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The Flipped Approach: The Use of Embedded Questions in Math Videos

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THE FLIPPED APPROACH: THE USE OF EMBEDDED QUESTIONS IN MATH VIDEOS

ASHLEY DANIELLE WILSON
Master’s Program in Mathematical Sciences

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Ashley Wilson

2015-2016
Abstract

This study investigates the use of embedded questions in math videos and their effect on students self-paced learning in a hybrid math course. A treatment group watched math videos with embedded questions and a comparison group watched the same videos but without the embedded questions. The two groups are compared in terms of (a) amount of video watched, (b) quality of written work, (c) performance in assessments, (d) course component scores, and (e) opinions about self-paced learning and the flipped classroom method. The pre-to-posttest improvement for the treatment group was higher than the comparison group. The embedded questions might have helped to draw students’ attention to their learning but there was no statistical significance in the data to support the claim that the embedded questions can enhance students learning.
THE FLIPPED APPROACH: THE USE OF EMBEDDED QUESTIONS IN MATH VIDEOS

by

ASHLEY DANIELLE WILSON, BS

THESIS

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Chapter 1: Introduction

The world we live in today is run by a large amount of technology. Everywhere you look someone has a cell phone, computer, tablet, or some kind of personal communication device that they are using. Schools are encouraging teachers to incorporate technology into their classrooms to better serve the students of this generation. Teachers may be set on the traditional ways of teaching but there is a way to blend traditional ways of teaching with use of technology. One way that allows students to work at their own pace is to use the flipped model of instruction.

The flipped approach to teaching has received increasing attention within the education community because of its potential to create a student-centered learning environment that incorporates active, hands-on learning activities in the classroom. A major component of the flipped approach is having the students watch videos or lessons about the material at home. Many teachers are trying this new approach because it suggests benefits such as increasing student engagement, motivation, and background knowledge, and offering slower learners the opportunities to pause, rewind, and review portions of videos on topics they may not understand (Bergmann & Sams, 2012). By having the ability to pause and rewind videos at their discretion, students are able to pace their own learning. This makes students responsible for evaluating their own level of understanding of the material and then deciding whether they are ready to move on or if they need to review the material again. However, the flipped approach is not successful if it is just made into a “high-tech version of an antiquated instructional method: the lecture” (Ash, 2012).

To make sure students are understanding the material, some teachers require students to answer questions that are either embedded in the video they are watching or placed at the end of
the video. The types of questions asked can vary from easy questions, like facts students can recall from the video, to questions that require more critical thinking similar to the Socratic Method. When questions are embedded within the video, the video gets paused and students cannot continue watching it until they have answered the question. If the student is unsure of their answer, they can re-watch that portion of the video to help them.

1.1 Background and Need

In teacher preparation programs, prospective elementary (EC-8) teachers are required to take a sequence of mathematics courses where they are expected to gain a deeper understanding of the mathematics that is taught in elementary and middle schools. Many of these students are used to being shown how to solve a problem, learning the procedure that goes with it, and then just mimicking the steps without understanding the mathematical concepts and ideas that underlie the problem. This leads to the students just memorizing facts and procedures for exams with little to no meaning and actual understanding. Prior mathematics learning experiences might have made it unnecessary for some students to read math text and grapple with the ideas to gain a deeper understanding. Many of the prospective teachers in this study read math text at a superficial level without really understanding what they have read.

An instructor at the research site taught a Geometry and Measurement course for prospective elementary teachers in a hybrid format. In the hybrid format, students only attend class once a week for 80 minutes and then learn the materials online for another 80 minutes at their own pace. For the self-paced learning (SPL) component, students are supposed to watch selected math videos and/or PowerPoint slides with narrations, and read assigned sections of the textbook. These activities are specified in a word document, one per week, where students are asked to answer questions related to the videos or assigned readings. Students are expected to submit their
completed online work at the end of each week before the next class meeting. In this sense, the lesson is self-paced per week, students aren’t allowed to go ahead into other weeks of lessons but they can go at their own pace for each week’s lesson.

During each class meeting, the instructor began by reviewing the concepts that seemed difficult for students and answered any lingering questions about the homework. Since the students come to class with background knowledge they have learned from their self-paced lesson, he then is able to engage students using active-learning tasks that foster mathematical thinking and that require students to apply their newly learned knowledge and skills. He concludes the class by highlighting key ideas that students will learn in the upcoming self-paced lesson. Also, students sometimes are given an in-class assessment over things they should have learned in the videos to make sure they are watching them and coming to class prepared.

The instructor wondered if embedding questions in the videos would enhance student learning. Embedded questions may help to draw the students’ attention to key ideas while they are watching the video as opposed to passively watching the video.

1.2 Purpose

The purpose of the study is to contribute to the design, development, evaluation, and refinement of self-paced learning materials including embedded questions in math videos that engage students intellectually. I am investigating the use of such embedded questions in math videos and its effect on students’ self-paced learning and engagement with the material that they are learning.

In order to see the effect of embedded questions on students’ self-paced learning and engagement, I will have a treatment group and a comparison group. The treatment group will watch the assigned math videos with embedded questions and then complete the rest of the SPL materials.
The comparison group will watch the exact same math videos but without the embedded questions and then they will complete the same SPL materials. Having the two groups will allow me to see the effect that the embedded questions have on the students because I can compare the quality of work and the level of engagement with the SPL materials between the two groups.

1.3 Research Questions

How do students in the two groups differ in terms of:

i. Amount of video watching for selected weeks?

ii. Quality of written work?

iii. Performance in assessments for selected weeks?

iv. Scores for entire course?

v. Opinions about self-paced learning and the flipped classroom method?

1.4 Limitations

The limitations of the study are that students are not randomly assigned into one of the two groups. Since students were allowed to form their own teams of four, we assigned each team into either the comparison or treatment group using their team’s grade point average (GPA) so that both groups would have approximately the same mean GPA. No other factors were considered in the assignment to ensure impartiality. Consequently, it is possible that one group might have more students with certain learning characteristics, such as study habits, time spent on schoolwork, and motivation to succeed. Another limitation related to the grouping of students is that we don’t have control over whether students stay in the course or drop it. In this study, the number of participants in the comparison (P) group dropped from 25 to 22 and the number of students in the treatment (Q) group from 25 to 19, and their group mean GPA’s are relatively close to one another.
This study is considered an action research which also has its own limitations. The research has to be conducted within the constraints of the course structure and syllabus. For example, the hybrid format reduces the class meeting time by 50% and consequently the number of in-class assessments is also reduced. Moreover, we cannot control factors such as absenteeism and the time students spend on working with the SPL materials. On the other hand, this research is conducted in an authentic setting and the findings, although they may not be generalized to other settings, reflect the reality of student learning in this particular setting.
Chapter 2: Literature Review

The setting for this study is a hybrid course where students have to learn some of the materials on their own prior to classroom discussion. This format has certain features that are similar to flipped learning. Flipping the classroom has largely been tied to incorporating video technology for students to learn class content while at home. Videos incorporated into students’ learning supports both the constructivist and cognitive information processing learning theories. Some research has been done on incorporating video technology into the classroom but not much of it centers on the idea of embedding questions (including critical thinking questions that align with the Socratic Method) into the videos students watch. However, there has been some debate between whether interactive or non-interactive video presents more opportunities for student learning and achievement. This literature review is presented along two strands: flipped classroom and video-based learning.

2.1 The Flipped Classroom

If you walk into any mathematics classroom in this region you are likely to see a classroom lecture taking place although the traditional lecture format has been criticized. One issue with lecture is pacing; some students may find the pace to be too slow or may already know the materials while other students may have trouble keeping up with the pace or lack the necessary prior knowledge (Goodwin & Miller, 2013). For this reason and others, some teachers are now turning to a newer model of teaching called the flipped classroom where students watch lectures at home in the form of videos created by the teacher and then work on assignments or other meaningful discourse in class. Teachers sometimes require students to complete a set of questions or take notes to turn in at the start of the next class for different purposes including as proof that they watched
the video. Such student work may also help the teacher identify students’ misconceptions or gaps in their understanding.

In terms of Bloom’s taxonomy, flipping the classroom means that students do the lower levels of cognitive work (gaining knowledge and comprehension) outside of class on their own and then focus on the higher levels of cognitive work (application, analysis, synthesis, and/or evaluation) in class where they have the support of their teacher and peers (Westermann, 2014). There are many advantages to flipped learning including the fact that it fosters self-paced learning and it allows students to have repeated access to learning materials. Teachers who have tried this method have indicated that most of them saw an improvement in student engagement, motivation, and achievement (Morgan, 2014).

