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Summing it up: Comparing and contrasting constructivist-based teaching practices

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Summing It Up: Comparing and Contrasting Constructivist-Based Teaching Practices

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Abstract

The purpose of this paper is to compare and contrast various aspects of focused teaching practices supported by constructivist learning theories in a mathematics classroom. This paper will analyze the advantages and disadvantages of three focused teaching practices and connect the results back to current literature in mathematics education. The three focused teaching practices observed were 1) involving students in classroom discussion (Discussion-Based Classroom), 2) implementing a flipped model of instruction (Flipped Classroom), and 3) incorporating problems related to real-world contexts (Real-World Applications Classroom). Each focused teaching practice corresponded to one secondary or post-secondary classroom that was observed over the course of two months. Similarities observed between all three classrooms were students working collaboratively in small groups, teachers asking guided questions, and students working on application activities. None of the classrooms supported constructivist-based teaching practices at all times, but rather, incorporated a blended approach of the traditional-based style of teaching with the constructivist-based style of teaching. This allowed the teachers to provide material to students in ways that worked best for the students understanding of each topic.

Purpose and Objectives

Background and Justification

Education is constantly being reformed. The student-centered classroom, where students gain independence and are responsible for their own learning with the instructor as a guide, is becoming more widespread in the classrooms today. Students work both together and independently to build their own knowledge instead of being told information; this is the basis of constructivism. Constructivism is a theory of learning where learners create their own knowledge and understanding based on interactions with their environment and others around them (Faulkenberry & Faulkenberry, 2006). Constructivism differs from the traditional approach to teaching. The traditional approach to teaching involves the teacher lecturing at the front of the room, telling the students algorithms or formulas, and leading them through guided practice (Faulkenberry & Faulkenberry, 2006). However, many reformers assert that this approach of telling students information, reviewing previous material, seatwork, and homework assignments makes it hard for students to recognize and use the mathematics they are learning in their everyday lives (Draper, 2002; Perkins, 1999). Research also supports the reformers' assertions (Ross & Willson, 2012). In contrast, constructivist-based classrooms involve hands-on activities and students working cooperatively in small groups, which support student interaction within a learning community (Faulkenberry & Faulkenberry, 2006). When students learn through the context of their life experiences, discover concepts on their own, make connections, and ask questions, their learning and understanding is enhanced (Gaser, 2011).

Even though the constructivist-based classroom is becoming more common now, the historical roots go back a lot further. Some of the founding fathers of constructivist-based

learning and teaching practices were John Dewey, Jerome Bruner, Lev Vygotsky, and Jean Piaget (Jones, Jones, & Vermette, 2010). Dewey believed quality education comes from experiences that are both active and reflective, achieved through having students construct their own meaning by manipulating ideas, recording observations, and drawing conclusions. Bruner thought effective instruction should be engaging to students while they are building on prior knowledge. Vygotsky strongly supported social interaction to clarify and change students' conceptual understanding. Piaget's theories, most commonly intertwined with constructivism, said that continuous interactions with existing schemas or ideas would lead to new learning. (A schema is an organization of a topic and its relationship among other similar ideas.) This is similar to a spiral method of teaching and learning where ideas learned previously are taught again by adding more detail and complexity each time. All of these theories are incorporated into the constructivist-based classroom to promote student learning (Jones, Jones, & Vermette, 2010).

There are many different elements to constructivist-based classrooms. Some of the key elements are relating, experiencing, applying, cooperating, and transferring (Crawford & Witte, 1999). These aspects correlate to real life contexts, learning through discovery and exploration, applying the information learned, allowing communication among students to promote cooperation, and using previously learned material to make connections to the new material. Rather than use constructivism as a single philosophy, it could be beneficial to view it as a toolbox (Perkins, 1999). All of the ideas and aspects of a constructivist-based classroom can be thought of as the tools to be used whenever appropriate because of the differences in students and classes. Instead of trying to fit all aspects of a constructivist-based classroom into each lesson, decide which tools would work best for each class and topic, keeping in mind the needs of the students. This strategy will keep the lessons and planning exciting and different. It will

also allow for differentiation among different classes and for different students. Because students are different, it is important to engage students in all three roles of a constructivist-based learner: the active learner, the social learner, and the creative learner (Perkins, 1999). An as active learner, students discuss, debate, investigate, and question during class to come to an understanding. The social learner is one who engages in dialogue with others through collaboration in groups. Being a creative learner requires that students create or recreate knowledge by rediscovering theories, proofs, and perspectives. Providing students with chances to be all three of these learners will help them to arrive at meaningful knowledge.

Many teachers are beginning to change their teaching methods as they come to realize the benefits of a constructivist-based classroom. One teacher, after teaching the same class for multiple years, decided to research student-centered classrooms (Inch, 2002). He noticed that he already used some of the main concepts but wanted to incorporate more. From his experiences, he found some classes are easier to incorporate a student-centered classroom in than others. For example, his Coding and Signal Processing class was easier than his Calculus class.

Mathematics does not come easy to all students, so mathematics teachers need to do everything possible to try and make mathematics interesting and engaging for their students. Teachers want their students to learn, to enjoy learning, and to relate what they are learning to their lives. However, many mathematics classes are not structured in such a way to allow this to happen. Historical roots dating back to Piaget support constructivism as a powerful avenue for student learning, but many teachers still do not use the constructivist-based tools. It could be hard to change one's style of teaching without knowing how well the changes will benefit students. That is why it is important to analyze the advantages and disadvantages of different

focused teaching practices before using them in practice. Having data to support certain teaching practices will lead to more changes in teaching and learning.

Observed Aspects

Our job as teachers is to prepare students for the "real world", fostering a desire to learn, and to ask why. Students are competing with international students for jobs and need skills to be able to do so. A study conducted of U.S. teachers' beliefs on effective mathematics teaching showed many of them relate to a constructivist-based approach of teaching (Cai & Wang, 2007). However, there are still many classrooms that do not support this style of learning. Contrastingly, in many international countries, learning seems to be more meaningful with less content delivered more effectively (Gaser, 2011). U.S students are not prepared to compete with these students for jobs. Skills we need to assist our students with are: problem-based instruction, student-led solutions, taking risks, having fun, and collaboration time (Gaser, 2011). All of these skills would be strengthened in a student-centered classroom. In life, students will need to work through a variety of problems and will not have a teacher to provide them with the solution. Discussing solutions with other students can help to gain independence. Therefore, teaching should be centered around the student by having students asking questions, developing their reasoning skills, making inferences, and coming to a conclusion in order to prepare them for their futures. Discussion in the classroom is a major aspect of students becoming less dependent on the teacher and more so on themselves and other classmates. This is why I chose to observe a discussion-based classroom.

