with Prof. A, whose shorter video had a worse grade than the longer video (67.50 and 88.33, respectively). Additionally, the grades for Prof. C's videos were within 10% of each other. Another interesting piece of information is the percent of students who completed the videos. The completion rate for Prof. B and C's longest video is less than for the shortest video, which makes sense. Students will

struggle completing the videos when timing is an issue. However, for Prof. A's asynchronous online course, the completion rate for the longer video is higher than the shorter video.

Table 4-23. Comparison of Shortest and Longest Video for Each Professor

	Prof. A		**Prof. B**		**Prof. C**	
Topic	Covalent Bonding	Reactions and Aqueous Solutions	How Big is a Mole	Polarity of Molecules	Naming Covalent Compound	Electron Configuration
Length of Video (min)	8.48	35.02	4.52	33.22	10.90	53.40
Median Watch Time (min)	8.40	40.00	6.30	27.30	13.30	92.30
Median/Length Difference (min)	-0.08	4.98	1.78	-5.92	2.40	38.90
Mean Watch Time (min)	21.30	41.40	28.10	108.40	30.40	112.30
Mean/Length Difference (min)	12.82	6.38	23.58	75.18	19.50	58.90
Average ± SD Grade	67.50 ±24.47	88.33 ±21.51	91.57 ±16.58	79.47 ±17.30	99.13 ±6.55	90.83 ±17.22
Median Grade	50	100	100	80	100	100
Percent Completed	57.14	85.71	89.73	67.26	92.31	71.20

Because the PlayPosit videos is where a majority of the content is given to the students, the grade distribution of PlayPosit videos was compared to the overall grade

distribution per professor (Table 4-24). Student's t-test was done on the grade distributions to see if there was a statistically significant difference between the PlayPosit grades and final class grades. All three professors' grade distributions were not statistically different from the PlayPosit grade distributions. It was mentioned among the faculty interviews that of all the assignments within the class, they saw a positive correlation between PlayPosit grades and exam grades. Overall, the grade distribution was similar between the PlayPosit grades and the final course grades for each professor. Further data analysis was done on the grade distributions to see if there was a correlation between PlayPosit grades and final grades. All three professors did have a positive correlation, but only Prof. B had a correlation higher than 0.9 at 0.942 with Prof. A having 0.325 and Prof. C having a correlation of 0.785 (Table 4-25). The correlations were not statistically significant for any of the professors.

Table 4-24. PlayPosit and Final Class Grade Distribution

	Prof. A		**Prof. B**		**Prof. C**	
	PP Percent	**Final Grade Percent**	**PP Percent**	**Final Grade Percent**	**PP Percent**	**Final Grade Percent**
A	17.14	13.04	13.98	22.46	41.50	22.61
B	54.29	21.74	46.02	33.33	39.00	29.14
C	22.86	30.43	30.09	26.95	13.60	25.17
D	0.00	8.70	8.50	12.06	3.58	13.29
E	5.71	26.09	1.42	4.96	2.33	9.79

Table 4-25. Correlation between PlayPosit Grade and Final Grade per Professor

	Prof. A	**Prof. B**	**Prof. C**
Correlation	0.325	0.942	0.785

CHAPTER 5. DISCUSSION

This research looked at the perception and usage of the interactive video platform PlayPosit in a college general chemistry I course (CHE 105). Activity theory was the theoretical framework utilized throughout the study to understand the interplay between faculty, teaching assistants, and students within CHE 105 (Engeström, 2001; Tamayo, 2002; Vygotsky, 1978). Vygotsky (1978) brought forth the concept of activity theory based on the ideas that learners do not learn in a vacuum all by themselves, there is an interaction with those around them and mediating tools that they use to learn. This early concept (see Figure 2-1) has been further expanded to include roles, division of labor, and community for a certain group (the subject) within an activity (Tamayo, 2002). However, when considering a larger complex activity (e.g., CHE 105), there are more subjects within the larger context. Looking at one specific subject within this activity (e.g., just faculty) can inform researchers of a lot of things, but a more complete picture would include the other subjects. Therefore, the theoretical framework was extended to include the three major groups within CHE 105: the faculty, TAs, and students; and resembled the design seen in Figure 2-3.

For this study, an embedded concurrent mixed methods approach was used to investigate the perceptions and usage of PlayPosit within CHE 105 (DeCuir-Gunby & Schutz, 2017; Yu & Khazanchi, 2017). Both qualitative and quantitative data was gathered and analyzed concurrently, where the quantitative data was used to help explain the qualitative data. Quantitative data consisted of surveys sent to students at the beginning and end of the fall 2022 semester to assess their acceptance of PlayPosit based of the technology acceptance model (Lee et al., 2013; Park, 2009). PlayPosit analytical information (e.g., length of videos, average watch times of the videos) was also gathered to help elevate and answer questions within the qualitative data. Qualitative data consisted of interviews with faculty and teaching assistants who taught

CHE 105 and the associated recitation sections. As part of the student surveys, open-ended responses were included that asked about their specific perceptions of PlayPosit. There was a total of eleven TAs who taught on average five recitation sections. Five of those TAs participated in the interviews. The TAs ranged from first year to seventh year graduate students.

5.1 Addressing the Research Question

Main research question: How does the perceptions of PlayPosit affect the usage of it by the faculty, teaching assistants, and students of CHE 105?

