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AUTHOR: Josephine Piranio

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Joni Kolman PROJECT COMMITTEE CHAIR	Joni Kolman SIGNATURE	12/5/17 DATE
Anne René Elsbree PROJECT COMMITTEE MEMBER	Anne René Elsbree SIGNATURE	12-6-17 DATE

ELEMENTARY MATHEMATICAL ARGUMENTS

Josephine Piranio

A Project Paper

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Abstract

Stakeholders identify higher-level cognition and communication as skills critical to the 21st century, STEM-capable workforce. These skills are reflected in the Common Core State Standards for Mathematics shift. Mathematical arguments have been shown to predict improved mathematical cognition and are a Standard for Mathematical Practice that teachers must develop in students. The Elementary Mathematical Arguments: A Guide to Using Metacognition and Screencast Technology to Support Students unit was created to address this challenge answering the question: What might a set of instructional strategies and tools look like to support second grade students' development of mathematical arguments, in a Southern California classroom? Literature reviewing metacognition, mathematical arguments, and screencast technologies, provided a foundation for the unit's curricular materials. The unit encompasses three distinct parts implemented over 12 lessons, including standards, learning objectives, assessments, and teacher instructional steps. The first part, screencasts, provides a means to capture student metacognition and mathematical arguments. Part 2, metacognition, directly teaches and provides tools to support metacognitive phases of problem solving. Mathematical arguments, part 3, provides language supports for justifying mathematical thinking using a model and explanation. Students participate in self-assessment and peer interaction throughout the unit to support cognitive and metacognitive understanding. This unit could be further developed to include all Standards for Mathematical Practice. It could also serve as a tool for further research on student generated screencasts. This project provides teachers with tools to develop students' mathematical arguments addressing some of the skills necessary to join today's workforce.

Keywords: unit, elementary, mathematical arguments, metacognition, screencast technology, Standards for Mathematical Practice

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CHAPTER 1

INTRODUCTION

Skills for the 21st century workforce and an increased demand in math and science jobs have created the need for teachers to develop curriculum to support higher level cognition and the ability to communicate in the areas of math and science. Through this project I illustrate how a teacher might support elementary students' ability to explain and defend their mathematical ideas. This chapter will provide a background of the problem, purpose of the project, and preview of the literature. A preview of methodology and the significance of project will be offered in addition to pertinent terminology.

Background

The current workforce, and that of the future, requires a skillset unlike those of generations past- one that requires higher cognitive abilities in core subjects. Critical thinking, communication, and the capacity to "innovate", alongside media and technology skills, are capacities that are required of the majority of individuals in today's workforce (Partnership for 21st Century Learning, n.d.). In fact, according to the US Commerce Department (2011) and National Science Foundation (NSF, 2015) jobs in science, technology, engineering, and math (STEM) are widely being discussed as the nation examines its global competitiveness. In fact, the demand for math and science related jobs will grow at a vastly larger rate than those of their non-math and science counterparts (US Commerce Department, 2011). The NSF (2015) report emphasizes "a strong, STEM-capable workforce" p. 12, and identifies access to high quality education as being crucial to building and sustaining this workforce. Educational institutions are being tasked with teaching these skills beginning in elementary school. This is being reflected in the new Common Core State Standards.

By June 2014, 43 states across the nation adopted the Common Core State Standards for math (CCSSM) in order to address the needs of the 21st century workforce. Specifically, the CCSSM was the impetus for three major shifts in how mathematics is taught (CCSSM, 2013). The first highlights “greater focus on fewer topics (Key Shifts in Mathematics, n.d.).” Going deeper into fewer conceptual topics rather than the mile wide, inch deep approach where many conceptual topics are addressed but merely at surface level. The next shift is “coherence among grade levels (Key Shifts in Mathematics, n.d.).” This states that mathematics are not isolated instances; rather, they are interconnected and the standards are meant to build upon each other year after year. Lastly, and perhaps most pertinent to the study discussed, the standards address “rigor (Key Shifts in Mathematics, n.d.)” detailing the emphasis on conceptual understanding while also discussing procedural fluency and the transfer of both for real world application.

The CCSSM is further broken down into content and process skills. It is the process skills, such as explaining and reasoning, that promote and develop the type of skills required of today’s workforce as they develop students’ abilities to understand content at a higher cognitive level and communicate their ideas about mathematics to others. These process skills are embedded in the Standards for Mathematical Practice (SMPs) based on both the National Council of Teaching Mathematics (NCTM) standards and the process standards and the mathematical proficiencies identified by the National Research Council’s Report “Adding It Up” (2001).

Purpose of Project

Given the new standards and goals, teachers require instructional strategies to support the development of higher-level cognition, innovation, and media and technology skills. Teachers were faced with the challenge of developing instructional strategies to support a higher level of cognition in mathematics and the communication of this understanding. Research has shown that mathematical arguments are a predictor of mathematical understanding (Yakel & Cobb 1996) thus SMP 3- “construct viable arguments and critique the arguments of others” (CCSSM, 2013, p. 6) addressed both higher level cognition and communicating understanding. The goal of this project was to develop instructional tools for teachers to facilitate students' abilities to make mathematical arguments. The guiding question was: What might a set of instructional strategies and tools look like to support second grade students’ development of mathematical arguments, in a Southern California classroom?

Preview Literature

This project aims to create and adapt instructional tools to support second grade students’ development of mathematical arguments. Three themes from the literature- metacognition, mathematical arguments, and screencast technologies- inform this mathematical unit’s design.

Metacognition is an individual’s awareness of how they carry out their cognitive processes (Flavell, 1976). The differentiation between metacognition and cognition is critical to the understanding of this project. Simply stated, cognition refers to an individual’s actions whereas metacognition refers to how an individual thinks about their actions (Artz & Thomas, 1992). King (1991) breaks metacognition down into three phases: planning, monitoring, and evaluating. A student's metacognitive ability has been shown to predict academic performance across curricular domains such as reading, science, and mathematics (Carr & Jessup, 1994; Van der Stel & Veenman, 2010) making metacognition a critical piece of teaching mathematics.

Effective assessment strategies using metacognition include self-report questionnaires (Pintrich & DeGroot, 1990) and real-time student think-alouds (Artzt & Thomas, 1992; Shraw, 2010). There are also specific metacognitive phases and strategies that students use to increase performance (Van der Stel & Veenman, 2010) such as planning, monitoring, and evaluating. While literature exists to support the instruction and assessment of metacognitive strategies, research is still being completed to facilitate the need for metacognitive instruction in the area of mathematical problem solving. These phases, in conjunction with effective student think-alouds, has the potential to support students' abilities to argue mathematical solutions at a high level of thinking. In addition to metacognitive strategies, other strategies to support students’ ability to argue mathematical solutions are presented.

Mathematical arguments are the justifications of students’ thinking and strategies for solving problems. Language supports that greatly support the development of mathematical arguments, such as cloze sentence frames (Ross, Fisher, & Frey, 2009) will be explored in depth. Models for presentation of mathematical explanations have been shown to be a critical component in the mathematical arguments of elementary students (Ericsson & Simon, 1998). These models will also be examined as tools to support students Another defining component of making mathematical arguments is teacher moves. Teacher questioning and classroom norms are discussed as they pertain to the development of student mathematical arguments. Teacher moves, language supports, and models for presentation combined with metacognitive tools and strategies, have the potential to improve students’ abilities to make mathematical arguments.