There are some teachers trying the flipped classroom (Moore, Gillett, & Steele, 2014). The flipped classroom uses technology by allowing the teacher to record his or her lecture and

the material the students need to learn. Even though the flipped classroom still uses lecture and is not entirely a constructivist-based classroom, it allows for more student discussion and hands-on activities during class, which are principles of constructivist-based teaching (Crawford & Witte, 1999). The students are able to watch the videos at home before class the next day. In class, the students are able to focus on group discussions and engagement to reinforce the student's learning. During their study on the flipped classroom, Moore, Gillett, and Steele found the homework completion rose thirteen percent because students did not consider the videos they needed to watch at home as homework (2014). This helped with having more student participation during class discussion since the students already had an idea of the material they would be learning about. It also provided the students with opportunities to ask questions. When students are engaged and interested in what they are learning, they will actually want to learn (Gaser, 2011). Never having seen a flipped classroom before it seemed like the perfect class to observe and learn more about; this is why I chose it as one of the three focused teaching practices to observe.

Constructivist-based classrooms involve teaching within context in order to engage students (Gaser, 2011). However, in most mathematics classes, students are used to solving problems that have no context or meaning to them. Having students solve problems related to their lives and future could help them realize the importance to the information they are learning. In addition, allowing the students to discover the algorithms on their own may help to eliminate the memorizing and forgetting aspect of math. The essential and core beliefs of constructivism are: mathematics knowledge is actively constructed through reflective abstraction, cognition is evolutionary, and it is a beneficial style of pedagogy that puts the students at the center of the learning process (Faulkenberry & Faulkenberry, 2006); teaching within context and allowing

students to discover mathematical knowledge on their own achieves this goal. Therefore, incorporating a student-centered classroom as much as possible will promote student learning. It is possible to adopt a blended approach between the traditional and constructivist theories of learning as long as the core beliefs from above are integrated (Faulkenberry & Faulkenberry, 2006). A classroom where the students are working on problems related to their lives was something I wanted to observe which is why I also chose a classroom that incorporates real-world applications.

Problem Statement

The purpose of this project is to analyze focused teaching practices based on the constructivist theory of learning. Although mathematics teachers are beginning to incorporate teaching practices that support a constructivist-based classroom, it remains to be seen what the advantages and disadvantages of these practices are. For this project, I answered the following research question:

- What are the advantages and disadvantages of the following three focused teaching practices that each support the constructivist theory of learning:
    - Involving students in classroom discussion
    - Implementing a flipped classroom
    - Incorporating problems related to real-world contexts

Summary

Education is constantly changing; there are changes in the content students are required to know and there are changes in how to teach effectively. Recent reforms adapted by teachers involve constructivist-based teaching practices as a way to help students learn. Mathematics is

best learned when students can apply it to themselves, discuss the steps and methods they are taking, and learn through hands-on activities (Crawford & Witte, 1999). Constructivist-based classrooms incorporate all three of these aspects. As a soon-to-be teacher, it is important I master the student-centered pedagogy and am able to educate others. Because constructivist-based teaching practices are so varied and because teachers cannot use all of them everyday, I focused my study on analyzing three key focused teaching practices that can incorporate a constructivist-based approach and determined the advantages and disadvantages to each of them. I did not know how well each of the three constructivist-based teaching practices would work in the mathematics classroom. I wanted to see each one implemented to decide how well they worked based on the students' understanding of the topics learned through observations, students' participation during class, and teachers' perceptions and opinions. Recording the outcomes in the classrooms helped me to see when and how these three focused teaching practices worked.

Methods

Data Collection

To collect data, I visited and observed three specific mathematics classrooms. These mathematics classrooms were chosen based on the teachers; each teacher incorporated one of the three focused teaching practices I chose to study. One of the classrooms that I studied was a calculus course at James Madison University (JMU) taught by a professor who taught using the flipped classroom technique. Another classroom that I studied was a high school classroom in Augusta County; the teacher in this classroom regularly used real-world applications to teach math. The final classroom I studied was at another local high school with a teacher who encouraged class discussion among his students to assist them with learning and understanding. I visited each classroom three times to collect my data.

During my visits I took notes about what I saw, paying attention to how the teacher interacted with the students and how the students responded. I watched the class dynamic and took note of various things I found interesting. I then reflected on the teaching practices observed across the three classrooms. I mainly focused on how the teacher incorporated the flipped classroom, real-world applications, or discussion depending on the classroom I was in. I took note of whether or not the teacher was using a student-centered approach or a teacher-centered approach. A list of my specific observations can be found in Appendix A.

In addition to classroom visits, I also collected data by interviewing the three teachers regarding their teaching ideas and practices after the three observations. I found out when and why they began to use the focused teaching practice (flipped classroom, real-world applications,

or discussion). I also asked the teacher what types of outcomes they noticed as a result of the changes. The complete list of interview questions can be found in Appendix B.

Data Analysis

After I collected data by visiting and observing the three classrooms, I started to analyze the data. I took into consideration what the instructors had said during the interviews and reviewed my notes from the observations. I analyzed the data by looking for patterns and themes related to constructivist theories of teaching and learning among all three classrooms. For example, I took note of the number of questions asked by students compared to the number of questions asked by the teacher to decide if the classroom was more student-centered or teacher-centered. I also took note of whether information was provided for the students or if they completed an activity to discover information themselves. I also looked for similarities between the mathematics classrooms I observed and the examples of constructivist-based classrooms that can be found in the literature (Cai & Wang, 2007; Moore, Gillett, & Steele, 2014; Perkins, 1999). Just because the teacher used one of the focused teaching practices does not necessarily mean that the classroom is a constructivist-based classroom. Therefore, I tried to determine whether the three teachers had more of a student-centered classroom or if they used more teacher-centered practices. I did this through my observations of the classrooms and the teacher interviews.

As part of my analysis, I considered what the advantages and disadvantages were of each focused teaching practice. Some advantages and disadvantages I considered were student interest, student understanding, and student engagement. I thought about whether the students seemed interested in the topic they were learning and if it seemed like they understood the

material. In a teacher-centered classroom, students are not always engaged in the learning process, so I looked to see if the students were engaged the entire time and if so, what were they doing to stay engaged.

Timeline

Below is a timeline outlining the process I used to complete my Senior Honors Project.