5.1.1 Faculty Perceptions and Usage

There was a total of four faculty who taught six different sections of CHE 105. Two of the faculty taught two sections each in a flipped classroom format that utilized PlayPosit for the main course content; one faculty member taught one section asynchronously online; and the fourth faculty member taught their one section in a traditional didactic lecture style. Professor B and C, who utilize PlayPosit in a more flipped classroom aspect, both had positive perceptions of PlayPosit. Both professors have been using PlayPosit for years, while Prof. B has been using it longer. Prof. A, while he used PlayPosit, was adamant about preferring traditional didactic lecturing. The main point he brought forth as to why he preferred in-person lecturing was the interaction with the students. Although this is a valid point to have, the fact that he was teaching CHE 105 asynchronously online could have altered his perceptions towards the platform. Prof. D, while from the beginning mentioned that she did not use PlayPosit for her CHE 105 section, was an interesting discrepancy to include in the research. She also preferred traditional didactic lecturing because of that interaction with students. The idea of engagement and being able to see the confusion or comprehension with the

students was brought up from all four professors. Even though Prof. B has been doing a flipped classroom the longest, she stated that she loved lecturing. She loved being able to engage and enrapture students in person, but she transitioned when she knew she was starting to lose out to technological distractions. Prof. D, however, did use PlayPosit in one of her upper-level courses. She saw the value in using it for the laboratory aspect to discuss pre-lab information before students came to class. There have been studies showing the value of interactive videos in pre-laboratory settings for improving student learning (Shelby & Fralish, 2021; Stieff et al., 2018). She mainly did not use PlayPosit for her CHE 105 section because she felt it would push her more towards a flipped classroom, and for a larger class, she did not think that format was conducive to student learning.

The three secondary aspects of activity theory (rules, division of labor, and community) were discussed in the interviews. Other discussions and eventually other themes arose throughout the interviews. The first aspect of activity theory discussed was rules. One of the first questions asked was whether the professor felt pushed into using PlayPosit. Besides the mention of transitioning to it during the COVID-19 pandemic, all of them stated that they were not forced to use it. Prof. D was the only one who did not use PlayPosit for her CHE 105 class, but she did mention that sometimes she got the sense that it would be easier on everybody if she made the switch. The major reason for this was the department's desire to keep all sections of CHE 105 as similar as possible, so if all of the professors use PlayPosit, there is less chance for students to complain about the differences among the different sections.

In terms of division of labor, all professors saw themselves as facilitators of knowledge. Although not explicitly stated, each of them hinted at the interaction between themselves and students was an interchange of knowledge, and they were not the keeper of the knowledge that they impart on the students. As part of this interchange of

knowledge, each of them mentioned that the students had their own responsibility in their learning. The students themselves have to put forth the effort to look at the material beforehand (via PlayPosit) in order to get the most out of the in-class time where more content clarifications and actual problems can be done. Without that effort on their part, the professors cannot uphold their side of the interaction.

All of the professors also commented on the community aspect of the general chemistry faculty. While they were given a fair amount of free reign to run their sections how they wanted, they all did mention that keeping on track with everyone else was an awareness that they had. Even though the three professors who did use PlayPosit made their own videos, there was mention of sharing videos or lecture notes among other faculty in the chemistry department. It usually is not the same faculty teaching CHE 105 each semester, usually there are research faculty that will rotate in for a semester. Prof. B specifically mentioned allowing these research faculty to use her videos so that they could concentrate more on what they would be doing in-class.

As mentioned earlier, during the interviews other themes emerged. The themes that emerged during the faculty interviews were student buy in, usefulness of PlayPosit, student engagement, and preference to flip. While some of the statements within these themes also correlated to the activity theory themes, enough mentions across the interviews deemed further discussion of these themes. Along with student responsibility mentioned during the division of labor section, student buy in was a secondary component of that statement. Studies show that when students buy in to some learning aspect, they have a more positive outcome to student engagement and learning (Cavanagh et al., 2016). A few of the interviews touched on this concept of if the students do not understand why they are doing something or have buy in, then they will not put in the effort that is required of them. When looking at the student survey responses, both of the questions pertaining to engagement and behavioral intention

decreased over the semester (-0.226 and -0.109, respectively, Table 4-4). Even when based on gender, major, and previous PlayPosit usage, both constructs decreased over the semester (see Tables 4-12, 4-17, and 4-21, respectively). Interestingly, the technology majors had an increase across all TAM constructs, and students who had used PlayPosit before had an increase in the engagement construct. This data does help reiterate the idea of student buy in increasing engagement and usage of some educational aspect.

When discussing student buy in, Prof. B brought up that as a professor, she had to sell the idea of PlayPosit and a flipped classroom, tell and show the students why they should buy in to something new. As part of that, the usefulness of PlayPosit came up in not only her interview, but others' as well. Some of the positive features of PlayPosit was the ability to embed questions that help keep students on track with the content, ability to rewatch the videos multiple times, and the ability to rewind and pause the videos. While the professors thought these were great features, it may not be the same for students. Some student comments in the survey did like that they could pause the videos and rewind when they needed to take notes or rewatch something for clarification. However, based on the PlayPosit analytics gathered, there were not many videos rewatched during the semester. Only 1-5% videos were rewatched throughout the semester (Table 4-25). However, on average students took 30 more minutes to watch PlayPosit videos than their actual length. This indicates that students could be taking their time, including pausing and rewinding videos, to ensure they understand the material, so they do not need to review the videos. Alternatively, some students commented in the surveys that they would just play the videos in the background and only return to do the problems. This is something that further studies could investigate even more.

One of the bigger indicators of student learning from the research is student engagement (Bond & Bedenlier, 2019; Carle et al., 2009; Dunn & Kennedy, 2019; Quan

& Buikema, 2018; Zaza & Neiterman, 2019). Student engagement was brought up in student buy in and division of labor. One of the reasons that Prof. D did not use PlayPosit was because of student engagement. She felt that being in person, teaching in real-time allowed her to engage more with the students. Prof. B also mentioned this as to why she loved lecturing, but with more technology and social media, that in-class engagement went away. This was another reason why she switched to a flipped classroom format because it allows her to push that lecturing engagement to more hands-on engagement with the actual work. Allowing students to engage with the material and ask questions among themselves and with her helped improve student learning outcomes. As mentioned earlier, the engagement construct in the student survey did not increase for the most part. Because engagement is tied to effect on student learning, the effect on student learning also shows a decrease across almost all categories of students (Tables 4-4, 4-12, 4-17, and 4-21). Based on the student surveys, they did not feel that the use of PlayPosit increased their in-class engagement, nor did it affect their learning.