2.1.1 Engagement

One advantage of having students work on assignments or activities in class is that it provides a lot of opportunities for meaningful student-teacher and student-student interaction. The teacher is able to see what the students are doing as they work on problems in class, to listen to their ideas, to probe their thinking, to look for weaknesses of their students and to fix mistakes as they happen. If the teacher sees the same mistake being made or the same question being asked by multiple students, they can call the class together and go over that specific problem or topic. The teacher also has the opportunity to speak with every student in class and see what their understanding of the material is, which means the teacher is constantly engaged in formative assessment so that they can diagnose each student’s understanding and modify the instruction as needed for topics that students are struggling with (Bergmann & Sams, 2013). The teacher is able to offer more guidance to the struggling students who need it and provide more challenging work for those who find the material easy (Morgan, 2014). There is also more time to support students
in working on higher cognitive demand tasks and to explore conceptual ideas. When the students are able to work on problems together in small groups they are able to get help from other students in the form of peer tutoring. This allows students to learn from each other and communicate their understanding to one another. Overall, students seem to be more engaged because they come to class with a stronger background knowledge of what they are working on and are able to do more in class (Gillett, Moore, & Steele, 2014).

Another advantage of the flipped classroom is the convenience that comes from the use of technology. Teachers can leave videos posted online so that students can refer back to old videos if they need a refresh on the material. Since the students have access to the videos all the time they feel less stressed to get concepts the first time because they can always re-watch the videos if they are still confused (Crouch, 2014). Teachers can also update and revise videos regularly if they see a certain topic multiple students are struggling to understand or topics that they may need to put more emphasis on. Having the videos posted online 24/7 gives the students easy access to course materials whenever and wherever so it is convenient for students who are absent to keep up with what is going on in class (Fulton, 2012).

2.1.2 Motivation

The flipped method seems to increase students’ motivation to complete assignments because they feel like they can actually do the work that is asked of them. Since the lectures are watched at home and the “homework” is done in class students feel more supported because they are doing the hard part in class and the easy part at home. Students are able to get help with homework right away and not struggle at home trying to figure out how to do it by themselves. In one study, the average homework completion rate of five classes rose by 13 percent during the flipped unit, even increasing by 19 percent in one class (Gillett, Moore, & Steele, 2014).
The flipped method also presents advantages for self-paced learning. Self-paced learning is when a student is allowed to move at their own pace when going through the learning process. This allows students to take control of their own learning and forces them to evaluate what they know well and what they still need to work on. Students can breeze through sections of videos on material that they understand well and watch the material they aren’t sure of over and over until they understand it (Fulton, 2012). If a teacher posts all of the videos online at the beginning of the school year, the students can get ahead if they feel ready for it or just watch the videos as they come up in class.

In a study done by Zhang et al (2006), students positively evaluated the online video lectures because they made them more efficient as learners and they were able to preview the learning before class, participate more easily in class, and repeatedly study the difficult parts which added to their motivation for learning. They were also motivated to make sure they knew the material because in class they participated in collaborative learning activities where they were able to solve problems, exchange ideas with each other, and enhance their understanding of the material.

2.1.3 Achievement

One way that some flipped classrooms are being taught is using the mastery learning approach. In this approach, all of the videos are posted online at the beginning of the course and the students have to show that they have mastered a particular objective before moving on to the next. Students in this sense get to material when they are ready for it and they don’t feel the pressure of learning too fast if they are struggling or learning too slow if they understand the concepts being taught (Bergmann & Sams, 2013). The mastery learning approach has been shown to lead to higher achievement of the class overall.
The flipped classroom is still a relatively new approach to teaching, but early data suggests that flipping the classroom contributes to significant increases in student learning and achievement as compared to baseline data on the same courses taught in the traditional classroom lecture mode using the same assessments (Fulton, 2012). In one survey of 453 teachers who flipped their classroom, 67 percent reported increased test scores with the highest benefit coming for students in advanced placement courses and for students with special needs (Goodwin & Miller, 2013). The same survey also reported an 80 percent improvement in student attitudes towards what they were learning and how well they felt that they could do the math involved (Goodwin & Miller, 2013). In a different survey, nearly 70 percent of students involved in a flipped classroom had increased standardized test scores as compared to students taught in a traditional classroom in previous years (Crouch, 2014).

Although there are many studies that show how the flipped classroom or flipped learning lead to improved scores in the classroom there are also some cases where it was ineffective. Yarbro et al (2014) looked at several cases where flipped learning was being applied in various schools in her research and found schools where this was the case. In a study done by Kevin Clark in a public high school in Louisiana in 2013, where Clark implemented flipped learning in two 9th grade algebra one classes for 7 weeks (or one grading period), students scored on average an 80.83 on the end-of-unit test which did not differ significantly from the scores of students in a traditional lecture class who averaged an 80 on the same test. In another study done by Lap, Levy, and Yong, professors at Harvey Mudd College in California, who in 2014 started a multi-year study of the impacts of the flipped learning model on students’ achievement in STEM courses, they had a similar outcome. As of the second year of their study, they have not found any significant differences in student learning between their flipped classrooms and their traditional classes. As a
result of their current findings, they concluded that what matters is really how the flipped learning method is being implemented in the classroom. Flipped learning has the potential to improve student scores, but only if it is made interactive and student-centered and not just as a new way to give a lecture.

2.1.4 Flipped Classroom Vs Flipped Learning

As described earlier, a flipped classroom refers to an instructional approach where the school work (acquiring information) and homework (applying newly learned knowledge) are swapped. Flipped Learning is defined as a “pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter” (Yarbro et al, 2014, p.5). Flipped learning emphasizes the active learning in class and not merely helping students work through problems that would otherwise be done at home. Hence, a flipped classroom can, but doesn’t necessarily always, lead to flipped learning. In our hybrid model, students participate in their self-paced learning in their individual learning space and we engage students in more interactive and hands-on activities at our weekly in-class session.

2.2 Video Based Learning

Video is a rich and powerful tool being used in flipped, hybrid, and e-learning classes across the country. It presents information in an attractive and consistent manner that incorporates both audio and visual cues. Since content is delivered both ways in a video, both audio and visual learners can benefit from it. Allowing students to have access to videos whenever they want gives students the opportunity to learn the material anywhere and anytime at their convenience. It also gives students the opportunity to watch them at their own pace and to re-watch material they don’t understand as well.
2.2.1 The Importance of Interactivity

Video watching can be a rather passive learning process. Recent studies have found that interactivity is key in videos to gain students attention and help enhance their learning (Vural, 2013; Zhang et al, 2006). Zhang and Vural presented two cognitive learning theories to highlight the importance of interactivity in video learning.

Constructivism refers to the idea that learners develop new knowledge by building on their existing knowledge through new experiences. Consequently, each person learns things differently and constructs their own internal representations for their unique version of knowledge (Zhang et al, 2006). Richer learning environments that incorporate graphics, videos, and other educational materials are required to help students discover things by themselves (Vural, 2013). Activities in which learners play active roles can engage and motivate their learning more effectively than activities where they are passive. According to Zhang et al, education supported by the constructivist theory should enable learners to engage in interactive, creative, and collaborative activities during knowledge construction.

The cognitive information processing theory posits that humans process the information they receive in a manner similar to that of a computer. In this perspective, students reconcile new information to be learned with their prior knowledge. They then store this new knowledge in their memory and retrieve it as needed. One major assumption of the cognitive learning model is that a learner’s attention is limited and therefore selective (Zhang et al, 2006). Hence, if a learning tool is interactive and creative it can help to enhance the learner’s attention and improve their learning because it attracts their attention. Another major assumption of the theory is that everyone has a different learning style. This implies that individualized instruction is needed for learning so if instructional methods are prepared in terms of each learner’s learning style they will be most
effective (Vural, 2013). Thus, education supported by the cognitive information processing theory should use interactive video-based learning environments that let learners play an active role and the videos should catch their eye and present visual and auditory learning materials (Vural, 2013).