A way to capture and document students’ mathematical arguments and metacognitive thinking are screencasts. Screencasts can collect students’ recorded think-alouds while students problem-solve in real time. Much of the research regarding screencasts pertain to the teacher use of screencasts in their instruction (Soto, 2014). Research regarding the student creation of screencast is very limited. However, there is great potential for it as a means of documenting student thinking. Methods of recording students presented in research include video recording students as they problem-solve. Student created screencast can further address the P21 skills of technology literacy in a digital age. Documented research regarding screencasts will include a description of screencasts, screencast and student thinking (Crespo, 2000), implications of using screencasts (Soto, 2015) and the anatomy of a screencast (Sugar, Brown, & Luterbach, 2010). The present project will build on and add to the existing body of research by discussing the use of screencast technology as an assessment of metacognition and mathematical arguments.

Preview Methodology

The unit presented here is designed to teach students how to make mathematical arguments that justify their solutions and mathematical thinking. A unit containing three parts-screencast technologies, metacognition, and mathematical arguments-was designed. A second-grade classroom of seventeen students in an affluent Southern California neighborhood will receive unit instruction. The Understanding by Design framework (Wiggins, 1998) will guide the design of the unit. The unit includes lesson plans, rubrics, and instructional tools such as problem-solving templates, sentence frames, and guided questioning tools. Additionally, the procedures for the development of the unit will be discussed.

Significance of Project

Students as early as kindergarten are required to justify their mathematical reasoning and it is the job of educators to directly teach this skill. This project has the potential to help educators facilitate this learning by adapting current metacognitive tools to support mathematics instruction. Through this unit, educators can see how a teacher can integrate metacognitive skills and mathematical arguments. Additionally, it supports the implementation of screencast technology for student-created videos. These videos might support teachers in the classroom with time-management and assessment of students' mathematical arguments and metacognitive thinking. Overall, this unit provides tools that have the potential support instruction in developing students' abilities to make mathematical arguments using metacognition and screencast technologies.

This unit provides a context for applying a widely researched strategy for reading instruction, metacognition, to instruction in mathematics. The current metacognitive tools for mathematics are not designed for use in the primary grade levels. This project aims to adapt these tools to be developmentally appropriate for younger, elementary students. Lessons that directly teach students language supports are synthesized in one unit and geared specifically towards making mathematical arguments. This provides a tool that teachers may use to directly teach SMP 3. Different from other approaches, student created screencast videos might add 21st century skills such as technology literacy to mathematics instruction. Screencast videos might allow teachers to collect recordings in greater volume than they have been able to otherwise as well as create opportunities for students to give constructive feedback in new ways that further support 21st century skills.

Summary of Chapter

Demands of the 21st century workforce promoted shifts in state standards. The ability to communicate cognitive understanding is a skill needed for the 21st century workforce and mathematical arguments has been shown to support students in this skill. This project draws on literature to support students' ability to make mathematical arguments to justify their mathematical solutions and thinking. Metacognition was a reoccurring theme in the literature in supporting higher level cognition and the development of mathematical arguments. Language supports such as cloze statements and teacher questioning were also highlighted in the research as tools that help students make mathematical arguments. Think-alouds were discussed as a valid strategy for assessing student metacognition. This project, informed by the research, uses screencast technology to capture student think-alouds in a way that adds to their 21st century skillset. Lesson plans and tools were created and adapted based on the presented literature and will be implemented in the described second-grade classroom. Chapter Two will present current and seminal research in the areas of mathematical arguments, metacognition, and screencast tools in mathematics instruction.

Definitions

Here are the definitions for the key terms of this unit project.

Mathematical Arguments

A mathematical argument refers to a students' ability to form, explain, and communicate reasoning of a mathematical process or answer.

Metacognition

Metacognition is an individual's awareness of how they carry out cognitive processes including planning, monitoring, and evaluating their thinking.

Screencast

A screencast is a digital whiteboard whereby students can record work digitally while simultaneously audio recording their thought process.

Think-alouds

A think-aloud is an assessment strategy whereby students orally think aloud and explain their thinking.

CHAPTER TWO

LITERATURE REVIEW

This project aims to create instructional tools that will support student development of mathematical arguments addressing the question: What might a set of instructional strategies and tools look like to support second grade students' development of mathematical arguments, in a Southern California classroom? This chapter reviews three themes in the literature: Metacognition, Mathematical Arguments, and Screencasts. All three themes inform the mathematical unit design.

Metacognition

There are many working definitions of metacognition as it relates to different fields. The common definition, thinking about thinking, can be somewhat abstract (Hacker, Dunlosky, & Graesser, 1998). Flavell (1976) was the first to formally address and define metacognition in his research. Flavell's original definition of metacognition was "an individual's awareness, consideration, and control of cognitive process, and strategies" (Wilson & Clark, 2004, p. 28). While researchers have crafted different definitions, they all relate to the thoughts people have about the cognitive processes and behaviors that are carried out during the learning process (Wilson & Clarke, 2004). This awareness is broken down by most researchers into three distinct phases of metacognition. These phases are defined as planning, monitoring, and evaluating (King, 1991; Pintrich, Wolters, & Baxter, 2000; Schoenfeld, 1985).

Cognition

Cognition refers to one's behaviors and actions or what someone does or does not do during a learning activity (Artz & Thomas, 1992). An example of a cognitive behavior is changing a denominator when adding and subtracting fractions to create like terms.

Metacognition on the other hand, is the thoughts and choices students are making during the planning, monitoring, and evaluation phases of learning. Deciding to change denominators after recognizing the need to have like terms when adding and subtracting fractions is an example of metacognition (Cozza & Oreshkina, 2013).

Metacognition as a Predictor of Success

Metacognition has been found to be a significant predictor of academic success. Originally researchers focused their metacognitive studies on students' reading comprehension and the strategies that students used to be successful readers. A correlation was found between metacognition and students' comprehension levels (Raphael & Pearson, 1985). These authors argued that choices related to strategy use can be taught to students so much so that metacognition is being directly taught in current reading curricula (Harskamp & Suhre, 2007). Researchers were able to determine that metacognition also shows a considerable relationship with success in math and science (Carr & Jessup, 1994), though people utilize different metacognitive processes with these differing academic areas (Van der Stel & Veenman, 2008).

The CCSSM requires K-6 students to not only master procedural fluency, but also acquire a deeper conceptual understanding of mathematics. Because metacognition is a strong predictor of students' academic success in mathematics (Carr & Jessup, 1994; King, 1991) the need for metacognitive instruction in the classroom is emphasized.

Planning phase. Sometimes called exploration or awareness phase, the planning phase is typically where problem-solvers initiate a task. Wilson & Clarke (2004) go on to explain that during this phase students think about previous experiences or knowledge that they have that pertains to the task. Students may set goals, develop a plan, and make decisions about the strategies they will use. Problem-solvers might determine what the problem is asking and contemplate multiple strategies for solving. Students also consider pertinent information and how that information might guide them to a solution. Cozza & Oreshkina (2013) found that metacognitive verbalizations were most common during this phase.

Monitoring phase. After making decisions and beginning the task, students monitor their progress. They think about the strategies they are using and their usefulness in the ability to find a solution, which might result in a change in strategy as needed. This may include analyzing their use and the success of their plan and their potential need to make changes (Wilson & Clarke, 2004). It is found that this stage of metacognition is utilized more often when completing complex tasks (Cozza & Oreshkina, 2013).

Evaluation phase. Lastly, students evaluate their outcome. They reflect on strategies that worked and those that did not; and they take note of what they might do differently in the future. With more complex tasks, students use these skills through learning and problem-solving in order to achieve successful outcomes (Wilson & Clarke, 2004)

Metacognitive Instructional Strategies

Initially, research was concerned with identifying the difference between students who used metacognitive skills and those who did not. Since the research consistently demonstrated a significant difference in academic performance between students who used metacognitive strategies and those who did not, the focus shifted to how educators could teach metacognitive strategies in their classroom.