The use of interactive videos has been tied to the flipped classroom aspect (Bakla & Mehdiyev, 2022; Haagsman et al., 2020). Because of this an interview question specifically asked the professors about flipping their classroom. As mentioned earlier, Prof. B and C both have flipped while Profs. A and D prefer the traditional lecture style. There were other reasons why they chose to flip or not, but the more common reason was engagement. Student engagement was discussed earlier, but a few things should be added. One of the touted advantages of the flipped classroom is that it allows students to do the harder, usually at home, work in class where they can ask for clarification in real time (Eichler & Peeples, 2016; Wang et al., 2019). This was a specific advantage from Profs. B and C, that having the students watch PlayPosit to learn the

content before class and do the more difficult work in class allowed for a better understanding of the material.

Although it is difficult to measure student learning, grades are usually what is used (Schwab et al., 2018). To try to assess student learning, PlayPosit grades and overall grade distributions were gathered. When looking at overall grade distributions via ANOVA, there was a statistical difference among the grade distributions across the four professors. A student's t-test showed that Prof. A was statistically different compared to all the other professors (see Table 4-23). There most likely were other contributing factors as to why Prof. A's grade distribution was statistically different, but they would all be speculation at this point. A more potential reasoning for the statistical difference is the fact that Prof. A's section was taught asynchronously online. That could be a larger contributing factor to why the grades were different. Another interesting observation is that Prof. D's (in-person lecture with no PlayPosit) grade distribution was not statistically different compared to Profs. B and C who use PlayPosit. Again, there are potentially a number of other variables that could play into that. One of these could be that while Prof. D did not use PlayPosit in their CHE 105 class, they did video record the lectures via Echo 360. This feature of her classroom would allow students the ability to go back an watch the lectures on their own time similar to watching PlayPosit videos again. This avenue of research could be further investigated to see the potential differences in video usage (e.g., reviewing), how the two video formats differ, and student learning. Other future in-depth research could look into these and other differences between the four professors.

In conjunction with the overall grade distributions, the grades for the PlayPosit videos were also analyzed. Table 4-26 shows the average grades for PlayPosit videos for the three professors who used the platform. The average grade for Profs. A, B, and C was 78.65, 80.65, and 85.36, respectively. When comparing the grade distribution of the

Playposit videos and final grade, including correlation (Tables 4-28 and 4-29), the grade distributions had a positive correlation but only Prof. B had a correlation of higher than 0.9. This indicates that there is some correlation between how well students do on the PlayPosits to their final grade, but without investigating further into the complete gradebook, we cannot say definitively how impactful this correlation is.

5.1.2 Teaching Assistants Perception and Usage

For the fall 2022 semester, there were a total of eleven teaching assistants covering 45 recitation sections. Five of the eleven teaching assistants participated in the study. Two of the TAs were at least second years, while one of them also taught CHE 109 online over the summer. The other three TAs were first years, and one of them had received their undergraduate degree from UK. Although CHE 105 recitations do not use PlayPosit, the TAs are aware of the platform and interact enough with the students to have their own perceptions about the platform. Some of the interactions that the TAs discussed were based on time spent in the general chemistry learning center, where students come in to study and receive help from chemistry TAs. Most of the help is like tutoring, so some students ask for help on PlayPosits or at least the content from the videos.

Similar to the faculty, interviews were structured around activity theory, but other questions and discussions came up resulting in other themes emerging. The structure of recitation was fairly consistent across the different sections. Prof. D was actually the recitation coordinator, which made her the point person between the faculty and TAs. She would create worksheets a couple weeks in advance based on where the students would be in their lecture. The worksheets were first handed to the TAs so that they could work through the worksheets a week before the students would get them. This allowed the TAs to know what the students were covering in lecture and allow them to work

through the problems themselves. These worksheets fostered group work but included a scaffolding question that the TAs would work through with the students. After class, the worksheets were to be handed in and graded by the TAs.

As far as the rules theme from activity theory, the worksheets and how recitation should generally be run was the main focus. There was no requirement for the TAs to look at the PlayPosits, but all of them mentioned that they originally looked at them at the beginning of their graduate TA career to get an idea of what was being covered. TA-1, who was an international student, also looked at the PlayPosits in their earlier TA career because he wanted to see how the undergraduates were learning the content compared to how he learned it.

Generally, the TAs knew that their main role was to facilitate learning. Again, the worksheets were written based on the idea of group work that the TAs would help when needed. However, some of the TAs mentioned that this role was often blurred into an actual teaching role, especially depending on when their recitation section was in comparison to the lecture section. Some recitation sections met earlier in the week before the lecture, so the students may not have seen the material yet. However, for the lectures that used PlayPosit, the students were able to watch the videos before their recitation section. Because the students may not have seen the material or at least worked through the material yet, those TAs mentioned that they felt a little more like teachers covering the content instead of facilitating the work.

Even though activity theory has grown to include multiple subjects and their interactions, there is not much interaction and community between the CHE 105 faculty and TAs. As mentioned earlier, mainly Prof. D interacts with the TAs since she was the recitation coordinator. Some of the TAs did mention that in the past they have directly contacted a professor to inquire about the content, but most of the interactions go through Prof. D. On the other hand, all of the TAs discussed the community within

themselves. The first year TAs mentioned not only the overall TA community, but also their individual cohort community. While the recitations were run similarly, they still had a slight independence between the TAs. However, the TAs discussed the comradery among the TAs based on their weekly TA meetings and interactions in the learning center.