2.2.2 The Importance of Questioning

Another important factor in teaching and learning is the use of questions to engage in higher-order thinking, to ascertain students understanding of the material and to determine where students are struggling or may have gaps in their knowledge. In the context of classroom instruction, Ainley (1987) differentiated among three types of questions: (1) test questions are those where the teacher already knows the answer, (2) genuine questions are those where the teacher wants to know the answer, and (3) provoking questions are those where the teacher seeks to draw student attention to what we want students to think about. In the context of learning through video watching, test questions and provoking questions can be embedded in a video to assess student understanding and to evoke thinking accordingly.

More than two thousand years ago, Socrates employed a dialectic process where he posed another question in response to student responses, proceeded from proposal to counter proposal, from less adequate to more adequate definitions in an effort to discover a universal method (Howard, 2006). This process became known as the Socratic Method and this method of instruction continues to be a key method for developing critical thinking skills. According to Howard, teachers today must develop teaching modules that employ technology (like video-based learning) where students can refine their ideas through the Socratic Method. Using video-based learning with learner control lets students be active and determine much of their learning process to accommodate their own interest, needs, and learning styles. This also allows teachers to blend
this multimedia technology into an interactive process to take advantage of the Socratic Method (Howard, 2006).

2.2.3 Non-Interactive Vs Interactive Videos

A major problem with the use of instructional video is the lack of interactivity that it provides. For some students, browsing a non-interactive video is more difficult and time consuming than browsing a textbook because they have to view and listen to the video in order, which makes searching for a specific portion difficult (Zhang et al, 2006). Simply incorporating video into online learning environments may not always result in improved learning since it doesn’t motivate students to interact with instructional materials.

The rise of interactive digital video technology allows students to interact with instructional video which presents many advantages and benefits for students and in turn many implications for students learning. First, it helps entice learners to pay attention to the learning material through active interaction between the learner and the video. It not only provides visual and verbal cues but it makes it easy for learners to view any portion of the video as many times as they want or need. This may help students enhance understanding of the material and achieve better performance. Second, it increases the learner-content interactivity which potentially motivates students and improves learning effectiveness. Third, it reduces limitations on students learning by providing control over the learning process which helps students in the self-construction of the content being taught. Engagement in interactive video-based learning can be seen as facilitating a constructivist learning environment (Zhang et al, 2006).

In a study done by Vural (2013), on the impact of a question-embedded video-based learning environment on e-learning he used a format similar to what was employed in my research. He developed two different groups- the IVE which used interactive videos and the QVE which
used question-embedded videos. Students in the IVE group were allowed to watch any video they wanted on the material in whatever order they wanted and they didn’t have to do anything to move on in the material. Those in the QVE group had to answer a multiple-choice question after watching each video to go to the next topic and if they answered incorrectly they had to watch the same video again. He found that those who used the QVE tool spent more time interacting with the learning materials than those in the IVE group. The findings indicated that the question-embedded tool promoted student learning and improved student interaction with the learning materials.

My study is similar to Vural’s study in that I am also investigating whether the questions embedded in the videos help improve students’ learning. The QVE group differs from our treatment group but the idea behind the tool is the same. In our treatment group, the embedded questions pop up during the video and students have to answer the question before continuing to the next part of the video. If they aren’t sure of the answer they can re-watch the portion of video before the question to get a better understanding of it but they can’t continue watching the video until they have answered the question. Unlike the IVE group in Vural’s study, the comparison group in my study watches the exact same videos as those in the treatment group, the videos just don’t have the embedded questions and students have to watch them in the same order that the treatment group does.
Chapter 3: Methods

3.1 Research Design

This study followed the design-based research methodology (Wood & Berry, 2003), where we created a product or learning environment, performed iterative cycles of design, implementation, analysis, reflection, and redesign, accounted for how the design functioned in authentic settings, and documented and connected implementation to the desired outcomes. The overall goal of the research project is to produce self-paced learning (SPL) materials which include math videos (some with embedded questions and some without).

The SPL materials were used in two sections of a hybrid course for prospective teachers on Geometry and Measurement. Students in each section were divided into two groups - the treatment and the comparison group. The treatment group watched the assigned math videos with embedded questions and then completed the rest of the SPL materials. The comparison group watched the same math videos but without the embedded questions and then completed the same SPL materials. The research design allowed me to see the effect that the embedded questions had on the students’ engagement and achievement.

3.2 Participants

The participants for this study were prospective middle-school teachers who were enrolled in the two sections of the Geometry and Measurement course in spring 2015. The Tuesday 6 pm class initially had 17 students enrolled but ended up with 13 students, 3 males and 10 females. The Thursday 12 pm class had 33 students enrolled initially but ended up with 29 students, 2 males and 27 females.

The students enrolled in the course who signed the consent form were considered participants. By signing the consent form, students gave me permission to make copies of their assignments and tests, keep electronic copies of their online work and surveys, analyze their work, and analyze the audio recording of the focus group. All students, except one student in the Tuesday 6 pm course, gave consent.
On the first day of class students were allowed to form their own teams of three or four and then we assigned each team into either the comparison (P) or treatment (Q) group using their team’s mean grade point average (GPA). We did this so that both groups would have approximately the same mean GPA. The breakdown of each team’s average GPA, the number of students in the team, and the group they were assigned to is listed in Table 3.1 below.

Table 3.1: Team GPA’s, Number of Students, and Group

<table>
<thead>
<tr>
<th>Team</th>
<th>Number of Students</th>
<th>Average GPA</th>
<th>Group</th>
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</tbody>
</table>

Teams 1 to 4 are in the Tuesday 6pm class whereas Teams A to H are in the Thursday 12pm class. The mean GPA for the 22 students in the P group is 3.13 and the mean GPA for the 19 students in the Q group is 3.16 (one student did not have a GPA). Also, one of the students in
group 4 somehow ended up in the P group, probably because he signed into the wrong class on the Edpuzzle website. The breakdown for each group is listed in Table 3.2 below.

Table 3.2: Breakdown of Students

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Tuesday 6 pm</th>
<th>Thursday 12 pm</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Male</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>5</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>Q</td>
<td>Male</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4</td>
<td>13</td>
<td>17</td>
</tr>
</tbody>
</table>

3.3 Procedure

Students completed one module per week and the lesson structure was as follows. Students began the week by attending the in-class meeting in which students were exposed, via class activities, to some of the concepts they would be learning in the self-paced learning module. For the self-learning component in lieu of the second in-class meeting, students had to watch the math videos (some embedded with questions), read selected pages in the Beckmann textbook, and answer questions in the Word document (online work) that would be submitted by Sunday at 11:59 pm via Blackboard. For homework, students had to complete selected problems from the textbook and turn them in at the next in-class meeting. During the in-class meeting, the instructor would answer questions students had on their homework and/or online work and then we would start the process over again for the new module.

3.4 Data Collection Instruments

The data that I collected from both Math 2304 sections for each module were students’ written responses in the Word document (online work), students’ answers to homework problems, students’ survey responses, in-class assessment scores, students’ performance on embedded questions, students’ performance in selected items in the final exam, their scores on pre/posttests
with items related to the math content in each module (see Appendix A), and an audio recording of a focus group session. The focus group was conducted by a mathematics educator not involved in the study almost 2 months after the final grades were turned in. Only four students participated; participation was completely voluntary. The purpose was to obtain feedback from students about their learning experience with the SPL materials and see if they had any suggestions for improving the materials. The focus group session was audiotaped.

The questions in the online work were chosen based on the videos students watched and the material they read from the textbook. Most questions require students to reflect, apply, and/or explain what they learned from watching the videos and reading the textbook. The homework problems were selected for students to apply what they had learned in class and via the self-paced learning materials. Some of the problems are rather challenging and require students to think.

A pre/posttest was administered on the first day of class and then again on the last week of class. The pre/posttest questions were based on the three different topics chosen for this study: (a) angles, (b) conversion of units and magnitude (measurement), and (c) areas and perimeters of 2D figures (including the Pythagorean Theorem). This pre/posttest allowed me to see whether they had a better understanding of the concepts, how the embedded questions and other SPL materials helped students, and if they improved.

### 3.4.1 Course Management System: Blackboard

In the course we also used the online learning system Blackboard. We had a class shell on this website and all class materials were posted on here. Students could download the PowerPoint slides used in class, homework, and online work assignments. They submitted their online work through Blackboard. I downloaded and graded student assignments each week and then uploaded a copy with feedback for each student to download.