Researchers first identified that students could be trained to use metacognitive strategies (Harskamp & Suhre, 2007). Specifically, the literature shows that when students are provided with direct instruction on the importance of using these strategies in addition to when and how to use them, students demonstrated and increased understanding in the subject area (Delclos &

Harrington, 1991). Directly teaching metacognitive strategies is often done using guided questioning strategies.

King (1991) concluded that students who received direct instruction and specific guided peer questioning strategies were more prone to success. Also, students in King's treatment groups used significantly more explanation statements than that of the unguided questioning and control groups. This demonstrates that when students are directly taught guided questioning strategies, their ability to communicate their thinking and justifications for mathematical procedures were improved. In this study, all participants were given a rationale for using metacognitive strategies, followed by teacher modeling and think aloud, as it pertained to the question set. Further research designs (Jacobse & Harskamp, 2012) included guided questioning without direct instruction; they were used as prompting questions throughout the problem-solving process.

Assessing Metacognition with Think-Alouds

The analysis of one's verbal statements can be used to represent their thoughts around a given topic (Artz & Thomas, 1992; Desoete, 2008). This allows researchers to analyze the cognitive and metacognitive processes during a learning task (Cozza & Oreshkina, 2013; Schraw, 2010). It has been shown to be more powerful when think-alouds are collected while participants are in the midst of completing tasks rather than after the fact, making them less vulnerable to overlooking part of their thought process (Jacobse & Harskamp, 2012). Think-alouds can be collected directly by a researcher or participants can have audio and/or video recording as they work through tasks. New technologies allow for students to work independently on problem-solving tasks as they personally record their thinking while solving.

For the purpose of this project, metacognition, while an in-depth idea, is a tool for improving cognitive tasks with students. Ideally, with direct instruction in metacognitive strategies, students have the potential to improve metacognitive abilities. This project will specifically focus on the cognitive task of making mathematical arguments.

Mathematical Arguments

The Common Core State Standards for Mathematics (CCSSM) detail the need for a higher-level cognition of mathematical concepts. Making mathematical arguments has been shown to support this cognition (Yakel & Cobb 1996). The third Standard for Mathematical Practice (SMP) is to "construct viable arguments and critique the reasoning of others." The CCSSM Framework, specifically for second grade, states that students may "construct arguments using concrete referents, such as objects, pictures, math drawings and actions" (p. 122). While making mathematical arguments have been invaluable to mathematical understanding at the secondary level with reasoning and proofs (Stylianides, 2007), less research exists regarding how students at the elementary level justify mathematical thinking. The present research informs the creation of tools to support elementary students in making mathematical arguments.

Predictor of Deeper Understanding

Many studies demonstrate that students who can articulate how they solve a problem and defend their thinking to others are more likely to have this deeper understanding (Yakel & Cobb 1996). Chi et al. (1994) go on to explain that in the case that students explain incorrectly, they will come to a point of conflict or contention forcing them to revise their thinking and explanation. Likewise, students benefit from listening and questioning the reasoning of their peers (Mueller & Maher, 2009).

Expectations of Mathematical Arguments

In most classrooms, you can observe students talking about math. Traditionally, they might present answers and strategies and notice patterns, but mathematical arguments and discourse are expected to go beyond simply talking about math. Kazemi and Stipek (2001) argue that many classrooms engage in general social norms in their classrooms. These norms include sharing strategies, explaining reasoning, and working in groups. Sociomathematical norms are those specific to mathematics and require students to analyze and compare strategies and come to consensus based on appropriate argumentation. Mathematical arguments require students to justify and defend their thinking while thinking critically and questioning the justifications of their peers. In order to convince others of their claims, students must provide evidence and reasoning (Rumsey & Langrall, 2016).

Elementary aged students typically justify their arguments with the "justify by example" strategy (Carpenter, Franke, & Levi, 2003). This is when a student uses examples to convince another that their answer is true. Visual representations are argued to be at the center of a students' justification at the elementary level (Schifter, et al. 2008). These representations provide a context for assigning meaning to operations using representations such as diagrams and manipulatives.

Presentation of Mathematical Explanations

The work of Ericsson and Simon (1998) asserts that mathematical explanation can be elicited while students work or after they have completed the work. Both means are valuable, but serve a different purpose. Ericsson and Simon (1998) went on to identify the differences between each. Think-alouds that occur while working most resemble what students are actually thinking. They tend to be a bit more disjointed, but provide the teacher with a more accurate representation of how students are processing. Models that require students to explain after completing a problem tend to be clearer and more articulate and encourage more of a social reflection. Because they are more social, by nature, they may be more filtered and less accurate.

Teacher's Role and Instructional Strategies

The teacher's role is to facilitate the process of mathematical dialogue and discourse in the classroom setting. Rumsey and Langrall (2016) present instructional strategies to facilitate mathematical discourse in the classroom.

Language supports include sentence frames that are introduced during whole group learning sessions (Ross, Fisher, & Frey, 2009). The frames are partially cloze statements that give students the syntax and academic language necessary for communicating arguments. Ross, Fisher, and Fry (2009) offer several sentence frames that address the following categories: making a claim, providing evidence, asking for evidence, offering a counter claim, inviting speculation, and reaching consensus. All of these frames provide a rich context for students to engage in the deeper level mathematical discourse that facilitates argumentation. These authors also indicate the importance of teacher modeling these frames for students as a way for students to safely interact before using in context with other students. However, they also argue that simply listening to the teacher is not enough, students must interact with their peers while using sentence frames.

Mathematical Norms, Talk Moves, Critiquing the Arguments of Others

Kazemi and Hintz (2014) offer a list of mathematical discussion norms to support students in routines and create a safe learning and sharing community. This list includes: making sense of mathematics, persevering through challenging problems, embracing mistakes and revising thinking, sharing thinking, listening to others, asking questions, agreeing or disagreeing with ideas rather than each other, and remembering that all students have good mathematical ideas.

Chapman, O'Connor, and Anderson (2009) outline five talk moves that support classroom discussions. Revoicing repeats what a student has said allowing the student to verify its accuracy. This move can be used to make sense of, expand, or draw attention to a student's idea. Repeating is a move that asks a student to restate or rephrase another student's idea. This move slows the conversation and draws attention to important and complex ideas. Reasoning requires students to make sense of other's ideas and reason about their own. They make statements of agreement or disagreement based on their own sense making. Adding on allows all students to engage in a conversation by taking another's idea and adding on an idea or thought along the same lines. Wait time, is the last of the five offered by Chapman, O'Connor, and Anderson (2009). A teacher uses this move to allow time for students to think and process before responding. Students can also ask for more time to think before responding. Turn and talk allows students to share their ideas on a small scale. Students can gain an entry point based on the thoughts the share and listen to from others. This also allows the teacher to move around the room and listen to ideas to make intentional choices on who to call on during discussion. Lastly, the strategy of revise empowers students to make revisions to their thinking. This allows students to be mindful of and to embrace any mistakes in their ideas as well as their thinking in response to other's reasoning (Kazemi and Hintz, 2014).

Screencasts

Metacognition and language supports have been identified as strategies to support mathematical arguments. Screencasts can be utilized to capture students' metacognition and mathematical arguments. Computer screencasts are described as a digital capture of a user's screen. This includes the user's movements and actions. Audio can also be recorded as the user captures these actions (Educase, 2006). Soto and Hargis (2014) describe digital screencasts on a tablet as a tool that captures what is written, erased, highlighted and said. They go on to explain that "student-generated screencasts give educators a window into students' thinking as they watch and listen to how that thinking unfolds" (p.32).