Throughout the interviews with the TAs, other themes emerged, and these included: general perceptions of PlayPosit, student learning, and teaching style differences. Despite not using PlayPosit in their recitation sections, all of the TAs had some experience with the PlayPosit platform or something similar. The first- and second-year TAs mostly interacted with PlayPosit through online learning during the COVID-19 shutdowns. However, TA-2 had a positive perception of PlayPosit because she used it during her undergraduate career at UK. Similar to student comments, she liked that you could pause, rewind, and return to the videos whenever you choose to review the material. TA-1 also used it during their online course over the summer. Despite seeing the benefits of using the platform, he preferred teaching in person. All of the other TAs also saw the general benefit of the videos, but thought that for some of the content, it could be more beneficial to teach the difficult content in person. Because PlayPosit and other interactive videos lend themselves towards a flipped classroom format, all of the TAs voiced the idea that if the department went fully flipped, there may not be a need for recitation.

Another secondary theme that arose during the interviews was student learning. The one thing that came up about student learning was that despite all of PlayPosit's benefits, there were still generally two categories of students: those who want to learn and do the work, and those who just push through to pass the class. This ties into student engagement. While there are students who utilize PlayPosit to its full extent,

e.g., pausing to take notes, intentionally working through the embedded questions, etc., there are other students who try to plow through the videos just to get the credit.

Because students feel more comfortable talking with TAs about their courses, the TAs had some insight into the students' perceptions of their CHE 105 courses. One of the comments that students bring up (and the TAs brought up during the interviews) was the difference of teaching styles of their professors. Although the department tries to be the same across the board, different professors are going to have different teaching styles, and students talk among themselves comparing the different professors. The TAs alluded to the students' attitudes of PlayPosit being affected by who their professor was and their style of teaching. Some studies show that students have more positive attitudes towards interactive videos when their specific professor does them compared to other professors (Bakla & Mehdiyev, 2022). Each of the professors did their own videos, so we cannot fully comment on whether a difference in video personalities affects students' attitudes, the surveys did ask whether having their professor do the videos affected their perceptions of PlayPosit. Most of the students' comments who were affected by their specific professor doing the videos had more positive comments about the perceptions. Some of the comments were that they would know what to expect (e.g., verbiage) in class based on the videos.

5.1.3 Student Perceptions and Usage

The student perceptions and usage were taken from the student surveys taken at the beginning and end of the fall semester. Not enough students signed up for follow-up interviews to get a decent variety of students, so all of the qualitative data from the students was via the open-ended questions on the survey.

As mentioned briefly in the teaching assistant section, students were asked if their professor was the one to do the PlayPosit video and whether that had any affect on

their perceptions of PlayPosit. All of the professors did their own videos, so no remarks can be made about the perceptions of another professor doing the videos. However, most of the students who said it did affect their perceptions gave positive comments. These included knowing the way the content was talked about and taught would be similar between the videos and in-class. While we cannot comment on whether that would have been a disadvantage, we can assume the consistency helped students have a more positive perception. Further studies could look into this a little more. A couple students commented that the biology department uses PlayPosits for their general course, but only one professor does all of the videos, so it would be interesting to see if that causes any difference in perceptions.

To cover a lot about perceptions of PlayPosit and to allow students to have free reign in what they wanted to speak about, the two main open-ended questions were about the advantages and disadvantages of PlayPosit. From the comments in both of these questions, some themes arose. For the advantages, these were viewing and reviewing, ease of use, and interaction. Many of the students commented about being able to rewind, pause, and change the speed of the videos. This allowed students to watch the videos at their own pace and own time and use that to their advantage when trying to clarify something. Some of the students commented about being able to rewatch the videos at a later time, like to review before an exam. However, when looking at the proportion of videos rewatched per professor (see Table 4-25), only a handful of videos were actually rewatched. Theoretically, students could rewatch the videos, but the data did not confirm that. However, the students may have had intentions of rewatching the videos if need be and by the time exams came around, they realized that they did not need to rewatch them. Without looking at every student and video, only speculations can occur.

Somewhat related was the ease-of-use theme. Students found that actually working the platform was quite easy. Based on the technology acceptance model, ease of use is one component that has a positive outcome on behavioral intentions towards technology usage (Anthony et al., 2020; Lazar et al., 2020; Lee et al., 2013; Park, 2009). When technology users find a technology easy to use, it makes them more inclined to actually use it. This can be seen in the TAM construct tables (4-4, 4-12, 4-17, and 4-21) where the pre- to post-semester difference between the ease of use and behavioral intention constructs follow similar patterns. While there is a similar trend, the other constructs do have some affect on behavioral intention of technology usage (see Table 4-5).

The last advantage that most students commented on in the surveys was termed interaction. Most of the students liked that the embedded questions helped them stay engaged with the video. They also commented on how the professors worked through problems in the video helped them understand the material. Also, they did like that having the videos for content outside of class and working through the more complicated work in person was advantageous. The engagement construct touched on the ability of the PlayPosit videos to increase their engagement in the lectures. As with the ease of use, there was a positive correlation between engagement and behavioral intention, but also not very high (see Table 4-5). This does indicate that increased engagement increases behavioral intentions. However, for most of the categories, there was a decrease in engagement over the semester (see Table 4-4, 4-12, 4-17, and 4-21).