### 3.4.2 Video Management System: Edpuzzle

The math videos used in this Geometry and Measurement course were posted on the website Edpuzzle.com. We chose this website because of the features it offered. It allows teachers
to search for videos on any topic, browse through videos on that topic, and choose the appropriate ones. Teachers can then opt to crop the video. Most importantly, teachers can embed questions into the video. This question-embedding feature is crucial for this research. Recall that only students in the Q group would see the embedded questions and were required to answer them. Students in the P group would watch the same video without having any embedded questions. Another feature that is helpful is that Edpuzzle tells you how much of each video that every student watched and how many times they watched each part of the video.

We created two different classes (one for the P group and one for the Q group) at the Edpuzzle site. We then sent an email to students with instructions on how to log on and the code that corresponded to the group (either P or Q) they were assigned to. I obtained from Edpuzzle data on whether students watch the video and how much of it they watch. Edpuzzle splits each video into ten portions and tracks the number of times each portion is watched by each student. For the embedded questions in a video, it records students’ responses and gives each student an overall score based on the percentage of questions answered correctly.

3.5 Data Analysis

For the purposes of this research, I focused on three topics: (a) angles, (b) conversion of units and magnitude (measurement), and (c) areas and perimeters of 2D figures (including Pythagorean Theorem).

To determine how the two groups (P and Q) differ in terms of various course components I looked at various types of data that were collected. First, to compare the amount of a video students watched between the two groups I looked at how much of the video each student watched and then I counted how many times each portion of the video was watched by each student. There are ten portions to watch in each video so after adding up the number of times each portion was watched by each student I divided these sums by 10 to get a number that was either greater, smaller, or equal to 1. A 0 meant the student didn’t watch the video at all, a number smaller than 1 meant that they watched parts of the video but not all of it, a 1 meant in most cases that they watched the
entire video only once, and a number greater than 1 meant they watched some portions of the video more than one time.

For students’ written work, I did a word count of all students’ online work assignments to see how much they were writing in their responses. I subtracted the word count of the questions so that the word counts I was left with were only for the students’ responses. To analyze students written work qualitatively, I developed a rubric for questions related to the three topics we focused on and used it to score student responses. I started out with a generic rubric to indicate what each score meant (see Table 3.3). As I started analyzing student responses to each question, I made the rubric more specific and the revised rubric is used to score all responses for that particular question. An example of a question-specific rubric is in Appendix B where you can see the question, its correct answer, a brief description for each score, and some student responses and their respective scores.

Table 3.3: Generic Rubric

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Answer correctly with detail, make connections, gave all of the parts of the answer that we were looking for</td>
</tr>
<tr>
<td>4</td>
<td>Answer correctly and explain why with detail</td>
</tr>
<tr>
<td>3</td>
<td>Keyword answer or an answer with little to no detail or elaboration</td>
</tr>
<tr>
<td>2</td>
<td>Answer is related to the topic in question but not correct</td>
</tr>
<tr>
<td>1</td>
<td>No answer or the answer was irrelevant to what was being asked</td>
</tr>
</tbody>
</table>

To compare performance in in-class assessments between the two groups, I identified the assessments that are related to the three selected topics. For each assessment, I computed the mean score and standard deviation for each group. For the final exam, I identified the questions that are related to the three topics, and found the percentage of questions answered correctly for each student. I then computed the mean and standard deviation for each group for the selected questions in the final exam.
To compare the two groups in terms of scores for the entire course, I looked at the different course components including the online work, homework, in-class assessments (all in-class assessments and not just those related to the 3 topics), and the final exam. I found the averages of each assignment and the final exam for each group. Scores for online work and homework consist of two sub-scores: 50% for how much of the assignment they complete and 50% for quality or correctness of work. For example, if the total score is 20, then 10 points is allocated for completion and the other 10 points for quality of work (how many answers they have correct and how well they explained their answers). So a student who completes the assignment and answered half of the items correctly would get a 15/20.

To compare students’ opinions about self-paced learning and the flipped classroom method between the two groups, I looked at the online surveys students took at the beginning and towards the end of the semester to see if their views had changed. Students took a total of five online surveys, administered in weeks 1, 4, 7, 13, and 15. All the items in Survey 1 (except the one about student opinion and prior experience of online learning and hybrid courses) are in Survey 5. All the items in Survey 2 (except one) were identical to those in Survey 4 (see appendix C for surveys 4 and 5). In order to compare the change in student opinion between the two groups from the beginning of the course to the end, I chose to focus on the items in Survey 1, 2, 4, and 5. Survey 3 was not included in the data analysis because it was specific to one week of materials (week 6) and is not students’ opinions about self-paced learning and the flipped classroom method.

I listened to the audio recording of the focus group session but chose not to present the results of that because only four students attended and there was only one representative from the P group. Also, students frequently deviated from the questions posed by the facilitator; for example, one particular student took the focus group as an opportunity to vent her frustration with the course because she didn’t have internet access at home and would have to do her work at a library. Consequently, we were unable to elicit information from the focus group that was useful for answering the research question.
I conducted statistical tests on the numerical data that I collected. I ran a paired T test to compare the pre/post test scores to determine whether the changes from pre-to-post were substantial for each group. To compare pre-post improvement scores between the two groups, I conducted a two-sample T test. I also conducted two-sample T tests to compare the two groups in terms of average time each video was watched, average word count for each assignment, average rubric scores for the selected weeks, average in-class assessment scores for the selected weeks, the selected-items final exam score, score averages for the entire course (including online work, homework, all in-class assessments, and total final exam score) as well as the difference in opinion between the two groups on the surveys.
Chapter 4: Results

Of the 14 weeks of class, there were 6 weeks which made up the 3 topics that we focused on. Week 2 dealt with angles. Weeks 5, 6, and 10 dealt with conversion of units and magnitude (measurement). Finally, weeks 5, 6, 7, 8, and 10 all dealt with area and perimeter of 2D figures including shearing and the Pythagorean Theorem. These weeks are how the information will be presented. Table 4.1 displays the learning results for both groups of students on the three selected topics.

Table 4.1: Pre/Post Test Results

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Effect Size</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>P</td>
<td>3.68</td>
<td>2.51</td>
<td>7.86</td>
<td>3.09</td>
</tr>
<tr>
<td>Q</td>
<td>4.05</td>
<td>2.46</td>
<td>8.90</td>
<td>3.02</td>
</tr>
</tbody>
</table>

Using a paired t-test for both groups the results were significant at the 0.01 level. Overall, learning did occur for both groups of students with an average score improvement of 4.18 points for the P group and 4.84 points for the Q group. The effect size (Cohen’s $d$) for each group is very large with the P group having an improvement from pre to post test that is 1.35 times the standard deviation and the Q group having an improvement that is 1.60 times the standard deviation. Using a two sample t-test to compare the student gains for each group, the gains were not significantly different between the 2 groups with a p-value of 0.502.

4.1 Amount of Video Watching for Selected Weeks

In terms of video watching on Edpuzzle, the P group watched the videos more than the Q group both overall and within each week. The P group watched each video an average of 1.4 times
whereas the Q group watched an average of 1.2 times. However, this difference was not significant with a p-value of 0.094 using a two sample t-test.

4.2 Quality of Written Work

The average word count for each group was found for all 14 online work assignments (see Appendix D for an online work example). There were 12 questions scored using the rubric in total, two for week 5, five for week 6, one each for weeks 7 and 8, and two for week 10 (although one question that had parts a-e was graded on two different concepts within the question so the rubric was split one for each concept). Table 4.2 shows the average word count and rubric scores for the groups for each week. There were no significant statistical differences between the two groups in terms of overall word count or overall rubric scores.

Table 4.2: Word Count and Rubric Averages

| Week | Word Count | Rubric | | | |
|------|------------|--------|----------|----------|
| P    | Q          | P      | Q        |
| 2    | 245        | 184    |          |          |
| 5    | 485        | 457    | 2.89     | 3.11     |
| 6    | 577        | 517    | 3.23     | 2.95     |
| 7    | 432        | 391    | 2.27     | 2.26     |
| 8    | 449        | 403    | 2.95     | 3.00     |
| 10   | 670        | 630    | 3.20     | 3.21     |
| Average | 476    | 430    | 2.91     | 2.91     |

To compare the quality of responses between the two groups, I looked at student responses in week 5 and 6 assignments because those weeks had the biggest difference in average rubric scores. In week 5, the biggest difference was on question 5 where the P group averaged a score of 2.86 and the Q group averaged a score of 3.11 (this difference was not significant with a p-value of 0.525). This question asked students what 1 square unit meant to them; a response that receives
a rubric score of 5 indicates that 1 square unit is the area of a square with a side length of 1 unit and unit can be meter, inch, etcetera (see Appendix B for the descriptors for the other rubric scores). The P group had quite a few students who only talked about a square unit measuring area or they just said that a square unit is when you multiply a number times itself. However, the Q group better understood that a square unit was an area of 1 unit by 1 unit (some of them were able to say a square/rectangle) so they were able to connect the area to their response.