Date	Activity
Summer 2014	• Contacted the three teachers I would be observing • Developed the interview questions
September – October 2014	• Conducted classroom observations • Conducted teacher interviews
November – December 2014	• Analyzed data
January – February 2015	• Wrote rough draft of thesis
March 2015	• Received feedback from readers • Made revisions and finalized draft • Created poster for JMU Honors Symposium
April 2015	• Submitted final draft to JMU Honors Program • Presented poster at JMU Honors Symposium

Results

The results presented in this section were formed from data collected during observations of three different mathematics classrooms three times each, for a total of nine observations. The three different classrooms each corresponded to a particular constructivist–based instructional strategy, which was often emphasized or employed in that classroom. The three teaching practices observed were discussion in the classroom, real-world applications, and implementing a flipped classroom. I had specific questions for each class that I wanted to collect information on based on the teaching practice being analyzed (see Appendix A). Some aspects were advantageous to the students' understanding of mathematical content and other aspects were not.

Discussion-Based Classroom

The class I observed that emphasized classroom discussion was Mr. Newton's pre-calculus class at Harrisonburg High School. The students in this class were receiving duel-enrollment credit for both high school and college. The observations in this classroom took place on September 2nd, September 16th, and September 30th of 2014. There were many similarities between the three observations as well as some aspects of the classroom I was not expecting. In addition, many of the characteristics of the class could be connected back to support the literature.

Because the teaching practice being observed was discussion in the mathematics classroom, which is heavily focused on questioning techniques, I was interested to find out the wait-time provided for students after questions were asked. Wait time is the amount of time a teacher waits for a student to respond before prompting them or letting someone else respond. Wait time is an aspect of questioning techniques since one is providing the person with adequate

time to think about a valid response before blurting out an answer (Cai & Wang, 2007). Throughout the three observations I found consistent results. When Mr. Newton asked the class as a whole a question, he provided them with about 10 seconds of wait-time for the students to think and respond. However, when students were working in groups, which they often were, Mr. Newton had the students discuss their mathematical ideas in their groups for anywhere between two to five minutes before asking each group for their answers. For example, Mr. Newton gave the class five to ten seconds to answer, "What does the shape of the graph $y = x^3$ look like". Then, later he asked the students to work in groups to find an answer to the following question: "What is the 'rule' for graphing absolute value functions?" which he gave them five minutes to discuss and decide on an answer. He allowed the students enough time to discuss with each other and to make sure everybody in the group agreed on the same answer before calling on any group. One group he called on had a few answers based on what the function was. They said if there is a plus or minus inside the absolute value sign, such as $|x + 5|$, then the graph goes that many units in the opposite direction. However, if there is a plus or minus outside the absolute value sign, such as $|x| - 5$, then the graph moves up or down that many units in that direction.. Allowing students to think through problems and discover possible solutions requires a lot more patience than most mathematics teachers have (Gasser, 2011). Mr. Newton was able to tell when his students needed more time to think about an answer and when he needed to provide them with a hint to lead them to the answer.

Another similarity between the three observations was having the students complete interactive, kinesthetic activities. During the first observation, students went outside and played Simon Says. The students needed to graph various functions using their bodies and the space around them. For example, Mr. Newton would say, "Mr. N. says, graph $y = x + 2$". The

students would need to make their arms in the shape of the graph $y = x$ and then move forward (the direction representing "up" on the y-axis) two steps. This activity went on for about half an hour with students graphing different functions and discussing in groups the "rule" for each function. Symbolic and physical representations can help students think about mathematics in new ways (Ross & Willson, 2012). Rather than having students graph multiple functions on paper, they were moving around and having fun with it. The students were "learning by doing through exploration, discovery, and invention" (Crawford & Witte, 1999). The students were very excited to go outside for class and seemed to enjoy playing a "game" to learn.

Not only were there a lot of interactive activities but the students also worked in small groups for some part of all three observations. The groups were typically three to five students, sometimes chosen by the students and other times by Mr. Newton. In the second observation, students completed an activity with water balloons to assist them in learning about quadratics. They worked in groups of three with each student doing each one of the three "jobs". One student had the job of throwing the balloon, another student had the job of timing how long the balloon was in the air, and the third student had the job of measuring how high off the ground the balloon was when leaving the throwers hand. Then, they switched "jobs" and repeated the task. The students were talking during the task to give the information they collected. This is important because, communicating with peers and working cooperatively allowed students to work on mathematical applications in groups and make sense of the material (Ross & Willson, 2012). The students completed the activity in groups outside, then went inside to complete questions. Each student needed to answer the questions related to his/her data but they were allowed to work on the non-computational questions together and assist each other. This allows the students to feel less embarrassed about asking questions because they are in a smaller group.

Also, “by listening to others, students re-evaluate and reformulate their own sense of understanding” (Crawford & Witte, 1999). Working in groups provides students with the opportunity to learn from each other. Students become less dependent on the teacher and instead seek answers from peers. This allows students to clarify and construct knowledge. Students learn best when their interactions are with both peers and adults (Jones & Jones & Vermette, 2010).

In Mr. Newton’s classroom, students could not “get away” with simply asking questions and immediately receiving the answers. In a constructivist-based classroom, the instructor is “often asking questions to guide thinking, but not giving solutions” (Faulkenberry & Faulkenberry, 2006). Throughout all three observations, I rarely heard Mr. Newton give a student an answer without first trying to guide their thinking. I do not believe that a mathematics teacher is supposed to provide an easy way out, a way to get the answer without actually thinking about the topic or understanding why it makes sense. Instead, I think a mathematics teacher is supposed to act as support for the students, leading students to the answer while still allowing them to discover it on their own. Mr. Newton did this constantly by asking the students questions when they were confused to help them figure out the answer on their own. Guiding students can be done by presenting material to students and resolving any discrepancies that may arise in meaningful ways (Inch, 2002). When the students were confused on a topic, Mr. Newton would have them go back to previous example or class notes to help resolve the confusion. In addition, answering students’ questions with more questions gives them the opportunity to understand the problem in a different way. Students become more independent and begin to answer their own questions without the teacher’s assistance. When students are out in the “real world” they will not have a teacher to rely on. Fostering student led solutions will be beneficial to the students when applying to colleges and starting their careers (Gasser, 2011). The earlier teachers start to

foster student-led solutions, the more confident students will be when they need to use it. The students in Mr. Newton's class were used to this style of teaching and did not expect for Mr. Newton to provide them with answers when they were having trouble.