One of the larger disadvantages (or dislikes) about PlayPosit was the theme of time. This was mostly to how much time commitment the videos took. Most of the students complained either about how long the videos were or how many there were (for these numbers see Table 4-24). While the average length was around 20 minutes, for all three professors, the videos ranged from 4.52 minutes to 53.40 minutes. As part of the

videos are the embedded questions where students have to complete the questions before moving on in the video. Some complaints from students were the inability to fast forward the videos. While from an educational standpoint, professors want students to engage with the material, students, however, do not want to sit through all of the video especially if they understand the material. One way that students are able to get around lack of fast forwarding is playing the videos at twice the normal speed. Looking into this information could be done for future studies. When comparing the length of the videos and how long students took to watch, most of the time to watch was longer than the length of the video (see Table 4-25).

This need to speed up content could be a generational attribute. Most of the students are freshman, making them part of Generation Z (Gen Z). There have been some studies on teaching Gen Z students who are now a majority of undergraduate students. While not applicable to every Gen Z student, most want quicker content retrieval, respond well to gamification, and generally are leaning away from traditional educational styles (Cickovska, 2020; Seemiller & Grace, 2016). Even with the transition to PlayPosit videos for their content, students may still struggle with the longer times it takes to watch the videos, especially when other courses and extracurricular activities are added into the mix.

Touching on this aspect of time is the theme of focus. Since the students found that there were too many videos (in general and due weekly) and they were overall long, it made it difficult to focus on the material. This could also play into the fact that there are less distractions in a traditional lecture. As some of the professors stated, competing with the internet and social media means that the students generally are not completely focused in class. However, when left to watch the videos on their own time with more distractions, can cause even more lack of focus (Mischel, 2019; Seemiller & Grace, 2016).

Also tied into the time to watch the videos and focus is student engagement. While some of the students liked the embedded questions and stated that they helped them engage with the material, others did not like that they were being asked about content they just learned a few minutes earlier in the videos. Others complained that the major issue with the videos was the lack of being able to ask questions in real time to their professors. Most of the professors do have online discussion boards that they do have pulled up during the day, and students can always ask questions when they reach lecture. However, some students did comment that they would do that but by the time they get to class, they have forgotten what they were wanting to ask. While not explicitly mentioned in the open-ended responses in the surveys, students have talked about being able to work in the class and that engagement has helped them. Like the other TAM constructs mentioned earlier, engagement showed a low positive correlation with behavioral intention (see Table 4-5).

It was not explicitly asked, but both the TAs and students commented on how to improve CHE 105. Besides the general comments about less videos or shorter times, most of the students stated that the biology department utilized PlayPosit well. While similar to chemistry, where there are multiple professors teaching multiple sections of a course, all of their material is the same. Chemistry does use the same content, homework, and exams, so there is that similarity. However, biology also uses the same PlayPosit videos while chemistry does not. Since the departments are wholly different, comments cannot be made to whether chemistry could be done like biology, looking at how the department works could help the chemistry improve.

5.2 Limitations and Further Research

One of the major limitations that occurred was the number of respondents to the survey, especially the post-semester survey. The lower number of respondents made

the likelihood of having paired data slim. This limitation could have been improved with follow-up reminders for the students to complete the surveys.

Further research would hopefully have more student responses to potentially see paired data. While unpaired data is not inherently bad in research, paired data allows for a clearer picture of individuals' change over a time. Further research could also include a more in-depth look at the grades within the different CHE 105 sections. It would have been interesting to investigate whether the faculties' claims of the higher correlation between PlayPosit grades and exam grades were accurate or not. While we were able to look at the overall grade distribution between the four faculty, trying to conclude whether using PlayPosit is better for students or not among the four faculty cannot be done. Another research study that could be used to investigate this claim more is to have one professor teach two different sections, one with PlayPosit and one without, to see if the outcomes are different.

5.3 Recommendations

While this research study was small, and any conclusions based on the results cannot be transferred to many other situations. However, based on the results some recommendations can be made about PlayPosit usage in college chemistry courses. One common theme that arose throughout the interviews and student comments was the idea of time. For students, it was the amount of time required to watch the videos and do the embedded questions. From the faculty and teaching assistant interviews it came down to the amount of work and the time commitment required by the students. One recommendation based on this finding is for those in a place of implementing PlayPosit or other interactive videos into their courses is the time commitment that they are requiring of their students. As mentioned by a couple of the faculty, there is a trade off on how long the videos are and how many videos there are. Again, this is something

that faculty, or others who want to implement these interactive videos should take into consideration.

Tied in with the idea of time commitment that faculty should be aware of is student buy in and selling the idea. There were comments throughout the study that when the students were aware of why they were doing these videos and how the semester would be formatted, they had a slightly more positive view of the interactive videos. The idea of student buy in has been mentioned in the research in other areas of educational tools, especially when introducing new tools, ideas, or pedagogy (Cavanagh et al., 2016). So, being upfront about the interactive videos from the beginning may help students be more open to using the educational tools intentionally.

Another comment that came up from the students was the actual grading of the PlayPosit videos. The research is not recommending to not grade the PlayPosit videos; however, based on student feedback, how they are graded should be reviewed. Some of the students did not like that some of the questions they could repeat and others they could not, making it confusing. Other students also did not like that they were being graded for correctness on material they just learned. Therefore, one recommendation would be to have the embedded questions still inform the students whether they were right or not, but only grade the completeness of the questions. This could allow the students to not worry that they have to be knowledgeable about the material before they have even completely learned about it.

While the study was about the interactive video platform PlayPosit, similar results could be obtained from different avenues. As mentioned earlier, Prof. D did not use PlayPosit in their CHE 105 course, but did video record her lectures via Echo 360. Although actual conclusions cannot be made based on just the grades, the fact that Prof. D's grade distribution was not statistically different than Prof. B and C while not using

PlayPosit indicates that the two different video avenues may not be different. This would have to be further investigated to make any kind of conclusions.