The biggest difference in week 6 was on question 11 where the P group averaged a score of 2.95 and the Q group averaged a score of 2.00 (this difference was significant with a p-value of 0.009). This question asked the students to briefly explain why we can multiply a quantity like 25 $m^2$ by a conversion factor like $\frac{10,000 \text{ cm}^2}{1 \text{ m}^2}$ and a response that receives a score of 5 indicates that a quantity like 25 $m^2$ can be multiplied by a conversion factor such as $\frac{10,000 \text{ cm}^2}{1 \text{ m}^2}$ because $\frac{10,000 \text{ cm}^2}{1 \text{ m}^2}$ is equal to 1 since 10,000 cm$^2$ is equal to 1 m$^2$. The P group had more students who realized the fact that 10,000 cm$^2$ was equal to 1 m$^2$ although not many seemed to understand that the conversion factor equaled 1. The Q group had several students who just said that they used conversion factors to convert units but they weren’t specific to why we can multiply quantities by conversion factors (since the values of the quantities in a conversion factor are equal).

4.3 Performance in Assessments for Selected Weeks

Students took six in-class assessments. Table 4.3 below shows the scores for in-class assessments 3, 4, and 5 (see Appendix E for an example of an in-class assessment) which were the ones related to the three topics I focused on in this study. All in-class assessments are scored with a maximum of 10 points. The differences in assessment scores between the two groups are not significant.

Table 4.3: In-Class Assessment Averages

<table>
<thead>
<tr>
<th></th>
<th>P-Group</th>
<th>Q-Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>--------------------</td>
</tr>
<tr>
<td>ICA 3</td>
<td>6.50</td>
<td>2.96</td>
</tr>
<tr>
<td>ICA 4</td>
<td>6.05</td>
<td>2.94</td>
</tr>
<tr>
<td>ICA 5</td>
<td>6.86</td>
<td>2.59</td>
</tr>
<tr>
<td>Total</td>
<td>6.50</td>
<td>1.76</td>
</tr>
</tbody>
</table>

For the final exam, the difference between the two groups was significant for some items involving the three topics which were covered in weeks 2, 5, 6, 7, 8, and 10 (see Appendix F for examples of these questions). Each row in Table 4.4 shows the two groups’ average scores for final exam items that are related to concepts covered in a particular week. An asterisk indicates that the difference between the two group averages is significant to the 0.05 level based on a two sample t-test.

Table 4.4: Final Exam Averages

<table>
<thead>
<tr>
<th>Week</th>
<th>P Group Average</th>
<th>Q Group Average</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>5.33/10</td>
<td>7.18/10</td>
<td>0.006*</td>
</tr>
<tr>
<td>Week 5</td>
<td>2.86/6</td>
<td>2.26/6</td>
<td>0.448</td>
</tr>
<tr>
<td>Week 6</td>
<td>6.60/9</td>
<td>6/9</td>
<td>0.678</td>
</tr>
<tr>
<td>Week 7</td>
<td>10.07/17</td>
<td>12.05/17</td>
<td>0.040*</td>
</tr>
<tr>
<td>Week 8</td>
<td>7.05/13</td>
<td>7.37/13</td>
<td>0.389</td>
</tr>
<tr>
<td>Week 10</td>
<td>8.88/16</td>
<td>10.53/16</td>
<td>0.146</td>
</tr>
<tr>
<td>Total</td>
<td>40.76/71</td>
<td>45.39/71</td>
<td>0.103</td>
</tr>
</tbody>
</table>

There are four final exam items that involve topics in week 2. Q scored higher than P for all but one question. The three items that Q scored better on are: (a) identifying that an angle measures the amount of rotation from one ray to another ray, (b) knowing that degrees were also units of measurement for temperature, and (c) applying their knowledge of the various properties
of angles, such as vertical angles and alternate interior angles to determine the measure of an unknown angle without measuring it, and listing the properties that they used in their solution. P scored better on a yes/no question that asked if it was possible to have an angle that is less than 1 degree, yet it was the Q group students who had answered an embedded question that was similar to this question.

There are six final exam items that involve topics in week 7. Again, Q scored higher for all but one question. Items that Q scored higher on included: (a) finding the expression for the area of a parallelogram, (b) finding the volume of a figure using the moving principle, and (c) drawing the height on a triangle given the base and then subsequently finding the area of the triangle using the base and height (after measuring the height). The only question where P scored better involved identifying the given triangle with the greatest area. Students were assessed whether they knew that all triangles would have the same area because the base and height remain the same while shearing a triangle.

4.4 Scores for Entire Course

Table 4.5 shows the average of the various course component scores for each group. The scores between the two groups are only 1% apart for homework, online work, and in-class assessments. For the final exam, the difference between the two groups is 8% but it is still not significant.

<table>
<thead>
<tr>
<th></th>
<th>P Group</th>
<th>Q Group</th>
<th>Effect Size</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Average 76%</td>
<td>Average 75%</td>
<td>-0.05</td>
<td>0.866</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation 18.8</td>
<td>Standard Deviation 16.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online Work</td>
<td>Average 87%</td>
<td>Average 86%</td>
<td>-0.14</td>
<td>0.708</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation 6.90</td>
<td>Standard Deviation 5.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-Class Assessment</td>
<td>65%</td>
<td>17.55</td>
<td>64%</td>
<td>17.60</td>
</tr>
<tr>
<td>---------------------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>Final Exam</td>
<td>58.4%</td>
<td>19.69</td>
<td>66.5%</td>
<td>14.11</td>
</tr>
</tbody>
</table>

4.5 Opinions about SPL and Flipped Method

As mentioned in the discussion section, two out of three surveys were taken twice by students. One particular item appeared in Survey 1 but not in Survey 5; this item has statements about student experience with online learning and the flipped instructional approach. Twenty-three out of the forty-one students had previously taken a hybrid course, only four students had taken a math course where flipped instruction was used, and twenty had watched online videos to learn math before.

The remaining four items in Survey 1 were repeated in Survey 5. One particular item on their opinion about online learning had three Likert-scale statements where students indicated their level of agreement from 1 (strongly disagree) to 5 (strongly agree). When asked whether they preferred a hybrid or traditional version of a math course, the P group was neutral both at the beginning and at the end of the course whereas the Q group preferred a traditional version at the beginning of the course but were neutral at the end of the course. When asked if they believed that a flipped approach would be more effective than a traditional approach, both the P and the Q group were neutral both at the beginning and at the end of the course. When asked whether they minded learning math from watching videos, the P group was neutral at the beginning of the course but by the end of the course they agreed that they didn’t mind learning math from videos whereas the Q group was neutral both at the beginning and at the end of the course.

In surveys 1 and 5, we asked them to rate their level of agreement (based on a 5-point Likert scale) with statements about teaching and learning. Table 4.6 shows these results for each group including the change in their opinion.

Table 4.6: Survey 1 and 5 Results
<table>
<thead>
<tr>
<th>Statement</th>
<th>P Group</th>
<th>Q Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survey 1</td>
<td>Survey 5</td>
</tr>
<tr>
<td>A1: I need to be shown the steps to solve a new problem.</td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td>A2: If I cannot solve a math problem within a few minutes, I will stop trying to solve it.</td>
<td>2.1</td>
<td>2.2</td>
</tr>
<tr>
<td>A3: Learning mathematics mainly involves memorizing procedures.</td>
<td>2.9</td>
<td>2.4</td>
</tr>
<tr>
<td>A4: To understand mathematics, students must solve many problems following examples provided.</td>
<td>3.8</td>
<td>3.4</td>
</tr>
<tr>
<td>A5: Getting the right answer is the most important part of mathematics.</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>A6: Often in mathematics, I do not understand the concept behind a problem.</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>B1: I am able to remember most of the mathematics I learn in a course after the course is over.</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td>B2: I prefer to think through a math problem than to look up a worked example in a book or online.</td>
<td>2.4</td>
<td>2.9</td>
</tr>
</tbody>
</table>

The statements in group A are considered “negative” questions whereas those in group B are considered “positive.” The interesting part of these results is that the P group improved their opinion on the negative statements by an average of 0.17 points meaning by the end of the semester their opinions were less negative. They also improved their opinion on the positive statements by an average of 0.36 points so their opinions on teaching and learning math overall seemed to improve over the semester. However, the Q group’s agreement with the negative statements went up by an average of 0.017 points so by the end of the semester their opinions were actually slightly
more negative than at the beginning of the course. They did improve their opinion on the positive statements by an average of 0.05 points but overall their opinions on teaching and learning math didn’t seem to get better over the semester. The differences between the P and Q groups in terms of change in scores from survey 1 to survey 5 were not significant for both the positive or negative statements.