Screencast and Student Thinking

Gains in technology both necessitate 21st century teaching and provide access to tools that foster 21st century learning. Teachers originally worked within a top down framework in regards to screencasts. Teachers would record a screencast for students to watch and learn from. This was designed to allow a model in which students would preview or review at videos at home and participate in application activities in the classroom. During this application, the teacher addresses misconceptions and supports individual student's learning. This model is also known as a flipped classroom model.

Teachers are now employing technology for student created screencasts (Soto & Ambrose, 2016). Screencasts allow students to capture student work as their gestures, written work, and/or verbalized thoughts are recorded. These digital screencasts can be used to discover the mathematical thinking of students as they work through problems as well as make arguments to support their answers. This allows teachers insights into their students' thinking and understanding of content in greater depth (Soto & Ambrose, 2016).

Crespo (2000) highlights that written mathematical explanations have limitations because students may not coherently convey their thoughts in writing. This may lead teachers to erroneous assumptions of a student's understanding. Student interviews are ideal as the student can articulate their reasoning in the presence of the teacher and the teacher can facilitate a conversation that engages students to express their thinking. That being said, current demands in the classroom do not allow time to interview individual students often. Using screencasts is a popular alternative that can allow teacher to capture student thinking without having to interview them directly (Soto & Ambrose, 2016).

This project explicitly teaches how to create a screencast video. The tools used for these lessons were based on the research of Sugar, Brown, & Luterbach (2010). In their research, structural elements were identified in online learning environments. One of these elements includes bumpers. Bumpers serve as an introduction at the beginning of a video and or a corresponding conclusion at the end. These researchers also identified instructional strategies used by professors. One of these strategies is providing context by introducing the topic of focus for a given screencast. Another instructional strategy element is to present and explain the specific concept.

Summary of Chapter

This chapter outlined the research and best practices pertaining to the elementary mathematical arguments unit. The major themes included metacognition, mathematical arguments, and screencast technologies. Metacognition, an individual's awareness of their cognitive practices, was defined as a predictor of students' ability to make mathematical arguments and an improved cognitive understanding of mathematical principles. The three phases of metacognition- planning, monitoring, and evaluating- can be directly taught to students using the metacognitive instructional strategy of guided questioning. Think-alouds were identified as a way to assess metacognition by recording statements as they work through the problem-solving process.

Mathematical arguments or a students' ability to justify their mathematical thinking, were identified as a predictor of deeper mathematical understanding. The expectations of mathematical arguments go beyond simply explaining solutions but require a model and reasoning to justify mathematical thinking during the problem-solving process. The teacher's role is to facilitate mathematical discourse in the classroom with talk moves, guided questioning, and math norms. Students can be taught how to create screencast videos that allow teachers to collect students' mathematical thinking without having to complete one-on-one interviews. These screencast videos can be taught based on typical anatomy of a screencast according to present research.

CHAPTER THREE

METHODOLOGY

The mathematical shifts identified by the Common Core State Standards for Mathematics (CCSSM) create rigorous demands for educators. This rigor addresses a deeper knowledge of mathematical concepts and conceptual understanding (CCSSM, 2013). The purpose of this project is to create instructional tools that will support these demands specifically in supporting students' development of mathematical arguments.

The tools outlined in this chapter support three areas of instruction: screencasts, metacognition, and mathematical arguments. Screencast technology tools are used as a vehicle for students to communicate mathematical arguments and metacognitive planning, monitoring, and reflection. Mathematical discourse is also addressed by these tools. Metacognition tools are developed as a means to improve students' mathematical arguments. These tools may support teachers in guiding students' abilities to make sense of mathematical content and make a plan as well as monitor and reflect on their plan for solving. Lastly, teachers are supplied with tools to teach students how to make mathematical arguments. These tools address a student's capacity to justify their mathematical thinking using a model and a written/oral explanation as well as listen, ask questions, and critique the arguments of their peers.

These tools and the overall unit was implemented in a second-grade classroom in Southern California. More details about this classroom are addressed in the participant and settings section of this chapter. The design section of this chapter details how these unit parts are built one upon another while the procedures section explains how the unit was created.

Design

Elementary Mathematical Arguments: A Guide to Using Metacognition and Screencast Technology to Support Students is comprised of three parts with 4 lessons in each. These 12 lessons are broken into three major components: screencasts, metacognition, and mathematical arguments. Screencast instruction is taught as a fundamental base as metacognition is assessed using student recorded think-alouds. Metacognition is considered a tool to support students' abilities to make mathematical arguments, justifying this unit's place in succession. The unit culminates in students making mathematical arguments using both metacognitive tools and strategies in congruence with screencast technology. All lessons include lesson objectives, assessment, instructional strategies and tools to support student metacognition. Lesson objectives are developed around three sets of standards: Common Core State Standards (CCSS), English Language Development standards (ELD), and International Society for Technology in Education (ISTE) standards. These instructional strategies and tools are developed to support second grade students' development of mathematical arguments.

Participants and Setting

The audience for this unit is 17 students in a self-contained second grade classroom in a Southern California suburban community. The class is made up of 8 girls and 9 boys ranging from ages 7-8. Fifteen of the 17 students in this class went to Watson Elementary for first grade. Two students came from outside of this school. While there are no English Language Learners in this class, 24% of the class is Redesignated Fluent English Proficient and 12% tested as Initially English Fluent Proficient. Two students receive speech and language services. These two students in addition to a third student receive reading intervention outside of the general education setting 30 minutes daily. All students were present to receive instruction in metacognition and mathematical arguments.

Watson* Elementary School is located in an affluent community in Southern California. This population comes from a predominantly upper-socio-economic status. Ninety-four percent of students have at least one parent with a graduate level degree. Students come from diverse cultural backgrounds. The surrounding community is actively involved in school activities and there is strong parental involvement including a high degree of volunteering in the classroom and valuable fundraising efforts to support extracurricular programs and weekly supplementary classes. Parents and students are extremely conscientious of student achievement.

Watson Elementary School is a publicly funded school of 550 kindergarten through sixth grade students. The school's mission is to "inspire greatness in tomorrow's leaders." With this mission, there is a strong focus on student leadership. There is a high demand on teachers from the community and administration for individualized learning and innovative teaching and learning. This school emphasizes technology integration, including coding and robotics. Students attend supplemental classes in science, art, physical education, technology, music, and media lab. The majority of these are funded by parent donations with a portion paid by school and district funds.

Curricular Materials

Curricular materials were created to support the implementation of this unit to scaffold the development of mathematical arguments using metacognitive strategies and screencast technologies. Each instrument is described.