There were also some common characteristics among all three observations that I was not expecting to see. One such aspect was the students rarely got off topic or talked when they should not have been talking. The students remained focused and typically kept to themselves and their work. When they were talking to others it was mostly about mathematical related topics and was usually one student asking another for assistance. Also, while the students were encouraged to work together, many of the students chose to work alone. They would ask their peers for help with one or two questions, but mainly worked individually. While this was surprising, students do not always need to be working in cooperative groups to learn effectively. It is important to allow "students to work in whole groups, small groups, and *individually* [to] make the learning valuable and worthwhile" (Jones & Jones, 2010, emphasis added). It was surprising to see because based on my personal experiences, when given the chance, many high school students gladly work in groups so they can socialize.

Another surprising aspect of the three observations was that Mr. Newton typically was the one who led the discussion, instead of having the students lead the discussion.. This was surprising because I expected the students to be the ones leading the class discussion and asking all of the questions in a Socratic manner. (The Socratic method of teaching usually involves asking a series of questions to increase critical thinking instead of providing answers. It involves a great amount of discussion between students with the teacher as a guide.) However, relating this back to the literature, "effective lessons should have productive peer interaction *and* teacher-guided discussion" (Cai & Wang, 2007, emphasis added). This makes more sense since it was a

high school classroom. The students still need to be guided by the teacher and at least start the year off with the teacher leading the discussion. This could have been a different case had I observed at the end of the year after students had the chance to learn effective and powerful ways to lead the discussion.

Overall, incorporating discussion into the classroom has many benefits for the students. Allowing students adequate wait time to respond to questions provides them with an opportunity to think before just blurting out an answer. Also, teaching in a Socratic manner and providing guiding questions gives the students a chance to think critically. Mr. Newton did both of these things, which seemed to increase student understanding based on my observations. The class was able to do activities to learn which made it fun and interesting. This also gave the students a chance to use some of their energy. Then afterwards, they were able to focus on sitting down and completing questions. Asking students a lot of questions allows the teacher to make sure the students fully understand the topic and to assist them by asking more questions if they do not.

Flipped Classroom

Just as with the discussion based observations, there were similarities among all three of the flipped classroom observations. Dr. Watson's Calculus I class had around 30 students, consisting mostly of freshmen with a few sophomores and juniors. The observations took place on September 9th, September 24th, and October 7th. When first hearing about flipped classrooms, I was under the assumption that the videos the students were expected to watch the night before would be the same length as a class. However, all of the videos that Dr. Watson shared with her class were relatively short. For example, for the first observations the students learned about the extreme value theorem and intermediate value theorem. The students were assigned to watch two

videos before class and both of the videos were under five minutes. Upon further reflection, this does make sense because most lectures are rarely over 15 minutes (Faulkenberry &Faulkenberry, 2006). Most of class time is spent with students doing examples, taking time to write down the information, and asking questions. The short length of the videos allows students plenty of time and freedom to rewind and to go at their own pace while taking notes. Another benefit of the short length of the videos is that the students can re-watch the videos if they are confused without the teacher having to explain the same thing multiple times. Yet another reason for the shorter videos is that Dr. Watson has found that students are more willing to watch a shorter video rather than a longer one.. "Less content, delivered more effectively has proven to be more meaningful" (Gasser, 2011). Rather than provide students with a lot of unnecessary material, a teacher should provide his or her students with the most important material and key examples. Dr. Watson did that in all of her videos.

Another similarity is Dr. Watson made her videos easy to understand. Even though she was not visible in any of the videos, she was speaking, underlining, and circling content on the screen throughout. It is important during the videos the teacher be present either visibly or through voiceover. This helps make the videos a success (Gillett & Moore & Steele, 2014). Dr. Watson did this by providing definitions, theorems, examples, and graphs and explained each one slowly with easy to understand vocabulary. Mathematics is its own language; it is very hard for some students to understand the different meanings of words in a mathematical context. Mathematics teachers need to assist their students in leaning how to read, write, and understand difficult mathematical topics. Dr. Watson made sure that her videos had vocabulary that the students could understand or would define terms that might be new to students. Students need to be able to replicate what they are learning but cannot do that without the appropriate content

knowledge and making sense out of the symbols in texts (Draper, 2002). Dr. Watson circled and underlined various symbols and words during her videos to help her students understand. For example, the video for observation three, which focused on implicit differentiation, Dr. Watson had a slide with a question about tangent lines. To assist her students, Dr. Watson drew a tangent line at a point and then explained to find the equation of that line one would need to take the derivative. Rather than simply saying all of this, she draws it out and goes through examples.

Since the students were expected to watch the "lecture videos" the previous night, Dr. Watson assumed they already had a basic idea of the class material coming into class the next day. This meant that the class could jump right into using the information rather taking time to learn it. The class always started off with a five-minute quiz with a problem or two using what they had watched in the videos. The students are allowed to use any notes they took while completing the quizzes. In my observations, I noticed there were typically a quarter of the students who did not take notes out for the quiz. This could be because the student did not take notes/watch the video or because they understood the questions and did not need their notes. The quizzes were a way for Dr. Watson to check and see who watched the videos and for the students to see how well they understood the material. For example, for the third observation, the quiz consisted of two questions. One was a true or false questions: "The point $(1, 3)$ is on the graph $x^2 + y^2 = 4$." The second question was directly related to the video: "What derivative rule was used to get $\frac{d}{dx} y^2 = 2y \frac{dy}{dx}$." It has been shown that in flipped classrooms "…quizzes are important to help students focus on key ideas and assess what students learned from the homework videos" (Gillett & Moore & Steele, 2014). After the quiz, Dr. Watson would go over the answers and ask the students if they needed to do any more examples as a whole class or if the students had any questions. This provided the students the chance to go over any information

they were confused about from the videos. For the second observation, the students were still a little confused so Dr. Watson did an example from the textbook on the board and invited the students to ask questions and to tell her what to do as she guided and explained.

During all three observations, students worked in groups of two to four during class and worked on application problems/activities that Dr. Watson assigned. The students sometimes chose their groups and other times Dr. Watson assigned them. This allowed Dr. Watson the chance to walk around and help each group and each student individually. Dr. Watson was then able to have a better idea of each students understanding and ask them guiding questions when they needed help. It is crucial as mathematics teachers to "…provide ample collaboration time for both our students and ourselves" (Gasser, 2011). Students need to learn to work together and not rely on the teacher all the time. Dr. Watson had her students working in groups on the application problems/activities every class. The students were helping each other and explaining how and why to solve certain problems. When none of the students in the group could figure out a problem, they would ask Dr. Watson who would then asking them guiding questions to lead them to the answer. The students asked each other for help before asking Dr. Watson. Leading the students to become less dependent on the instructor is a huge accomplishment of a teacher. I saw the students asking each other questions and others providing answers. Not only did the students provide how to solve a certain problem but they also were usually able to explain why.