In surveys 2 and 4, students rated their agreement based on a 5-point Likert scale with statements about the hybrid course and the math videos that they watched on Edpuzzle. Table 4.7 shows the results of these surveys for both groups including their change in opinion.

Table 4.7: Survey 2 and 4 Results

<table>
<thead>
<tr>
<th>Question</th>
<th>P Group</th>
<th>Q Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent do you agree with each statement below:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I wish there were fewer math videos I have to watch in the weekly online work.</td>
<td>2.7</td>
<td>2.3</td>
</tr>
<tr>
<td>My engagement with mathematics in this hybrid course is higher than my engagement with mathematics in my previous math courses at this university.</td>
<td>3.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Since taking this class I am beginning to like Geometry.</td>
<td>3.4</td>
<td>3.1</td>
</tr>
<tr>
<td>I think I would have learned more in a regular Math 2304 than this hybrid Math 2304.</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>If a video is not useful to my learning, it is usually because it is boring.</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>If a video is not useful to my learning, it is usually because I can’t ask questions.</td>
<td>2.8</td>
<td>2.3</td>
</tr>
<tr>
<td>If a video is not useful to my learning, it is usually because I already know most of the ideas before watching them.</td>
<td>3.0</td>
<td>2.6</td>
</tr>
</tbody>
</table>
The statements in Table 4.7 are about their liking and preferences rather than about desirable/undesirable views and beliefs in surveys 1 and 5. The P group increased their level of agreement from survey 2 to survey 4 on three statements and decreased their opinion on seven statements. On the other hand, the Q group increased their level of agreement from survey 2 to survey 4 on six statements and decreased their opinion on two statements. Overall, the change in level of agreement across all the items between the two groups from survey 2 to survey 4 is not significant.
Chapter 5: Discussion and Conclusion

5.1 Discussion

The results show that almost all of the differences between the groups are not significant. Nevertheless, there are four differences between the two groups that are worth noting in my attempt to make sense of the results. These differences are presented in the following sub-sections.

5.1.1 Relating Final Exam Items to Embedded Questions

As presented in Section 4.4, the Q group had very similar scores to the P group for homework, online work, and in-class assessments, yet they have a higher score, although not significant, than the P group in the final exam. As presented in Section 4.3, the Q group did better in 3 of the 4 final exam items on topics covered in week 2, and in 5 of the 6 items on topics covered in week 7. Among these 8 items, four are similar to the embedded questions. For example, the questions on the final exam from week 2 that asked what an angle measured the amount of rotation from (one ray to another ray) and the one that asked what degrees were a unit of measurement for were presented as embedded questions. The students in the Q group had been exposed to those questions previously which might be the reason they did so well on them when they came up again. It seems that the Q group did better only on final exam items that are similar to those in the embedded questions. This study was not designed to compare the two groups in terms of their performance in assessment items that are similar to the embedded questions and in those that are not similar.

5.1.2 Relating Survey Results to Edpuzzle Videos

In terms of the number of times students watched the videos, the P group (1.4 times) watched all of the videos more than the Q group (1.2 times). In the survey, the P students said that they agree that they did re-watch parts of a video that they didn’t understand and the agreement level increased from survey 2 to survey 4. The Q group, on the other hand, was more neutral to re-watching the videos and they had no change in their opinion of it from survey 2 to survey 4. One
possible reason is that the Q students didn’t want to re-watch the videos because they would have to go through the embedded questions again.

On the statement about whether they wished there were fewer videos to watch each week the P group changed their opinion from neutral in survey 2 to disagree in survey 4, meaning that they did not wish that there were fewer videos. The Q group, on the other hand, changed their opinion in the opposite direction, from disagree in survey 2 to neutral in survey 4. This could be because the embedded questions were too intrusive for the Q group which made it take longer to get through all of the videos while the P group got to watch the video straight through without interruption so they didn’t mind the amount of videos to watch.

Another statement where the two groups’ change in opinions differed was “if a video is not useful to my learning, it is usually because I can’t ask questions.” The P group changed their opinion from neutral to disagree meaning that not being able to answer questions is not their reason for finding that the video is not useful. The Q group kept their opinion at neutral. It is possible that the embedded questions might have resulted in a need for the Q students to ask questions.

Another difference in opinion was that the P group strongly agreed that they enjoyed watching most of the videos on Edpuzzle whereas Q group was neutral. Also, the P group agreed that they didn’t mind learning from the videos whereas the Q group was neutral. One possible explanation is that the embedded questions got in the way for the Q group. If that was the case, the Q students wouldn’t mind learning from the videos and they would enjoy them more if they weren’t interrupted to answer questions. At the focus group, a Q student said that she would be into watching the video and taking notes but then it would stop them to answer a question which would throw her off and distract her from what he she was learning. Another student commented that the embedded questions were helpful but it would be better if they were all at the end of the video so that they wouldn’t interrupt his learning and the questions could test his knowledge of what he had learned in the video. On the other hand, a student from the P group thought that having those embedded questions might have helped guide her learning of the material.
5.1.3 Changes in Opinions and Perspectives

Based on the results, the embedded questions seemed to decrease students’ opinion of the class and in learning and teaching math. The Q groups opinions got worse as the semester went on whereas the P groups opinion improved. For example, on the statement that were rated as negative questions on survey 1 and 5 such as if I can’t solve a problem within a few minutes I will stop trying to solve it or getting the right answer is the most important part of mathematics, the P group’s opinion got less negative as the semester went on whereas Q group’s opinion got more negative as the semester went on. These results could be taken to mean that the Q group seemed more likely to give up when trying to work problems whereas the P group would give it another chance. I think this might be because the Q group felt like they had already done more work with having to answer the embedded questions that they didn’t want to take more time trying to solve the problems.

5.1.4 Hybrid Vs Traditional Course

When asked if they preferred a hybrid version of a math course to a traditional version, the Q group was more neutral whereas the P group disagreed, meaning that the P students preferred a traditional version rather than the hybrid version. I think one reason for this could be that the embedded questions helped guide the students learning as far as what was important and what to focus on in learning from the videos and they got to see if they were understanding the material as they were watching each video since they could see whether they answered a question right or wrong and the P group didn’t have this opportunity. In a sense the Q group had some questions answered on whether they were understanding the material or not (through the embedded questions) whereas the P group didn’t get the chance to clear up their misconceptions or understanding of material until the next class. The extra guidance that the embedded questions gave the Q students could have contributed to them feeling more comfortable with a hybrid class than the P students who didn’t have that same guidance.
5.1.5 Practical Significance

Based on the results, the study doesn’t have any statistical significance to support the claim that the embedded questions enhance students’ learning. This could be due to the small sample size of 41 participants (22 in the P group, 19 in the Q group). However, if we look at practical significance in terms of effect size, computed using Cohen’s d, we can see that some score differences between the two groups do show moderate to high practical significance. Particularly, the effect sizes of the pre-to-posttest improvements show very high practical significance (1.35 for the P group and 1.60 for the Q group) and the effect size for the final exam averages (0.41) shows moderate practical significance based on the standard interpretation of Cohen’s d (Vacha-Haase & Thompson, 2004). This could mean that although we don’t have any statistical significance to show for the study we do have practical significance which means that the embedded questions were slightly more effective in helping enhance students’ learning.

5.2 Recommendations

Based on the findings I obtained from this study, I would make the following recommendations for future research on this topic:

• Trying embedded questions with both groups but placing them within the video for one group and at the end of the video for the other group to see whether this has a different effect since it wouldn’t interrupt students while they are watching the video
• Randomly assigning the students to the two groups (P and Q) instead of allowing them to form their own teams and then assign the teams to the two groups

5.3 Conclusion

The purpose of this research was to investigate the effect of embedded questions in math videos on students learning in a self-paced learning model. I did this by looking at the differences between the control group that watched regular math videos on Edpuzzle as part of the self-paced
learning materials and the treatment group which watched the same exact videos on Edpuzzle but with embedded questions added in to draw their attention to the video.