5.4 Concluding Remarks

This research study looked at the perceptions of the interactive video platform PlayPosit and its usage among the faculty, teaching assistants, and students of CHE 105 at the University of Kentucky. The studied utilized the theoretical framework of Activity theory to see how the participants within CHE 105 viewed themselves within a larger context to reach one singular goal of student learning. While there was a lot of information gleaned from the data, there is still more work to be done to fully understand the perceptions and usage of the video platform.

For the most part, the faculty saw the benefit of using PlayPosit. Two of the faculty have completely switched to a flipped classroom style, while the other two still enjoy teaching in the traditional lecture style. While they did not directly interact with PlayPosit, the TAs had similar perceptions of PlayPosit to the faculty. From an educational standpoint, they saw how valuable it can be to have students be given the content material outside of class with embedded questions and to work through the harder material (e.g., homework problems) in class where they can ask for clarification with the professors and their fellow students. However, based on a number of factors, including when their recitation section was, the TAs still felt like they fulfilled more of a teaching role than a facilitator role during their recitation sections. Also, because of their standing with the undergraduate students, the TAs were able to hear and see how the students really view the platform and CHE 105 overall.

Based on student surveys which included open-ended responses, students had some positive perceptions of PlayPosit. These included the ability to pause, rewind, watch, and rewatch the videos on their own time. Although they generally liked the ability

to work on the difficult problems in class, students still complained that the videos were too long or there were too many and with their busy schedules, a lot of times they tried to speed up the process by speeding up the videos or putting them on in the background. The questions of the student surveys were based on the technology acceptance model originally developed by Davis (1989) that showed certain constructs, like ease of use and perceived usefulness, of technology increase the likelihood that people will use the technology. Correlations between the constructs showed that all of them had a positive correlation on behavioral intention to use PlayPosit. These correlations, however, were small (under 0.5), so they either contribute a lot as a group of constructs or there is another factor that was not considered in the research. When looking at the quantitative data, which included PlayPosit analytics, students generally did not favor PlayPosit. However, despite only about 75% of videos being watched across all CHE 105 sections, the grades of PlayPosit had a positive correlation with the final grades.

Overall, this study filled in an area of the literature that was lacking. There are numerous studies showing the values of interactive videos among STEM courses, and specifically chemistry (Agustian & Seery, 2017; Estriegana et al., 2019; Pulukuri & Abrams, 2020; Quan & Buikema, 2018; Shahrokni, 2018). One area that is lacking is its use within larger classes. Most of the research discusses laboratory settings or small class sizes (Agustian & Seery, 2017; M. K. Seery, 2013); however, there are far fewer discussing its use with larger class sizes like that of CHE 105. This research helped to fill in that gap of its use within a larger class setting. It also looked at all of the participants within the larger CHE 105 context: the faculty, TAs, and students. When studies look at perceptions of technology or some new educational area, most look almost exclusively at professors and students (Berga et al., 2021; Heflin et al., 2017; Neiterman & Zaza, 2019). This study added more perceptions to the current research while including those who are often overlooked, teaching assistants. While they do not play a major role in the

development of these educational tools, they do play a role in how they are used. Also, their interactions with students tend to open up perceptions that faculty and educators are not usually privy to.

While this research does not fill all of the gaps in the current literature, it has started to fill in those areas that may not have been looked into before. This research also has opened up other potential studies that could be investigated in future research. It could also be the basis for research into other educational technologies or similar structures to CHE 105.

APPENDICES

Appendix A: Teacher Interview Protocol

Topic: PlayPosit

- What is your comfort with PlayPosit?
    - Do you feel like your level of comfort affects how you utilize and how much you use them in your class?
- Before teaching his class, have you used PlayPosit or something similar?

Topic: Teaching

- How long have you been teaching/how many times have you taught gen chem 105?
- What is your teaching method? Could you describe it?
- In your opinion, what is the best method of teaching General Chemistry?
    - How do you view PlayPosit as part of this method?
- Would you consider your classroom a flipped learning classroom (*give definition if needed)?
    - If you could quantify it, how much FTF versus online content?

Topic: Student learning

- Do you believe professionally (and/or personally) that the PlayPosits aids in your students' understanding of the material? How so?
- What are your feelings on the integration/use of PlayPosit and student learning? Specifically, how it pertains to your class.
- How do you, personally, assess student learning?

Appendix B: Teaching Assistant Interview Protocol

Topic: PlayPosit

- What is your comfort with PlayPosit?
    - Do you feel like your level of comfort affects how you utilize and how much you use them in your class?
- Before teaching his class, have you used PlayPosit or something similar?

Topic: Teaching

- How long have you been teaching/how many times have you taught gen chem 105 recitation?
- What is your teaching method? Could you describe it?
- In your opinion, what is the best method of teaching General Chemistry?
    - How do you view PlayPosit as part of this method?
- Would you consider your classroom a flipped learning classroom (*give definition if needed)?
    - If you could quantify it, how much FTF versus online content?
- Do you feel like you have a lot of say/control over what happens in your recitation section(s)?

Topic: Student learning

- Do you believe professionally (and/or personally) that the PlayPosits aids in your students' understanding of the material? How so?
- What are your feelings on the integration/use of PlayPosit and student learning? Specifically, how it pertains to your class.
- How do you, personally, assess student learning?

Appendix C: Student Survey (Pre-Semester)

In the space, please type the first three letters of your birth month (January=Jan), your birth date, and the last four digits of your phone number. For example, if you were born January 2nd and your last four were 1234, you would type Jan021234.