There were some aspects of Dr. Watson's class that I was not expecting as well. One aspect is that students rarely got off topic, which seems to be an advantage to this focused teaching practice. While I was walking around the classroom I listened in on the students' conversations. I was able to tell whether they were discussing topics related to mathematics or if they were talking about their weekend plans. For example, in the second observation, the

students completed eight problems that each had multiple parts. There were ten groups of students with three students per group. Only two groups of students got off topic, each for about 8 minutes total of the forty minutes spent on the assignment. The rest of the groups only discussed the mathematics problems or only got off topic for 1-2 minutes. Based on my personal experiences, in most college classes students tend to talk about non-subject related topics while in class. This is especially the case when there are freshmen in the class, as there were in Dr. Watson's class. Surprisingly, the students stayed on topic so they could finish the assignment even though it was not collected at the end of class. Dr. Watson also would post the solutions later on in the week for each assignment so the students would have the correct answers to study from. However, the students knew they would learn best if they completed as much of the activity in their groups during class.

Unlike many Calculus I classes, the students in Dr. Watson's class were encouraged to use technology. For example, while observing during the first observation, students completed an activity that involved a lot of graphing. Dr. Watson had told her students the day before to make sure they had their calculators for this class knowing there would be a lot of graphing. She also told them to use their phones or tablets with graphing websites if they did not have a calculator. Walking around, I expected to see students using their phones or tablets to text or to check Facebook or some other social media. However, I observed students were only using the graphing websites. I was surprised to see this even though the literature does say, "…teachers have increasingly turned to technology to support student learning" (Gillett & Moore & Steele, 2014). Students should not use technology as a crutch but rather as a way to help them see the "why" of solving problems more clearly. Technology helps to see information in pictures and graphically and starting off by viewing those pictures/graphs using technology can help the

students to later create those representations on their own. Technological tools help to provide a means to visualize and explore (Ross & Willson, 2012). Many high school teachers are beginning to use technology to make learning more interesting for students and help them become engaged in the mathematical process. It was interesting to see college professors are also incorporating technology into their classrooms.

There are many advantages to flipping a mathematics classroom. Some advantages include videos students can re-watch if struggling, spending full class periods doing mathematics, and having a better idea what the students do and do not understand. Starting class with a quiz to check for understanding and then walking around during class to answer questions, asking guiding questions, and making sure students are doing problems correctly provides the teacher with a decent understanding of how his or her students are doing. It is important to make sure all students stay on task and are all helping each other. Observing all groups multiple times throughout class makes this task relatively simple. Also, it could be difficult to start flipping a classroom. It would take a teacher time to make all of the videos for each topic, especially if there are edits needed to be made. Before a teacher wants to implement this, it would be important to think about the time commitment.

Real-World Application Classroom

The third class I observed incorporated real-world examples and applications on a regular basis. I observed Mr. Sylvester's Algebra I class at Stuarts Draft High School; the students in this class were struggling with mathematics and needed a slower pace of instruction. The class had about 20 students in it ranging from sophomore to senior. During the three observations that took

place on September 17th, October 1st, and October 22nd, I observed some similarities in this class and some aspects of this class I was not expecting.

One of the aspects of this class I noticed throughout every class was that Mr. Sylvester would provide students with an example before having them work on problems alone. The literature supports this behavior in regards to individual practice starting only after students have a decent understanding of the concept (Cai & Wang, 2007). For example, during the first observation the students presented projects they had been working on related to conditional, converse, inverse, and contrapositive statements using advertisements. Before having the students start presenting, Mr. Sylvester did a shorter version of what their presentations would look like. He did this so the students would be prepared; students could see what he expected from them when it was their turn to present. He followed his practice presentation by giving examples of possible questions he might ask the students after their presentations. Mr. Sylvester was aware not all students enjoy presenting and he wanted to put them at ease by providing an example demonstration they could follow.

Another illustration comes from the second observation. Mr. Sylvester wanted the students to complete some problems on finding parallel and perpendicular slopes, which connected to a real-world application project of designing city streets. He wanted to first provide them with some examples that would guide them when they did individual practice, so he did a few problems with the whole class to start. This allowed Mr. Sylvester the chance to "model mathematics ideas and assist students in their mathematical reasoning" which is a key concept for teachers to do in order to deepen student understanding by helping them construct their mathematical knowledge. (Draper, 2002).

Mr. Sylvester regularly incorporated real-world applications and discovery activities whenever possible. Students learn best and are more interested when there is "active problem solving that makes connections to their world" (Perkins, 1999). Students do not always relate to the typical mathematics problem that only contains numbers and is without context. However, when a teacher is able to relate the mathematics they are studying in the classroom to the student's everyday lives, students are often able to commit the concepts to memory and enjoy the process of learning more. Mr. Sylvester made sure to relate to the students whenever he could by both joking around with them and assigning real-world application projects. Making mathematics questions relate to real-life situations, "…promotes the understanding and realization of applicability of such skills" (Ross & Willson, 2012). One instance that Mr. Sylvester used to incorporate real-world applications occurred during the second observation. The students had the last half of class to work on a group project he had assigned. The students needed to create a city using various types of lines and angles, which were their current course topics. For example, students needed to use a certain amount of parallel lines, perpendicular lines, alternate exterior angles, etc. This allowed students to be creative and have some fun while learning and showing Mr. Sylvester what they understand related to this topic. Research claims students will be active learners and have a higher interest in learning when teachers incorporate "problems that are more meaningful to students and relevant to their current and future lives" (Gasser, 2011).

Another example of a discovery activity that I observed was during the third observation. Students were learning about different triangle congruencies. Instead of simply telling the students Angle-Side-Angle was one of the congruencies, he led them to discover it on their own. He passed out protractors and rulers and told the students to make a line that was 7 cm long, the

left angle 60 degrees and the right angle 40 degrees. Then he told the students to connect the lines to make a triangle. He had the students hold their paper up to the light with another student's paper to see how the two triangles compared. The students were able to tell the triangles were the same and therefore congruent. It is important for students to be active learners and they become active when teachers provide hands on activities that help them discover new concepts rather than just being told through lecture (Crawford & Witte, 1999). Mr. Sylvester found ways to relate to the students and to spark their interest to learn mathematics.