Rubrics

Rubrics were created as both an instructional tool to clarify expectations and as a tool to assess whether students met the objectives. The content of the rubrics was designed based on expected target goals and learning outcomes. These goals and outcomes were determined by state standards and a review of the best practices found in educational literature. Rubrics assessing students' mathematical explanations were created based on the research of Carpenter, Franke, and Levi (2003), Kazemi and Stipek (2001), Rumsey and Langrall (2016), and Schifter, et al. (2008). The use of screencast and the rubrics that assessed them were created based on the research of Artz & Thomas (1992), Desoete (2008), Jacobse & Harskamp (2012), and Pintrich, Wolters, and Baxter (2000). All rubrics are on a four-point scale ranging from a 1 (beginning score) to a 4 (an advanced score). The advanced score (4) require competency in all components without exception. The score of proficient (3) require competency in all or attempts at all components required. Approaching (2) met only some competency requirements and a beginning score (1) had limited requirements met. (Figure 1)

	4 - Advanced	3 - Proficient	2 - Approaching	1 - Beginning
Introduction	- Includes first name - Clearly states the purpose of screencast	- Includes first name - Tries to state the purpose of screencast	Includes first name only	Does not include name or purpose of the screencast
Presentation of Learning	− On topic − Explains thinking − Provides evidence or examples of learning	− On topic − Tries to explain thinking − Tries to provide evidence or examples of learning	- On topic - Presents learning using appropriate digital tool (photo, drawing, note) only	- Off topic - Does not present learning using appropriate digital tool, explain thinking, or provide evidence

	− Presents learning using appropriate digital tool (photo, drawing, note)			or examples of learning
Conclusion	- Clearly restates the purpose of screencast - Includes a send-off message	- Tries to restate the purpose of screencast - Includes a send-off message	Includes a send-off message only	Does not include purpose of the screencast or send off message
Visual Quality	- Drawings, photos, and images are clear and easy to read - Fonts and text are clear and easy to read - Colors are nice to look at - Content is easy to read	- Drawings, photos, and images are mostly clear and easy to read - Fonts and text are mostly clear and easy to read - Colors are mostly nice to look at - Content is mostly easy to read	- Drawings, photos, and images are sometimes clear and easy to read - Fonts and text are sometimes clear and easy to read - Colors are sometimes nice to look at - Content is sometimes easy to read	- Drawings, photos, and images are not clear or easy to read - Fonts and text are not clear or easy to read - Colors distract from the presentation - Content is not easy to read
Oral Presentation	- Speaking voice is clear and easy to understand - Speaking voice is fun to listen to - There are no interruptions or distractions	- Speaking voice is mostly clear and easy to understand - Speaking voice is mostly fun to listen to - Only some interruptions or distractions	- Speaking voice is sometimes clear or easy to understand - Speaking voice is sometimes fun to listen to - Sometimes there are interruptions or distractions	- Speaking voice is not clear or easy to understand - Speaking voice is not fun to listen to - There are many interruptions or distractions - There is no recording
Audio Quality	- No background noise is present - No audio feedback is present	- Only some background noise is present - Only some audio feedback is present	- A lot of background noise is present - A lot of audio feedback is present	- No recording

Figure 1: Screencast Rubric

Lesson Plans

The lesson plan format used is an adaptation of the California State University Single Subject Program Lesson Plan template (http://lessoninstructions.weebly.com/). All lesson plans include: lesson title, estimated duration of lesson, list of materials, standards (Common Core State Standards, International Society for Technology Education, and English Language Development), objectives, assessment, length of lesson, resource materials, and instructional.

Sentence Frames

Sentence frames are developed to scaffold language for the screencasts and feedback as well as communication of mathematical arguments. Ross, Fisher, and Frey (2009) identified cloze sentence frames best practices for supporting students' academic language development. Sentence frames encourage academic language and accurate syntax for academic explanations. Sentence frames for screencasts, metacognition, and mathematical arguments, were broken down into sections or categories such as introduction, content, and conclusion depending on specified requirements. The following sentence frame was an example used in Unit 1: Screencast. It was a tool that was designed to aid students in introducing and concluding their screencasts. (Figure 2)

Screencast Sentence Frame Tool

Introduction:

Hi. My name is _________________________________ and this video is about

____.

I will talk about

____

____.

Conclusion:

I hope after watching you learned

____

____

____________. Thanks for watching!

Figure 2: Screencast Sentence Frame Tool

Making Mathematical Arguments Questioning Tool

Metacognitive thinking is used to support students in their abilities to make mathematical arguments. The I Can Be a Problem Solver Checklist supports students' ability to problem solve using metacognition. King's (1991) research regarding metacognitive, guided questioning offers the foundation for directly instructing students in these methods using the checklist format. The following checklist was adapted from King's (1991) study as well as from the research completed by Wilson and Clarke (2004) examining the different phases of metacognitive thinking in mathematical problem solving. This checklist was broken down into three phases and was implemented in Unit 2: Metacognition. (Figure 3)

I Can Be a Problem Solver Checklist

Ask:

- ❑ Is there anything about this problem that confuses me?
- ❑ What is the problem asking me to find out? What will my solution statement be?
- ❑ What do I already know? What information does the problem give me?
- ❑ How can I solve this problem? What strategy will I use to solve?

Decide:

- ❑ Am I on the right track?
- ❑ Is there another, more efficient strategy I can use? Is there another strategy that makes more sense to me?
- ❑ What should I do next?
- ❑ Is my strategy working?

Check

- ❑ Where was I most successful?
- ❑ What were some of my challenges?
- ❑ Is there something I would do differently when solving a similar problem?

Figure 3: I Can Be a Problem Solver Checklist

Explain Your Thinking Problem Template and Sample Story Problem

Mathematical arguments require students to show and explain their thinking. In order to facilitate and scaffold the development of this skill, a document template was created for students based on the best practices presented in the research (Carpenter, Franke, & Levi, 2003; Kazemi and Stipek, 2001; Rumsey & Langrall, 2016; Schifter, et al. 2008). Story problems create a strong foundation for students to use multiple strategies in solving and justifying their thinking. The following is a template that includes a story problem that addresses the second-grade content standard for adding and subtracting within 100. The template gives students space to show evidence of their thinking in a way that makes sense to them. Lastly, the tool includes a sentence structure for explaining students' thinking. These sentence frames support students with oral explanations. After time, students no longer need to write down these explanations with the goal that they can articulate themselves orally during class dialogue and in screencast videos.

The emphasis is placed on the students' reasoning for their strategies rather than the steps taken in solving. Lastly, the template includes a sentence frame for a solution statement. This supports students in using a solution statement in their problem-solving explanation. (Figure 4)

Story Problem Template

Avery has 22 Legos. Jackson has 23 Legos. How many Legos do Avery and Jackson have all together?

Show Evidence (model, drawing, equations, etc):

Explain:

First I ____.

Then I ____.

I used this strategy because ____

____.

Avery and Jackson have ________________ Legos altogether.

Figure 4: Story Problem Template

Procedures

This unit was developed using the Understanding by Design Framework (Wiggins & McTighe, 1998). First, the desired results were first identified. Questions such as: what do I want my students to be able to do to demonstrate understanding and what processes must they master in order to appropriately demonstrate this understanding were asked. With these questions in mind, the CCSSM Standard for Mathematical practice of constructing viable arguments became a dominant theme. This is an outline of the development of the Elementary Mathematical

Arguments: A Guide to Using Metacognition and Screencast Technology to Support Students unit.

1. Identify desired results as modeled in the first of three steps from the Understanding by Design process by Jay McTighe and Grant Wiggins (2012). The overall desirable outcome is for students to understand a process for making mathematical arguments, also referred to as McTighe and Wiggin's Enduring Understandings. The main objective for the unit is for students to be able to form, explain, and communicate reasoning of a mathematical processes or answer.
2. Complete a literature review of possible strategies for facilitating mathematical arguments for elementary. Metacognitive instructional strategies dominate as research based practice. To implement these instructional strategies, complete a literature review of how screencast recording technology could showcase the metacognitive process.
3. Identify a list of best practices from the literature review to implement into the unit: unit backward planning (Wiggins & McTighe, 2006), metacognition guided questioning strategies (King, 1991), screencast anatomy (Sugar, Brown, and Luterbach, 2010), screencast feedback rubric (Mueller & Maher, 2009; Wiggins & McTighe, 2006), sentence frames (Rosss, Fisher, Frey, 2009; Rumsey & Langrall, 2016), mathematical norms (Kazemi and Stipek, 2001), mathematical argument teacher talk moves (Kazemi & Hintz, 201), use of screencast rubrics (Wiggins & McTighe, 2006;), mathematical argument rubrics (Carpenter, Franke, & Levi, 2003; Ericsson & Simon, 1998; Schifter, et al. 2008; Wiggins & McTighe, 2006), and student explanation frames (Carpenter, Franke, & Levi, 2003; Ericsson & Simon, 1998; Schifter, et al. 2008).