Demographic

1. What is your gender?
    a. Male
    b. Female
    c. Non-binary/third gender
    d. Prefer not to say

2. What is your age?
    a. <18
    b. 18-22
    c. 22-25
    d. 25-30
    e. 30-40
    f. 40-50
    g. >50

3. What is your year in school?
    a. First year (Freshman)
    b. Second year (Sophomore)
    c. Third year (Junior)
    d. Fourth year (Senior)
    e. Fifth or more year

4. What is your race?
    a. White
    b. Black or African American
    c. American Indian or Alaska Native
    d. Asian
    e. Native Hawaiian or Pacific Islander
    f. Other

5. Are you a Kentucky resident?
    a. Yes
    b. No

6. Are you an international student?
    a. Yes
    b. No

7. What is your major/area of study?

8. Is this the first time you are taking this class?

    a. No
    b. Yes
        i. Why are you retaking this course?

9. Have you taken any chemistry class before this semester?
    a. No
    b. Yes, but as a blend of science courses
    c. Yes

10. Why did you choose to take this particular section?
    a. It fit in my schedule
    b. I wanted to take it with this professor/TA
    c. I knew someone else taking it
    d. No particular reason

11. Have you heard of or used pre-recorded interactive videos (e.g., PlayPosit, EdPuzzle, etc.) before this class?
    a. I have heard of it but never used
    b. I have heard of and used it before
    c. I have heard of it before and will use it the first time this semester
    d. I have never heard of it

12. State whether you agree or disagree with the following statements about PlayPosit

	Strongly Agree	Somewhat Agree	Neither/Neutral	Somewhat Disagree	Strongly Disagree

PlayPosit will enhance my learning of key concepts					
PlayPosit will be integrated well into the course					
PlayPosit will be frustrating to use					
PlayPosit will be easy to use					
PlayPosit will contribute to my interest in the course material					
The professor					

will make good use of PlayPosit					
PlayPosit will help me feel more engaged and involved					
PlayPosit will make me more inclined to participate in class discussions					
PlayPosit will contribute significantly to my learning					
PlayPosit will not contribute to					

my learning experience					
The TA will make good use of PlayPosit					

13. Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools

	Strongly Agree	Somewhat Agree	Neither/Neutral	Somewhat Disagree	Strongly Disagree
I find digital tools easy to use					
Learning how to use digital tools is easy for me					
It is easy to become skillful at using digital tools					
PlayPosit will improve my					

learning performance					
PlayPosit will increase my academic productivity					
PlayPosit will make it easier to study course content					

14. State whether you agree or disagree with the following statements about PlayPosit

	Strongly Agree	Somewhat Agree	Neither/Neutral	Somewhat Disagree	Strongly Disagree
Studying through PlayPosit is a good idea					
Studying through PlayPosit is a wise idea					

I am positive towards PlayPosit					
I intend to check/view PlayPosits frequently					
I intend to be a heavy user of PlayPosit					

15. State whether you agree or disagree with the following statements about digital tools in general

	Strongly Agree	Somewhat Agree	Neither/Neutral	Somewhat Disagree	Strongly Disagree
I am confident of using digital tools					
I am confident that I can overcome any obstacles when using digital tools					
I am confident of using					

different digital tools to learn other subjects					
I am confident of using digital tools even if I have never used it before					
I believe that working with digital tools is very difficult					
I believe that working with digital tools is very complicated					
I believe that working with digital tools let me feel psychological stress					

Appendix D: Student Survey (Post-Semester)

In the space, please type the first three letters of your birth month (January=Jan), your birth date, and the last four digits of your phone number. For example, if you were born January 2nd and your last four were 1234, you would type Jan021234.

Demographic

1. What is your gender?
    a. Male
    b. Female
    c. Non-binary/third gender
    d. Prefer not to say

2. What is your age?
    a. <18
    b. 18-22
    c. 22-25
    d. 25-30
    e. 30-40
    f. 40-50
    g. >50

3. What is your year in school?
    a. First year (Freshman)
    b. Second year (Sophomore)
    c. Third year (Junior)
    d. Fourth year (Senior)
    e. Fifth or more year

4. What is your race?
    a. White
    b. Black or African American
    c. American Indian or Alaska Native
    d. Asian
    e. Native Hawaiian or Pacific Islander
    f. Other

5. Are you a Kentucky resident?
    a. Yes
    b. No

6. Are you an international student?
    a. Yes
    b. No

7. What is your major/area of study?

8. Is this the first time you are taking this class?
    a. No
    b. Yes
        i. Why are you retaking this course?

9. Have you taken any chemistry class before this semester?
    a. No
    b. Yes, but as a blend of science courses
    c. Yes

10. Why did you choose to take this particular section?
    a. It fit in my schedule
    b. I wanted to take it with this professor/TA
    c. I knew someone else taking it
    d. No particular reason

11. What will be your final grade in this course?
    a. A
    b. B
    c. C
    d. D
    e. F
    f. Prefer not to say

12. Have you heard of or used pre-recorded interactive videos (e.g., PlayPosit, EdPuzzle, etc.) before this class?
    a. I have heard of it but never used
    b. I have heard of and used it before
    c. I have heard of it before and will use it the first time this semester
    d. I have never heard of it

13. State whether you agree or disagree with he following statements about PlayPosit

	Strongly Agree	Somewhat Agree	Neither/Neutral	Somewhat Disagree	Strongly Disagree
PlayPosit enhanced my learning of key concepts					
PlayPosit was integrated well into the course					
PlayPosit was frustrating to use					
PlayPosit was easy to use					
PlayPosit did contribute to my interest in the course material					

The professor did make good use of PlayPosit					
PlayPosit helped me feel more engaged and involved					
PlayPosit made me more inclined to participate in class discussions					
PlayPosit contributed significantly to my learning					
PlayPosit did not contribute to					

my learning experience					
The TA made good use of PlayPosit					

14. Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools

	Strongly Agree	Somewhat Agree	Neither/Neutral	Somewhat Disagree	Strongly Disagree
Learning how to use PlayPosit tools was easy for me					
It was easy to become skillful at using PlayPosit					
PlayPosit improved my learning performance					