Another advantage to Mr. Sylvester's classroom was his rapport with his students. Unlike some high school teachers who are very strict and serious with his or her students, Mr. Sylvester joked around with his students and did his best to relate to them. He did not want them to be intimidated by him or feel too nervous to speak up and ask questions. Instead, the classroom environment he provided was very safe and welcoming. Throughout every observation I heard laughter from both Mr. Sylvester and his students with dialogue both related to mathematics as well as other topics. At first I saw this as a distraction for the students. They would joke around with Mr. Sylvester and did not seem to do their work. However, I quickly realized this was not the case. If Mr. Sylvester noticed the students getting too far off track he would guide them back to the activity they were supposed to be working on. The literature supports the fact "a sense of humor is another important personal trait for inspiring students' learning mathematics" (Cai & Wang, 2007). If students cannot relate to their teacher or know nothing about him or her, then they will less likely to go to the teacher for help or to trust the teacher. The students had no problem asking Mr. Sylvester for help on problems. A great teacher knows how to interact with his or her students. Rather than just talking to and lecturing students it is important to actually relate and interact with them (Inch, 2002). Students will be more likely to learn and focus when

they have spurts of laughter. During every observation there was joking around and laughter. However, it did not take away from the students learning mathematics. A mathematics teacher does not always need to relate to his or her students in a mathematics context. The students have lives outside of school and so does the teacher. Sharing some appropriate aspects of your personal life as a teacher can help the students also relate to their teacher and vice versa. It is important to remember, "the brain is not good at learning when devoid of joy" (Gasser, 2011). Mr. Sylvester not only brought real life examples into the mathematical context, but also brought other real life aspects into class. He would tell students things he liked or did not like when it was an appropriate time. If a student said something not related to mathematics, instead of getting angry or forcing the students to only discuss mathematics, Mr. Sylvester would connect to the students by discussing that topic for a minute before bringing the class back to the matter at hand. This allowed the students a brief distraction that would help them be more willing to focus and pay attention to the mathematics topic.

There were a few things that I did not expect to see during Mr. Sylvester's class. One such aspect was the students did not always like the real-world projects. When talking to Mr. Sylvester after all three observations, he said the students did not do very well on the city project that was mentioned earlier. He had assigned the students a rubric so they would make sure to include all the parts he wanted. However, many students did not follow the rubric. Mr. Sylvester gave students the option to redo the project or to take a test with the same concepts to replace their project grade. Rather than lower his expectations he told the students he would not accept work that was not done properly. It is important to continue to have high expectations for all students both academically and behaviorally during class and Mr. Sylvester seemed to do so (Cai & Wang, 2007). Mr. Sylvester mentioned the students had had another project a few weeks prior

that I was not there to observe. The students conducted a classroom debate, using logical reasoning skills. He said the students enjoyed and did well on that project. While the students enjoyed this previous project, it was interesting to see that students do not always enjoy doing real-world application projects. I was under the assumption if the options were take a test or complete a project for a test grade, most students would be very happy to complete a project. However, for the city project it seemed like the students did not take it seriously. When I observed the students working on it, many were talking and fooling around when the majority of their project had yet to be finished. Mr. Sylvester would walk around and try to direct them back to work but when he would go to another group the previous group would typically start talking again.

I was also surprised by the lack of group work completed during my three observations. Considering the other two classes I observed had a lot of group work I was not expecting this class to have as much individual work as it did, since much of the literature related to constructivist-based teaching practices promote collaborative learning (Gaser, 2011). However, thinking back to when I was in high school there was a lot of individual work when it came to practice problems and I was able to construct knowledge on my own. The city project was completed in groups, but most of the other activities done in the class were individual. Although much of the literature supports group collaboration in the classroom, not all classes work best with it. As a teacher it is important to notice when "a particular approach does not solve the problem, try another – more structured, less structured…" method (Perkins, 1999). Seeing how the class acted during the city projects when working in groups, Mr. Sylvester probably had the students work individually for a lot of class practice to diminish some of the talking that would have occurred otherwise. Class dynamics changes with each class depending on the students.

Deciding what is best for each class takes some time but adjusting the needs for all the different students is an extremely important trait in an effective teacher (Cai & Wang, 2007). Mr. Sylvester definitely has this trait.

Overall, this was an entertaining class to observe. It was advantageous that the dynamics of the class were enjoyable and the activities for the lesson made it interesting. It is so important to incorporate real-world examples into teaching so the students have something to relate to. Even though the students did not always enjoy or do well on the projects in this class, I think they would have done worse had the applications not been relevant to them as students. Having a teacher who can joke around with the students helps them trust you. However, it is important to also make sure the students know where to draw the line since class time needs to be for working. Having students develop algorithms and realize facts about mathematics on their own is a great way for the fact to stick with them.

Conclusions

The three classrooms each had different themes. While observing the discussion-based classroom, there were a lot of kinesthetic and group activities. Mr. Newton found interesting ways to engage his students with the material he was teaching. He incorporated group collaboration as well as providing individualized attention to all students. The flipped classroom also had a lot of group activities. Everyday the students were in pairs or groups working together. This classroom also had a daily quiz. This was a great way for the students to learn what Dr. Watson found important in each section and for Dr. Watson to check for understanding. Dr. Watson was also able to walk around the room constantly to help those who needed it as well as to have a better idea of what her students understood. The real world classroom always started with a warm up problem to have the students think about something they learned previously or something they would be learning about that day. Mr. Sylvester tried to incorporate as many real world applications as possible. Even when there was not a direct real world application, he would have the students discover a result on their own. This was a good way to make them active learners instead of just feeding them results. All three instructors asked guiding questions instead of providing students with answers. Observing the classrooms was a learning experience for me that was enjoyable.

After conducting the nine observations of the three different mathematics classes and after consulting the literature I read regarding constructivist-based classrooms in mathematics, there are some aspects of the focused teaching practices I would consider to be advantages while there are other aspects of the focused teaching practices I would consider to be disadvantages. Overall, the focused teaching practices have many effective aspects for students' understanding of mathematical concepts. One learns best by doing, and all three classrooms that were observed,

as well as the literature, support this (Perkins, 1999). The traditional style of teaching does not always engage students to the same extent the reform style of teaching does . When students figure out mathematical processes on their own and decide why they work, their mathematical knowledge will stick with them longer than if they are simply told what a formula is. With the constructivist-based theory students are in charge of their own learning. This is a great skill to have when going into the "real world". In my perspective, even though it is difficult to incorporate only constructivist-based practices every lesson, incorporating as many as possible will benefit the students. Any of the disadvantages seem outweighed by the advantages. In each of the three classrooms I found a few aspects that could be seen as a disadvantage but none that compared to the tremendous advantages observed.