4. The fourth step is the second step of the McTighe & Wiggin's (2012) Understanding by Design process. Determine the evidence that demonstrates the achievement of the objective for the unit: students will be able to form, explain, and communicate reasoning of a mathematical processes or answer. Create rubrics to articulate the criteria that is expected of students for assessment.
5. The key desired outcomes are further developed into a unit with three parts: screencast, mathematical arguments, and metacognition (McTighe & Wiggins, 2012).
6. The third part of the Understanding by Design process is to identify learning experience that supports the desired learning results (McTighe & Wiggins, 2012). These learning processes are developed into an outline of the unit with an intention to build a sequence of activities that would help all the students learn.
7. The next step of unit development is to design the lesson plans using the California State University San Marcos Lesson template (http://lessoninstructions.weebly.com/).
8. Instructional tools and strategies to support each lesson are created based on the best practices identified in the literature as referenced in step 3.
9. Reflect on the unit to make sure all of the best practices identified during the literature review are addressed.
10. Pilot the project with my students and revise unit in the following ways:
    a. Changed activity and assessment in lesson one to make lesson more concrete by requiring students to write down definitive qualities they enjoyed.
    b. Split lessons three and four into two lessons rather one.
    c. Added student self-assessment with all introduced rubrics.
    d. Made unit lessons much more detailed.

e. Added pre- and post-assessments for metacognition and mathematical arguments.

f. Added a lesson on mathematical norms to come before justifying arguments with classmates.

Summary of Chapter

In order to answer the guiding question of this project: what might a set of instructional strategies and tools look like to support second grade students' development of mathematical arguments in a Southern California classroom, the Metacognitive Mathematical Argument Screencasts Elementary Unit was designed. This chapter describes the design, participants, setting, instruments and procedures. The next chapter is comprised of the unit in full including a unit overview, table of contents, unit calendar, twelve lessons, assessments, rubrics, sentence frames, and other tools, as discussed.

CHAPTER FOUR

PROJECT

This chapter encompasses all parts of the Elementary Metacognitive Mathematical Argument Screencast Unit. As it is a standalone unit, the project encompasses a title page and a table of contents can be used to easily navigate the unit components. Additionally, an overview of the curriculum has been provided. The unit also includes detailed lesson plans, rubrics for assessment, instructional tools, and implementation considerations.

Elementary Mathematical Arguments:

A Guide to Using Metacognition and Screencast Technology

to Support Students

Unit Table of Contents

Unit Overview

The mathematical cognitive demands required of students at all educational levels is high. Beyond procedural fluency and students' abilities to merely solve problems, they must be able to complete mathematical processes at a higher level, including justifying their answers and critiquing the arguments of others, otherwise known as the third standard of mathematical practice in the Common Core State Standards for Mathematics (CCSSM). Expecting students to reach this peak in mathematical thinking and processing, teachers must be prepared to facilitate this learning. This project, Elementary Mathematical Arguments: A Guide to Using Metacognition and Screencast Technology to Support Students serves as a unit for second-grade students to use metacognitive strategies as well as online digital journals to make quality mathematical arguments. The unit includes three parts: Screencasts, Metacognitive Strategies, and Mathematical Arguments. Each part contains lesson plans that outline standards addressed, objectives, assessment, materials/resources, instructional steps, and lesson tools, such as rubrics, sentence frames, and questioning checklists.

This unit was developed under a math workshop implementation model. The following outlines the scope of one math instructional session around 75 minutes. The class begins by participating in a whole group number talk (Parrish, 2014) where students all complete one-story problem generated by the teacher based on grade level standards. Problems types are designed based on Cognitively Guided Instruction (Carpenter, et al., 2014). Students also rotate through teacher guided instruction, and activities such as counting collections, skip counting journals, and number decomposition.

There are a number of screencast technologies that could be used to implement the screencast part of this unit. The unit developer utilizes the app Seesaw. Other tablet screencast applications include: Explain Everything and Educreations. The unit is designed for a classroom with 1:1 tablet ratio, but could be adapted to fit any classroom with some access to tablet technology. Parts 2 and 3 could be implemented without part 1 in the event that there was no access to technology.

Brain breaks are referenced throughout the unit. These are provided to break up instruction and the time students are expected to listen during a given lesson. There are many resources that brain breaks can be accessed. For example, GoNoodle is an online database that provides a plethora of activities anywhere from 1-3 minutes long.

Unit Calendar

Lessons	Standards	Objectives	Assessment	Student Activities
Lesson 1	ISTE: 1d ELD: A. Collaborative 1.	Students will be able to (SWBAT) identify and list features of a model screencast.	Sticky notes with identified qualities.	Students will identify qualities of an advanced screencast.
Lesson 2	ISTE: 1d ELD: A. Collaborative 1.	(SWBAT) demonstrate knowledge of fundamental concepts of technology by creating a screencast with an introduction, presentation of learning, and conclusion.	Screencast	Students will create simple screencast video.
Lesson 3	ISTE: 1d ELD: A. Collaborative 1.	(SWBAT) demonstrate knowledge of fundamental concepts of technology by creating an All About Me Screencast with attention to visual quality, oral presentation, and audio quality.	Screencast	Students will create an All About Me screencast video.
Lesson 4	ISTE: 7a ELD: A. Collaborative 2	(SWBAT) connect with other learners and add to their own learning by providing feedback on digital portfolio post.	Peer Commenting	Students will practice leaving comments for their peers.

Lessons	Standards	Objectives	Assessment	Student Activities
Lesson 5	CCSS.ELA-L.2.6 ELD: C.	Students will be able (SWBAT) to define the word metacognition.	Picture representing understanding of metacognition	Students draw a picture on a sticky note representing metacognition
Lesson 6	CCSSM-MP1 ELD 1.B	SWBAT make sense of a story problem and make a plan for solving.	Teacher observation and annotated notes. Students completion of I Can Be a Problem Solver Checklist	Solve a mathematical story problem using the “Ask” questions of the I Can Be a Problem Solver Checklist
Lesson 7	CCSSM-MP1 ELD 1.B	SWBAT to make sense of a story problem and monitor their plan for solving.	Teacher observation and annotated notes. Students completion of I Can Be a Problem Solver Checklist	Solve a mathematical story problem using the “Decide” questions of the I Can Be a Problem Solver Checklist
Lesson 8	CCSSM-MP1 CCSSM- MP6 ELD 1.B	SWBAT make sense of a story problem and evaluate their plan for solving.	Teacher observation and annotated notes. Students completion of I Can Be a Problem Solver Checklist	Solve a mathematical story problem using the “Check” questions of the I Can Be a Problem Solver Checklist