The findings indicated that the differences between the two groups were mostly not significant. One possible explanation for lack of statistical significance in the results obtained in this study is that there could be other factors that might have a greater impact on student learning. Another possible reason to obtain statistical difference is that the sample size is relatively small.

Nevertheless, the improvement from pre to post test scores was greater for the Q group than for the P group. Also, the final exam scores were higher for the Q group than for the P group. It is possible that the embedded questions help to draw students’ attention to their learning instead of allowing them to passively learn from math videos. There is no statistical significance in the data to support the claim that the embedded questions in the videos can enhance students learning. However, we did find that some differences between the two groups had practical significance which means that the embedded questions actually were slightly more effective at enhancing students’ learning.
References


Bergmann, J., & Sams, A. (2012). Flip your classroom: Reach every student in every class every day. Eugene, OR: International Society for Technology in Education.


Appendix

A Pre/Post Test

For each multiple-choice item, there is only one correct answer. You can enter three answer choices in the three boxes (one point per box).

1. Given that the indicated lines in the figure are parallel, which statement is correct?

   A. $G^\circ = H^\circ = K^\circ$
   B. $H^\circ > K^\circ > G^\circ$
   C. $G^\circ = K^\circ$ but $H^\circ > G^\circ$
   D. $G^\circ = H^\circ$ but $H^\circ > K^\circ$
   E. $H^\circ = K^\circ$ but $G^\circ > K^\circ$

2. Angles $A$ and $B$ are made of line segments that meet at points $M$ and $N$. Which statement is correct?

   A. $A^\circ = B^\circ$
   B. $A^\circ > B^\circ$
   C. $A^\circ < B^\circ$

3. Angle $PQR =$ ________
   Angle $QPR =$ ________

4. The indicated lines in the figure are parallel.
   i. Find angle $S$. Show your work.
   ii. Find angle $T$. Show your work.
5. Given that 1 in = 2.54 cm, how many in² are there in 64 cm³? Show your work.

6. Given that 1 in = 2.54 cm, how many meters are in 3.5 feet? Show your work.

7. Given that 1 yard = 3 feet, fill in the box with either =, <, or >: 3 yd² \[\square\] 9 ft². Justify your answer.

8. Draw as accurately as a rectangle whose area is equal to 8 cm².

9. Both the parallelogram and rectangle have the same length and the same height.
   
   i. Is it true both shapes have the same area? Briefly explain your reasoning.
   
   ii. Is it true both shapes have the same perimeter? Briefly explain your reasoning.

10. The base of the parallelogram ABCD is AB. Draw a line segment to represent the height of the parallelogram ABCD.

11. The perimeter of the isosceles triangle is 80 cm. Its base is 30 cm. What is the height of the isosceles triangle?
### Rubric Sample

#### Online 5: What does 1 square unit mean to you?

<table>
<thead>
<tr>
<th>Score</th>
<th>Type</th>
<th>Answer</th>
<th>Correct</th>
<th>Video</th>
</tr>
</thead>
<tbody>
<tr>
<td>1432</td>
<td>P</td>
<td>1 All SU have SL of 1 unit &amp; units can be ft, mile, in, etc.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>1726</td>
<td>P</td>
<td>0 What I use to measure area.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2311</td>
<td>P</td>
<td>0 It only has 1 type of unit that can be squared or cubed.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2349</td>
<td>P</td>
<td>0 When you multiply a value times itself it’s that value SU.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>4129</td>
<td>P</td>
<td>0 1 unit by 1 unit.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3210</td>
<td>Q</td>
<td>1 A small square used to fill an object many times to get the whole area one square at a time.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3211</td>
<td>G</td>
<td>1 A SU is a way for us to know that there is a # being multiplied by the same #. $2^2=2*2$.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3456</td>
<td>Q</td>
<td>1 A unit multiplied by itself where all the side edges are 1 unit in length.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3812</td>
<td>Q</td>
<td>0 1 SU unit is the area of a square, with a side length of 1 unit. (“Unit” can be meter, inch, etc.)</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>4531</td>
<td>Q</td>
<td>0 5- AREA of square w/side-length 1 unit, can be m, in, etc.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2345</td>
<td>P</td>
<td>0 4- Area, side length 1 unit, can be etc. (2 of 5)</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3- 1 unit by 1 unit; measures 2D figures, area (general)</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2- multiply value times itself, measures area</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1- No answer, irrelevant</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
C Surveys 4 and 5

Survey 4

1. What is your 4-digit id?

2. Opinion about online learning:

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>For math courses, I prefer a hybrid version rather than a</td>
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<td>traditional version.</td>
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<tr>
<td>I believe a flipped approach (content is introduced through</td>
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<tr>
<td>videos) is more effective than a traditional approach (content</td>
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<tr>
<td>is introduced in class).</td>
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<tr>
<td>I don’t mind learning math from watching videos.</td>
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</tbody>
</table>

3. Views about teaching and learning math:

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I need to be shown the steps to solve a new problem.</td>
<td></td>
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<tr>
<td>If I cannot solve a mathematics problem within a few minutes, I</td>
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<tr>
<td>will stop trying to solve it.</td>
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<tr>
<td>Learning mathematics mainly involves memorizing procedures.</td>
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</table>
To understand mathematics, students must solve many problems following examples provided.

Getting the right answer is the most important part of mathematics.

I am able to remember most of the mathematics I learn in a course after the course is over.

I prefer to think through a math problem than to look up a worked example in a book or online.

Often in mathematics, I do not understand the concept behind a problem.

4. What makes learning math by watching a video effective?

**Survey 5**

1. What is your 4-digit id?

2. Which aspects of the Math 2304 hybrid course do you find to be MOST beneficial to your learning, and why?

3. Which aspects of the Math 2304 hybrid course do you find to be LEAST beneficial to your learning, and why?

4. What do you DISLIKE about the math videos at edpuzzle.com? Why?

5. What do you LIKE about the math videos at edupuzzle.com? Why?
6. To what extent do you agree with each statement below:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I wish there were fewer videos that I have to watch in the weekly online work.</td>
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<tr>
<td>My engagement with mathematics in this hybrid course is higher than my engagement with mathematics in my previous math courses at UTEP.</td>
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<tr>
<td>Since taking this class I am beginning to like geometry.</td>
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<tr>
<td>I think I would have learned more in a regular Math 2304 than this hybrid Math 2304.</td>
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<tr>
<td>If a video is not useful to my learning, it is usually because it is boring.</td>
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<tr>
<td>If a video is not useful to my learning, it is usually because I can’t ask questions.</td>
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<tr>
<td>If a video is not useful to my learning, it is usually because I</td>
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<tr>
<td>Already know most of the ideas before watching them.</td>
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<td>------------------------------------------------------</td>
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<tr>
<td>I enjoy watching most of the videos at edpuzzle.com.</td>
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<tr>
<td>I prefer learning from a teacher explaining the steps on a blackboard in class than a video explaining the steps.</td>
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<tr>
<td>When I watch a video, I re-watch the parts that I don’t understand.</td>
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<tr>
<td>I think I learn better with videos that have embedded questions (i.e., the videos are interspersed with questions that I need to answer before I can continue watching the videos).</td>
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<tr>
<td>If the same instructor teachers two sections for a math course, I will choose the hybrid section over the regular section.</td>
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</table>
**D Online Work Example**

Rename this word document as “OnlineWork05_FourDigitID”.
Submit this Online Assignment via Blackboard by Sunday 11:59pm.

1. Watch the PowerPoint Show on *Meaning of Quantity* in Module 5 in Blackboard.
   Illustrate your understanding, using UTEP as an object, by answering these questions:
   i. Give a non-measurable attribute of the University of Texas at El Paso.
      [Type your answer here.]
   ii. Give a measurable attribute (i.e., quantity) of the University of Texas at El Paso.
      [Type your answer here.]
   iii. Give a reasonable value for the quantity you identify in part ii.
      [Type your answer here.]

2. Read and understand each sentence on pages 487-489 in Section 11.1 on *Using Units of Area, Volume, and Capacity*.
   i. What is the difference between a square unit and a cubic unit?
      [Type your answer here.]
   ii. What is the difference between 1 in and 1 inch²?
      [Type your answer here.]
   iii. 1 kilogram is a metric unit for measuring ____________________________.
      [Type your answer here.]