Discussion-Based Classroom – Advantages and Disadvantages

One advantage of constructivist-based teaching that I observed particularly in the discussion-based classroom is how active, both physically and cognitively, students are. The first and second time I observed the discussion based classroom, the first half of the lessons were taught outside. The students were physically active throughout the outside portion of the lesson and completed activities that were fun and exciting ways to learn mathematics. For example, in the second observation, the students were tossing water balloons up in the air. The enthusiasm the students showed when Mr. Newton explained the class activity – after hearing they would be playing with water balloons – is not a typical response to learning mathematics. The students were engaged and all actively participating both in the outside activity and the write-up afterwards. It is important to note that the students were on a block schedule so they had the time to do this. The students were asked before going outside to read the directions carefully for the assignment and then went over it as a class to make sure everyone understood. Then, after the

activity, Mr. Newton would ask the students questions related to the height of their water balloons and what the different variables were when analyzing the path of the balloon as a quadratic equation. Rather than lecturing the students and presenting the mathematical information related to the activity, Mr. Newton would ask the students questions for them to think about and answer on their own. He did not want to simply provide them with answers but rather have the students try to figure it out with the help of guiding questions and the help of each other. If one student was not able to answer a question correctly, his or her peers would assist by answering and explaining their thinking.

One disadvantage I observed in the discussion-based class was not all students participated at the same level when split into groups. A few of the students would do all the work while the others would just listen and copy what the "leaders" were saying. In my opinion, group work is an excellent aspect to bring into the mathematics classroom. However, it is important to make sure all students are contributing to the mathematical discussion and knowledge creation. One way that Mr. Newton accounted for this was to have everybody turn in his or her own work. However, it is still difficult to tell if a student has copied from someone else. Also, even though encouraged to work together, a lot of the time the students would work individually and only ask a friend if they were struggling. The students in Mr. Newton's class were constantly reminded to work together and discuss the problems with their classmates if they needed help. It would have been nice to see the students engaged in more discussion between each other related to the mathematics.

Including discussion in any classroom is a great way to engage students. When working alone, students might not always do their work especially to the level of proficiency they should. However, working together and discussing problems allows for all students to help each other

and stay actively engaged. Having discussion also assists the teacher observe who is having more difficulty with a topic. If one student is not participating in discussion, then they might be struggling. One disadvantage to discussion in a classroom is when in groups, students may not all be participating the same amount. Some students may be copying off of others or not engaging at all. When including discussion in the classroom, it is a good idea to constantly walk around the room and listen to the students to make sure everyone contributes. Even though the students were not always leading the discussion, I found a lot of student-centered techniques used throughout this classroom. There was a lot of discussion and activities where the students were engaged and learning by doing. However, I think it had some traditional aspects like quizzes, tests, homework, and some lecture. This was a blended classroom with aspects of both a student-centered and teacher-centered classroom.

Flipped Classroom – Advantages and Disadvantages

Never having observed a flipped classroom before, I was amazed after observing three lessons. It is a new (to me) way of teaching that encompasses very short "lectures" on video to be watched before class, while class time is reserved for activities and problems. One of the major advantages for this teaching aspect is the whole class time is spent practicing the mathematics topic. It is a chance for the students to ask any questions they have about confusing topics and a way for the professor to see who is struggling. During my observations, I saw the students working in groups and assisting each other. When one person was confused another would "teach" that topic to him or her. Teaching and explaining a process to a friend is a great way to learn difficult mathematics. Rather than doing practice problems for homework where the teacher is not there to assist, all the practice problems are done in class with assistance from both peers and the professor rather than assigned for homework. Dr. Watson had the chance to listen

in on each group multiple times through out the lesson to make sure they fully understood the topic. Students mostly stayed on task and kept their talking related to mathematics except for a few minutes out of the whole period. I found it interesting the activities were never collected for a grade, but rather for student study and practice.

One of the disadvantages of flipping a classroom is making sure all students have access to technology to view the videos at home. Even though is not a problem for the college students it could be for middle- or high-school students. Parents of younger students do not always allow their kids to use the Internet and some families might not even own a computer. However, there are other ways to access the videos such as having students stay after school or come before school to watch them. Since the videos are short, it should not be a major problem having a few students watch the videos in school before or after school unless the whole class needs to. There could also be issues if students take the bus or have afterschool activities too. Depending on the grade level being taught and the location of the school, this most likely would not be a problem. However, it is something a teacher would need to consider.

The flipped classroom is still a relatively new from of teaching. Not many middle and high school teachers either know about it or implement it. However, there are some advantages to implementing this form of teaching. The students do the majority of "problems" and activities during class time. This means that if they are stuck on something they can receive help immediately without completing all the problems incorrectly or using their confusion as an excuse not to do their homework. The flipped classroom also provides the teacher with a better understanding of the student's proficiency on each topic he or she will have the whole class period to walk around and observe the students. The disadvantage to flipping a classroom is that not all students have access to the same technology. In lower income areas, this could create a

problem. There are other ways to have students watch the videos before class but requires extra time on the students' and teacher's part. Also, making the videos is very time consuming for the teacher. Having the students actively engaged during the whole class period doing problems and working together makes this a student-centered classroom. Even though there were quizzes at the start of each class and tests, it had a lot more constructivist-based teaching practices during the class than traditional methods. The students did have "lecture" videos to watch for homework but the class time was very student-centered.

Real-World Applications Classroom – Advantages and Disadvantages

Real world applications are important for students to have in a mathematics classroom so they can understand the fact mathematics is actually relevant to them. The first project I observed should have definitely helped students understand what conditional, converse, contrapositive, and inverse statements mean. Connecting the statements to an advertisement they enjoy and can relate to should help the students to remember what the various statements are. The students might not always appreciate real-world applications while completing assignments, however, I am sure they are more enjoyable then traditional style mathematics problems and exams. A huge advantage to real-world application problems is providing students with problems where mathematics could appear in their lives. It could be as simple as stopping at a four-way stop sign and recognizing that the streets are perpendicular. Either way, the students are thinking about mathematics outside of the classroom.

One of the disadvantages of incorporating a real-world application into a mathematics lesson is that it is hard to incorporate a real-world application into every lesson for every topic of every class. Different classes and topics are easier to find real-world application problems that

connect to those ideas. As a teacher, it could be draining to always be searching for a way to relate every topic to students. Not every topic needs to have an activity or project related to the students lives. Incorporating as many applications as you can is great as long as you are not driving yourself crazy. One solution could be to have students try to think of ways that the topics relate to real life scenarios. You should also realize that different groups of students will relate to different activities is different ways. Not every class will do well and enjoy every real-world assignment.. However, if they can relate to some of the mathematics topics, then that is a huge plus.