PlayPosit increased my academic productivity					
PlayPosit made it easier to study course content					

15. State whether you agree or disagree with the following statements about PlayPosit

	Strongly Agree	Somewhat Agree	Neither/Neutral	Somewhat Disagree	Strongly Disagree
Studying through PlayPosit was a good idea					
Studying through PlayPosit was a wise idea					
I am positive towards PlayPosit					

I intend checked/viewed PlayPosits frequently					
I was a heavy user of PlayPosit					

16. How often did you use PlayPosit besides when it was due?
    a. Never
    b. Rarely
    c. Occasionally
    d. All the time

17. Why did you use it more than when it was an assignment?
    a. To study for an exam
    b. To better understand concepts
    c. Other
        i. Why did you use it more than when it was an assignment?

18. Were the PlayPosit videos done by your professor?
    a. Yes
    b. No
    c. Unsure

19. Did whoever do the videos have an impact on your perceptions of PlayPosit?
    a. Yes
        i. How did it impact your perceptions
    b. No

20. What are some advantages, or things you liked, of using PlayPosit?

21. What are some disadvantages, or things you disliked, about PlayPosit?

22. Please add anything else about PlayPosit in your CHE 105 lecture or recitation course that you would like to add

23. If you would be willing to be contacted for a follow-up interview, please click this link https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_9SsOFxD93fRjZtk

Appendix E: Survey Questions Included in Data Analysis

The following survey questions (post-semester wording in parentheses or after a slash) were included in the final data analysis.

Question 1: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will enhance (enhanced) my learning of key concepts

Question 2: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will be (was) integrated well into the course

Question 3: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will be (was) frustrating to use

Question 4: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will be (was) easy to use

Question 5: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will (did) contribute to my interest in the course material

Question 6: State whether you agree or disagree with the following statements about PlayPosit - The professor will make (made) good use of PlayPosit

Question 7: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will help (helped) me feel more engaged and involved

Question 8: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will make (made) me more inclined to participate in class discussions

Question 9: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will contribute (contributed) significantly to my learning

Question 10: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will (did) not contribute to my learning experience

Question 11: State whether you agree or disagree with the following statements about PlayPosit - The TA will make (made) good use of PlayPosit

Question 12: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools – Learning how to use digital tools is easy for me/ Learning how to use PlayPosit was easy for me

Question 13: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - It is easy to become skillful at using digital tools /It was easy to become skillful at using PlayPosit

Question 14: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - PlayPosit will improve (improved) my learning performance

Question 15: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - PlayPosit will increase (increased) my academic productivity

Question 16: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - PlayPosit will make (made) it easier to study course content

Question 17: State whether you agree or disagree with the following statements about PlayPosit - Studying through PlayPosit is (was) a good idea

Question 18: State whether you agree or disagree with the following statements about PlayPosit - Studying through PlayPosit is (was) a wise idea

Question 19: State whether you agree or disagree with the following statements about PlayPosit - I am positive towards PlayPosit

Question 20: State whether you agree or disagree with the following statements about PlayPosit - I will check/view (checked/viewed) PlayPosits frequently

Question 21: State whether you agree or disagree with the following statements about PlayPosit - I will be (was) a heavy user of PlayPosit

Appendix F: Survey Questions According to TAM Constructs

- TAM Construct Implementation (I) Questions
    - Question 2: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will be (was) integrated well into the course
    - Question 6: State whether you agree or disagree with the following statements about PlayPosit - The professor will make (made) good use of PlayPosit
    - Question 11: State whether you agree or disagree with the following statements about PlayPosit - The TA will make (made) good use of PlayPosit

- TAM Construct Ease of Use (EU) Questions
    - Question 3: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will be (was) frustrating to use
    - Question 4: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will be (was) easy to use
    - Question 12: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools – Learning how to use digital tools is easy for me/ Learning how to use PlayPosit was easy for me
    - Question 13: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - It is easy to become skillful at using digital tools /It was easy to become skillful at using PlayPosit

- TAM Construct Engagement (E) Questions
    - Question 5: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will (did) contribute to my interest in the course material
    - Question 7: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will help (helped) me feel more engaged and involved
    - Question 8: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will make (made) me more inclined to participate in class discussions

- TAM Construct Effect on Learning (EL) Questions
    - Question 9: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will contribute (contributed) significantly to my learning
    - Question 10: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will (did) not contribute to my learning experience

- TAM Construct Perceived Usefulness (PU) Questions

    - Question 1: State whether you agree or disagree with the following statements about PlayPosit - PlayPosit will enhance (enhanced) my learning of key concepts
    - Question 14: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - PlayPosit will improve (improved) my learning performance
    - Question 15: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - PlayPosit will increase (increased) my academic productivity
    - Question 16: Considering PlayPosit is a digital tool, state whether you agree or disagree with the following statements about PlayPosit or digital tools - PlayPosit will make (made) it easier to study course content

- TAM Construct Attitude (A) Questions
    - Question 17: State whether you agree or disagree with the following statements about PlayPosit - Studying through PlayPosit is (was) a good idea
    - Question 18: State whether you agree or disagree with the following statements about PlayPosit - Studying through PlayPosit is (was) a wise idea
    - Question 19: State whether you agree or disagree with the following statements about PlayPosit - I am positive towards PlayPosit

- TAM Construct Behavioral Intention (BI) Questions
    - Question 20: State whether you agree or disagree with the following statements about PlayPosit - I will check/view (checked/viewed) PlayPosits frequently
    - Question 21: State whether you agree or disagree with the following statements about PlayPosit - I will be (was) a heavy user of PlayPosit

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