3. Read and understand each sentence on pages 489-490 in Section 11.1 on *Process of Measurement*.
   i. What is the difference between a direct way of measuring a quantity and an indirect way of measuring a quantity?
      [Type your answer here.]
   ii. What is wrong with this way of measuring the length of the centipede?
      [Type your answer here.]
   iii. A distance that is 0.3 kilometer is equal to ________ meters or ________ centimeters.
      [Type your two answers here.]

4. Watch the PowerPoint Show on *Measuring Area Directly* in Module 5 in Blackboard.
   Answer these questions:
   i. What does measuring an area directly mean?
      [Type your answer here.]
ii. Briefly describe the strategy for finding the estimate for the area of the irregular shape to be 35 cm\(^2\).

5. Go to http://edpuzzle.com and watch the 2-minute video Square Units. What does 1 square unit mean to you?
[Type your answer here.]

6. Read and understand each sentence on pages 493-495 in Section 12.1 on Length and Areas.
   i. “Length describes the size of something that is one-dimensional.” What does that mean?
   [Type your answer here.]
   ii. A rectangle is a 2-dimensional object. Why is the perimeter of a rectangle considered a one-dimensional object, yet when we trace the perimeter of the rectangle by tracing out the border we are moving on a 2-dimensional plane?
   [Type your answer here.]
   iii. What is the difference between area and perimeter?
   [Type your answer here.]

7. Go to http://edpuzzle.com and watch the 2-minute video Cubic Units. What does 1 cubic unit mean to you?
[Type your answer here.]

8. Read and understand each sentence on pages 495-496 in Section 12.1 on Volume.
   i. What does volume mean to you?
   [Type your answer here.]
   ii. “Many of the units that are used to measure volume—such as cm\(^3\), m\(^3\), in\(^3\), ft\(^3\)—have a superscript ‘3’ in their abbreviation.” How would you help a student understand what 1 m\(^3\) really represent?
9. Watch the PowerPoint Show on *Meaning of Area* in Module 5 in Blackboard.
   Answer these questions:
   i. How would you respond to a student who asks “Why do we use square inches instead of inches to measure area?” (This question is not explicitly answered in the PowerPoint show.)
   [Type your answer here.]
   ii. 12 in$^2$ can be interpreted in a few ways. List the different ways of expressing 12 in$^2$.
   [Type your answer here.]

10. Read and understand each sentence on pages 514-515 in Section 12.1 on *Areas of Rectangles Revisited*.
   i. The figure below is showing why the area of a 4-cm-by-3-cm rectangle is equal to 12 times the area of 1-cm-by-1-cm squares.

   Use your understanding of multiplication as a product of the *number of groups* and the *number of objects in each group* to help students see why 4 cm × 3 cm is equal to 12 × 1 cm$^2$.
   [Type your answer here.]
   ii. With the aid of the diagram below, show using the distributive property why the area of a 3½-cm-by-2½-cm is equal to 8¾ cm$^2$.

   $3\frac{1}{2} \text{ cm} \times 2\frac{1}{2} \text{ cm} = 3\frac{1}{2} \times 2\frac{1}{2} \text{ cm}^2$
   = $(3 + \frac{1}{2}) \times 2\frac{1}{2} \text{ cm}^2$
   = [Type an expression that is obtained using the distributive property]
   = [Type equivalent expression that involves the addition of two numbers]
   = 8\frac{3}{4} \text{ cm}^2$
11. Copy the $\frac{1}{10}$ unit by $\frac{1}{10}$ unit square and paste it as many times as you need to cover the figure such that all these squares form a rectangle that is $\frac{7}{10}$ unit by $\frac{9}{10}$ unit.

a. Given that the line segment shown is 1 unit long, use the grid to lightly shade a rectangle that is $\frac{7}{10}$ units by $\frac{9}{10}$ units.

![Diagram of a rectangle shaded with unit squares]

b. Show the $\frac{7}{10}$ unit width and $\frac{9}{10}$ unit length on your rectangle, by stretching/shrinking the purple brackets above.

c. How many $\frac{1}{10}$-unit-by-$\frac{1}{10}$-unit squares are in the $\frac{9}{10}$-unit-by-$\frac{7}{10}$-unit rectangle?

[Type your answer here.]

d. Apply the length times width formula to find the area of the shaded rectangle in part (a) and verify that the formula gives you the correct area for your rectangle. Attend carefully to units of area.

[Type your answer here.]

e. Briefly explain how your answer in part c (about counting) is related to the answer in part d (about area).

[Type your answer here.]
E  In-Class Assessment Example

1. Which of the following describe or are the same volume?
   i. 3 cubic centimeters
   ii. 3 cm × 3 cm × 3 cm
   iii. A 3-cm-by-3-cm-by-3-cm cube
   A. I and II
   B. II and III
   C. I and III
   D. All I, II, and III have the same volume
   E. Each has a different volume from the other

2. One of the difficulties with understanding whether to measure a length, an area, or a volume is that an object, such as a spherical balloon, has parts of different dimensions. (Fill in the blanks with either 0, 1, 2, 3, 4, or infinite)

   The length string of the balloon is a/an _________________ dimensional quantity.

   The total surface area of the balloon is a/an _________________ dimensional quantity.

   The space occupied by the air in the balloon is a/an _________________ dimensional quantity.

3. “Quantities can be measured directly or indirectly. Measuring devices such as scales, calipers, and speedometers allow us to measure quantities indirectly.” What does it mean to measure a quantity directly? (i.e., what is the simplest and most direct way to measure a quantity?)

4. “A construction site requires 60 cubic meters of concrete.” Illustrate with the aid of a diagram what 60 cubic meters means.
Selected Items from the Final Exam

1. A length measures the distance from one point to another point; an angle measures the amount of rotation from ______________.
   - A. one arc to another arc
   - B. one ray to another ray
   - C. one point to another point
   - D. one plane to another plane
   - E. one region to another region

2. Degrees are units of measurement for ________________.
   - A. rays
   - B. circles
   - C. volume
   - D. distances
   - E. temperature

3. Is it possible have an angle that is less than 1 degree?
   - A. Yes
   - B. No

4. Which expression is equal to the area of the parallelogram?
   - A. \( bh - xh \)
   - B. \( bh + xh \)
   - C. \( bh + \frac{1}{2}xh \)
   - D. \( \frac{1}{2}bh + xh \)
   - E. \( h(x + b) - \frac{1}{2}xh - \frac{1}{2}xh \)

5. Which triangle has the greatest area?
   - A. Triangle \( P \)
   - B. Triangle \( Q \)
   - C. Triangle \( R \)
   - D. All three triangles have the same area

6. The side-lengths of the triangle \( ABC \) are 4cm, 5cm, and 3 cm.
   In order to find the length \( AD \), we need to ____________________________.
   - A. find the area of the triangle \( ABC \)
B. find the perimeter of the triangle ABC  
C. find the length DC using the Pythagorean theorem  
D. find the length DC by subtracting the length BD from 5cm  
E. none of the above because it is not possible to find the height AD  

F.

7. (4p) The base of the triangle EFG is EG.  
i. Draw a line segment to represent the height of the triangle.  
ii. Using a ruler, find an estimate for the area (in cm²) of the triangle EFG.

8. (4p) Given that the indicated lines in the figure are parallel, determine angle \( x \) without actually measuring it. List the properties used in your solution. (Hint: draw another parallel line).

9. (4p) Without using a ruler, find the area of the parallelogram.

10. (3p) Use the Moving Principle to find the volume of the figure on the right.
Curriculum Vita

Ashley Wilson was born in El Paso, Texas. The youngest child of Micah and Kimberly Manns, she graduated from Eastwood High School, El Paso, Texas, in the spring of 2010 and entered The University of Texas at El Paso in the fall. While pursuing a bachelor’s degree in mathematics with a minor in secondary education, she was a part of the prestigious Math and Science Teacher’s (MaST) Academy where she was given additional preparation for teaching at the secondary level beyond her classes. She also worked as a peer leader as an undergraduate in the Mathematical Sciences department for an online Calculus course. She graduated with her bachelor’s degree in the spring of 2014 and decided to pursue a master’s degree straight through instead of first getting a job and teaching because she had decided that she wanted to teach at the community college level rather than the high school level. Since beginning her master’s program in the fall of 2014 she has worked for the Mathematical Sciences department as a teaching assistant, mainly working with the courses for pre-service elementary and middle school teachers.

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