Students are always asking the question, "when will I use this?" Providing real-world application problems will help to answer these questions. Without making material relevant to the students, they will not be as engaged and willing to learn. Students like to know what they are learning is useful to them as individuals. With real-world application problems, they will realize where a certain topic could show up in their everyday lives. One disadvantage to providing many real-world application problems is students may come to depend on them. It is difficult to provide them for every lesson with every topic. Sometimes simply lecturing on information is needed. As long as the teacher tries to incorporate as many as possible and make it known to the students they will not always have the real-world application problems, then it could be very helpful for student understanding.

Constructivist-based teaching practices come in many forms. There are multiple aspects to the constructivist-based style of teaching just as there are multiple aspects to the traditional style of teaching. It is hard to always incorporate constructivist-based teaching practices for every topic in every class. However, including as many constructivist-based tools from the toolbox as much as possible, can provide great benefits to students. The advantages from the

discussion-based, flipped, and real-world classroom far outweigh the disadvantages. Observing all three classrooms gave me the perspective it does not always matter how many different aspects of constructivist-based teaching one incorporates, but rather how one incorporates them. The three classrooms I observed made mathematics interesting and engaging for the students. As long as the students are learning and understanding the material, then there is not much that should need to be changed or added. Whether having a blended approach and assessing with traditional assessments or assessing with real-world assessments, as long as the students are understanding, then the approach is working. As a teacher, you need to know your students and do what will work best for their learning. My opinion is there are different constructivist-based teaching practices that will help the students to understand, relate to, and enjoy mathematics. I found this classroom to be a blended approach with a mix of both student-centered and teacher-centered aspects. The students had many real-world application projects which helped to make the class student-centered. However, there was also lecture for some topics and "regular" mathematics problems. Throughout any given day, the classroom would have parts student-centered and parts teacher-centered.

Limitations

Writing this thesis was a three semester long process. However, the observations only took place in one semester. This meant that I was only able to observe each classroom three times. Although I was able to still collect adequate data, one limitation was that I was not able to observe over a longer period of time. If given the chance to conduct the data again I would try to observe more often. Also, I would have liked to have observed different classes with the same teacher to see how a different group of students responded to the method of teaching. Another

limitation could have been my observations took place within twenty miles of each other. Had I been able to observe a wider range of areas, the data could have been different.

Future Research

From here, there are a few more ideas I would like to research in depth. I really enjoyed the flipped classroom and would like to know more about implementing it as a beginning teacher. Even though it is still rare to find teachers who use this form of teaching, it is becoming more common. I am considering flipping my classroom when I am a teacher and would like to know more about what that entails. Observing a few more flipped classrooms at the middle and high school levels as well as researching more on the topic is the next step I could take. Another topic I would like to research more is the best way(s) to incorporate real-world applications. The students in Mr. Sylvester's class did not enjoy all the activities and projects he assigned. However, the students did enjoy the debate project. Researching various ways to incorporate real-world applications that have students active and moving around the room could be another future topic to research. Also, even though the discussion-based classroom did have the students involved in a lot of group discussion, I would be interested to see a mathematics classroom using the Socratic method in a different fashion. For example, having the desks in a circle with everyone thinking through a more difficult problem together rather than in small groups. There are plenty of other topics to research and plenty more research that could be done on this topic; one such idea would be to develop and implement a quantitative research study, measuring students' procedural and conceptual knowledge when engaged in these three focused teaching practices.

Constructivist-based teaching practices in the mathematics classroom is a broad topic. Constructivist-based classrooms could mean many different things. Even though there are many teachers who consider themselves to have a constructivist-based classroom, it is difficult to have a completely constructivist–based classroom. Mathematics is sometimes seen as a subject where the students are simply told the formulas and given many problems to work on. This was how I learned mathematics the majority of the time. However, this traditional style of lecturing for teaching is changing. The three constructivist-based teaching practices I observed were incorporating discussion, flipping your classroom, and incorporating real-world applications. The students in these classrooms were not simply told information or answers. The instructors asked guiding questions and had students apply the information to learn the processes. In turn, the students seemed to have a more active learning process and ways to relate to the material. Even though these are not the only aspects one could use in a constructivist-based classroom, they do have their advantages. From the literature review and from my observations, it seems as though adding constructivist-based teaching practices aspects to a classroom has many benefits to both the teacher and students.

Appendix A

Classroom Observations

Discussion-Based Classroom Observations

1. How many questions were asked?
2. What type of questions were asked?
3. What are the questions asked?
4. How much wait-time was given?
5. How in depth were the student responses?
6. How many students participated during the class discussion?
7. Did the students seem engaged? How long are they working on the activity for? How much time is spent off topic?
8. Did the students ask questions? What kinds?
9. Was there a lot of group discussion? Or more whole-class discussion?
10. Are students leading the discussion? Or is the teacher?
11. What did students talk about with each other?
12. How much time is spent talking/discussing?
13. Did the class conclude with students summarizing what they learned?

Flipped Classroom Observations

1. How long was the video the students watched the previous night for homework?
2. Style of teaching during the videos?
3. Was the video easy to understand/follow? What was the application?
4. Was there a class review or did they go right to problems/questions?
5. Did students come prepared with notes/questions about the material?

6. Did the students have a decent understanding of the topic from the videos?
7. Style of teaching during class?
8. What type of activities were done during class?
9. Did the students seem engaged? How long did the students work on the activity? How much time is spent off topic?
10. Was the class group, individual, or whole-class based?
11. How many students seemed to actively participate?
12. How many different activities were done?

Real-World Applications Classroom Observations

1. How were the applications introduced to the students? How was it set up?
2. What were the application questions about?
3. How many real world problems/contexts were used?
4. Did the students seem to make a connection to the material?
5. Did this lead to student understanding?
6. How many questions did the students ask for clarification?
7. Did the students work in groups? If so, how many?
8. Were the activities/projects related to real world applications also?
9. Did the students seem to enjoy the class? Were they interested?
10. What other types of problems/applications were used?
11. Did the students seem engaged? How long did they work on the activity for? How much time is spent off topic?
12. How many of the total questions/activities were related to real world applications?

Appendix B

Teacher Interview Questions

1. What is one of your goals for the upcoming school year?
2. What are three teaching practices that you try to incorporate each year?
3. What do you do when some of your students do not understand a certain topic?
4. I want to focus on one teaching practice, (name the practice). How would you say you use this teaching practice in your classroom? How long have you used this teaching practice in your classroom?
5. Have you seen results of any kind, based on that teaching practice? If so, what types of results have you seen?
6. Are some topics easier to incorporate (name the practice) than others? If so, how do you manage that?
7. Have you heard of constructivism in education? If so, how would you define/describe it?
8. Do you consider yourself a constructivist teacher? Why or why not?

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