Lessons	Standards	Objectives	Assessment	Student Activities
Lesson 9	CCSSM-MP3 CCSSM-MP4 ELD: C.9.	Students will be able (SWBAT) to justify their mathematical thinking using a model.	Explain Your Answer Rubric (Categories: Label, Show, Presentation)	Students use a strategy to solve example story problem.
Lesson 10	CCSSM-MP3 ELD: C.9.	SWBAT to justify their mathematical thinking using a written explanation.	Students will complete a story problem. They will explain how they solved the problem using a model and a written explanation.	Students work independently to complete their explanation in writing.
Lesson 11	CCSSM-MP3 ELD: B. 5.	SWBAT listen, ask questions, and critique the mathematical thinking of a peer according to the classroom mathematical discussion norms.	Teacher will observe students as the engage in mathematical discussions.	Students will engage in discussion using the provided Mathematical Discussion Anchor Chart.
Lesson 12	CCSSM-MP3 ELD: B. 5.	SWBAT to listen, ask questions, and critique the mathematical thinking of a peer by using questions from the Critiquing the Arguments of Other's tool.	Students will be able to ask questions of their peers.	Practice using the Critiquing the Arguments of Others Tool

PART 1 – SCREENCAST

Lesson 1: Developing Criteria for a Model Screencast

Standards

- ISTE: 1d: Students understand the fundamental concepts of technology operations, use and troubleshoot current technologies and are able to transfer, their knowledge to explore emerging technologies.
- ELD: A. Collaborative 1. Exchanging information and ideas with others through oral collaborative conversations on a range of social and academic topics

Lesson Objective

Students will be able to identify features of model screencast videos that both help students learn and that they enjoy watching by expressing their ideas collaboratively with classmates.

Assessment

Students will add sticky notes with features of model screencast videos to the class anchor chart.

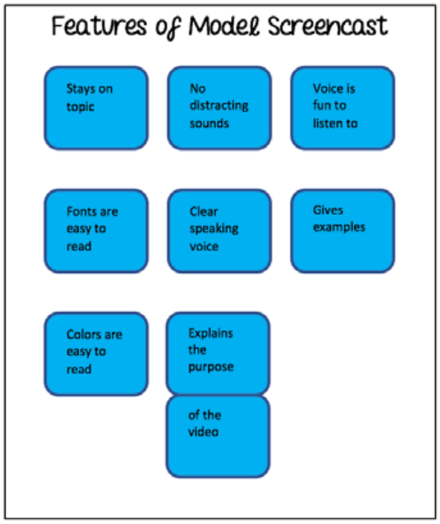
Length of Lesson

45 minutes

Resource Materials

- Projector
- Access to online Digital Portfolio, for example Seesaw Digital Journal (https://web.seesaw.me/)
- Access to technology (iPad or Chromebook)
- Screencasts for students to review (Sample Seesaw Student Journals (https://goo.gl/JZ5VTH)
- Anchor Chart: Features of a Model Screencast

- Example:



- Sticky notes (three per student)
- Pencils (one per student)
- Clipboard or hard surface to write on
- Screencast Rubric (for teacher reference only)

Teacher Instructional Steps

1. State the learning objective. Students will have a collaborative discussion and create a list of features in a model screencast.
   a. Explain that a model screencast is a video that you both learn from and enjoy watching. There are many features of a model screencast that help you learn and enjoy watching.
   b. Introduce the Features of a Model Screencast anchor chart that students will add to at the end of the lesson.
2. Review published videos

a. Explain to students that they will be watching screencast videos. While watching, they will be detectives on the lookout for features of model videos. Students should be prepared to explain, like detectives, why they think the video is a model video. “I think this is a model video, because...”

b. Project first video for the whole group. Pause video for a teacher think aloud. Find something to compliment to help students brainstorm ideas. For example, “Wow, I really like how clearly they’re speaking.” Add clear speaking to a sticky note and add to the anchor chart.

c. After watching the video, students report out their reflections to the group. As students report out, prompt for as much detail as the student can give. For example, if a student says they like a drawing or model, the teacher can ask why they liked it. The student may like the color choices, detail, organization, clarity, etc. Student responses will be used to support the Screencast Rubric used in future lessons. The Screencast Rubric included in this lesson can assist the teacher in guiding the collaborative discussion with students. The rubric should not be shared with students

d. Model how to write features on a sticky note. Consider using bullet notes. This may or may not be familiar to students. Notes should be quick ideas rather than sentences. For example, clear voice, artistic drawing, etc.

e. Hand out materials to students

    i. Sticky notes, pencils, and clipboards, if needed

    ii. Student grouping will depend on access to technology as well as teacher’s management style. Students can work independently, as partners, in groups, or continue to watch whole group facilitated by the teacher.

f. Allow students to watch/listen to videos from the previous year's students' digital portfolio for ten minutes. On the sticky notes, students should write down features of the video they really liked.

g. As students watch videos, they should add to the list on their sticky note. Students may need multiple sticky notes depending on the size of their handwriting and organization of their notes. Students will keep their sticky notes to share out during collaborative discussion.

   i. Differentiation: Provide students with a list of features to circle as they notice in the video.

   ii. As students work, the teacher circulates to monitor behavior and aid in writing notes on sticky notes. The teacher can also bring the class' attention to particular notes that students are making that others might also want consider.

3. Discuss model videos.

   a. Facilitate a conversation about features students wrote on their sticky notes.

   b. As students share out, the teacher pulls up the video they are referencing for the whole class and models commenting on a student's video. "Insert student name, I think this video is a model screencast because (list appropriate reasons)." For example: "Jojo, I think this is a model screencast because your drawings are very clear and your caption helps me to understand your video better."

   c. Drive the conversation to include content and audio/visual requirements per categories and content in the screencast rubric.

4. Close the lesson by reviewing the objective. Have students add sticky notes to the anchor chart and review student ideas.

Screencast Rubric

Category	4 - Advanced	3 - Proficient	2 - Approaching	1 - Beginning
Introduction	- Includes first name - Clearly states the purpose of screencast	- Includes first name - Tries to state the purpose of screencast	-Includes first name only	-Does not include name or purpose of the screencast
Presentation of Learning	− On topic − Explains thinking using examples	− On topic − Tries to explain thinking with examples	- On topic -Does not explain thinking	- Off topic
Conclusion	- Clearly reviews the purpose of screencast - Includes a send-off message	- Tries to review the purpose of screencast - Includes a send-off message	-Includes a send-off message only	-Does not include purpose of the screencast or send off message
Visual Quality	- Fonts and text are clear and easy to read - Colors are nice to look at - Content is easy to read -Presents learning using appropriate digital tool (photo, drawing, note)	- Fonts and text are mostly clear and easy to read - Colors are mostly nice to look at - Content is mostly easy to read -Presents learning using appropriate digital tool (photo, drawing, note)	- Fonts and text are sometimes clear and easy to read - Colors are sometimes nice to look at - Content is sometimes easy to read	- Fonts and text are not clear or easy to read - Colors distract from the presentation - Content is not easy to read

Oral Presentation	- Speaking voice is clear and easy to understand - Speaking voice is fun to listen to - There are no interruptions or distractions	- Speaking voice is mostly clear and easy to understand - Speaking voice is mostly fun to listen to - Only some interruptions or distractions	- Speaking voice is sometimes clear or easy to understand - Speaking voice is sometimes fun to listen to - Sometimes there are interruptions or distractions	- Speaking voice is not clear or easy to understand - Speaking voice is not fun to listen to - There are many interruptions or distractions - There is no recording
Audio Quality	- There is no background noise - There is no audio feedback	-Only some background noise - Only some audio feedback	- There is a lot of background noise - There is a lot of audio feedback	- No recording

Lesson 2: Audio/Visual Screencast Expectations

Standards

- ISTE: 1d: Students understand the fundamental concepts of technology operations, use and troubleshoot current technologies and are able to transfer, their knowledge to explore emerging technologies.
- ELD: A. Collaborative 1. Exchanging information and ideas with others through oral collaborative conversations on a range of social and academic topics

Lesson Objective

Students will be able create a self-portrait screencast video including a name label with clear visual quality, oral presentation, and audio quality as measured by the Screencast Rubric.

Length of Lesson

45 minutes

Assessment

Students will create a simple screencast including a self-portrait and name label with clear visual quality, oral presentation, and audio quality. Students will complete the Screencast Self-Assessment Tool.

Resource Materials

- Projector
- Access to online Digital Portfolio, for example Seesaw Digital Journal (https://web.seesaw.me/)
- Access to technology (iPad or Chromebook)
- Screencasts for students to review (Sample Seesaw Student Journals (https://goo.gl/JZ5VTH)

- Completed Anchor Chart: Features of a Model Screencast (from Lesson 1)
- Screencast Checklist (one per student)
- Screencast Self-Assessment Sentence Frame Tool (one per student)
- Pencils (one per student)
- Clipboards or hard surface
- Screencast Rubric (from Lesson 1); Options for display:
  - Large rubric on display
  - Rubric placed in class digital portfolio
  - Printed rubric for each student

Teacher Instructional Steps

1. Review Anchor Chart: Features of a Model Screencast from Lesson 1.
   a. Have students recall what they remember from Lesson 1. Read sticky notes from the anchor chart to remind students of features they noted for a model screencast.
2. State the learning objective. Now that students have determined the qualities they like in a screencast video, it is time for them to review with more focus and practice skills.
3. Building on Lesson One’s discussion, create a need for rubric
   a. Explain to students that published work in the class’s digital portfolio should be only their personal best and should show great effort towards learning. Ask students what it means to give their best effort in their classwork. Enlist specific examples such as: complete, neat, organized, clear, etc.
   b. Explain that the goal of a screencast is for the audience or the people who are watching these screencasts to learn a lot and enjoy watching. Have them recall some of their favorite videos from Lesson 1.

5. Explain the purpose of a rubric. A rubric describes the expectations for student's work.
6. Explain the components of a rubric. Cover the rubric and reveal in parts.
    a. Identify the scores along the top of the columns. Explain that four is the best score on this rubric and represents an advanced screencast. Four is what students should always aim to achieve.
    b. Identify each category along the first column. Explain that each row of the rubric represents a category that is being measured.
7. Introduce students to screencast checklist. Explain that each category on the rubric is also on the checklist. If students complete each requirement on the checklist, their screencast video will receive a 4 on the rubric.
8. Hand out materials to students
    a. Screencast checklist, pencils, and clipboards, if needed
9. Review the audio/visual categories on the checklist with students one category at a time. Audio/visual categories include: Visual Quality, Oral Presentation, Audio Quality. For each category:
    a. Read each requirement on the checklist
10. Play a model video for students to watch intently focusing on that specific aspect of the video. Students should check off each of the requirements that they see in the model video. Explain to students that they will have to pretend that it is their own video because each of the requirements start with an I statement. Students may also add their own additional notes or thoughts to this checklist.
11. Students discuss with partners what they checked off on their checklist.

12. Check in before moving on. Do students need a brain/body movement break before moving on?
13. Create and model a simple screencast video including a self-portrait and name label focusing on the Visual Quality, Oral Presentation, Audio Quality categories.
    a. Drawing: Self-portrait with name label.
        i. Explain to students that the while they may have different drawing abilities, the expectation is that they give their own personal best.
        ii. The name label should be capitalized since it is the name of someone. Also review that the label should not block any of the content.
    b. Recording should take place away from general background noise.
        i. Before recording, ask students to be very quiet. Remind them that when there's recording going on in the room, the class should be mindful and do their best to keep voices low.
        ii. Model a voice that is engaging but not silly. The voice should be strong and clear. "Hi. My name is ____________."
        iii. Pause the video when there is an anticipated interruption. Consider pausing after the word "hi," to model an interruption or distraction. For example, "Hi. Pause. Ooops! I forgot what I was going to say." Explain to the class that the best recordings are well planned and if they do forget or need more planning time, they should hit pause so that there isn't a long pause in the video with no sound.
        iv. Try to eliminate feedback. Model for students what happens if they fumble with the tablet or knock it on something. Something that could also cause

feedback is recording too close to the microphone. The sound quality could be distorted. Explain to students that they should be careful to avoid instances that cause feedback.

14. Model self-assessment using the Screencast Checklist. Check off the requirements for the Visual Quality, Oral Presentation, Audio Quality on the Screencast Checklist
    a. Read each category aloud
    b. Watch your own screencast example for each category. Think aloud for each category i.e., “Let’s see, is my speaking voice clear? Yes, it is very clear. Can I understand myself? You bet! I will check this box to show that I completed the requirements for an advanced score in the Oral Presentation category.”
    c. Using the rubric, give yourself a score for each category and complete the Screencast Self-Assessment Tool. Think aloud for each category i.e., “For the introduction, the score I give myself is a 4, because I included my first name and told the audience what I was going to be talking about in my screencast.”
15. Students create simple screencast video.
    a. Release students to independently create their screencast video for 5-10 minutes. They should include a drawing of themselves, a label with their capitalized name, and a recording that says “Hi. My name is______________.” As they work, should self-assess their screencast using the Screencast Checklist.
    b. When finished, students can complete the Screencast Self-Assessment Tool.
16. Close the lesson by having students share, in partners, their self-assessment. Students may watch each other’s screencast videos and discuss whether they agree on the self-assessment scores.

Screencast Checklist

Introduction

- ❑ I include my first name
- ❑ I explain what I am going to talk about or the purpose of my screencast video

Presentation of learning

- ❑ I stay on topic
- ❑ I explain my thinking using examples

Conclusion

- ❑ I review what I talked about or the purpose of screencast
- ❑ I include a send-off message like "Thanks for watching!"

Visual Quality

- ❑ My drawings, photos, and images are clear and easy to read
- ❑ My fonts and text are clear and easy to read
- ❑ Colors are nice to look at
- ❑ Content is easy to read
- ❑ I use the appropriate digital tool (photo, drawing, note)

Oral Presentation

- ❑ My speaking voice is clear and easy to understand
- ❑ My speaking voice is fun to listen to
- ❑ There are no interruptions or distractions in my video

Audio Quality

- ❑ There is no background noise in my video
- ❑ There is no audio feedback in my video

Screencast Self-Assessment Sentence Frame Tool

For my introduction, the score I give myself is ___________, because ________________________

____

____.

For my presentation of learning, the score I give myself is ___________, because ______________

____

____.

For my conclusion, the score I give myself is ___________, because _________________________

____

____.

For my visual quality, the score I give myself is ___________, because _______________________

____

____.

For my oral presentation, the score I give myself is ___________ because ____________________

____

____.

For my audio quality, the score I give myself is ___________, because _____________________

____

____.

Lesson 3: Content Screencast Expectations

Standards

- ISTE: 1d: Students understand the fundamental concepts of technology operations, use and troubleshoot current technologies and are able to transfer, their knowledge to explore emerging technologies.
- ELD: A. Collaborative 1. Exchanging information and ideas with others through oral collaborative conversations on a range of social and academic topics

Lesson Objective

Students will be able to create an "About Me" screencast video with an introduction, on topic content including a drawing and audio recording, and a conclusion as measured by the Screencast Rubric.

Length of Lesson

45 minutes

Assessment:

Students will create an About Me screencast including a drawing and audio recording. Students will complete the Screencast Self-Assessment Tool.

Resource Materials

- Projector
- Access to Digital Portfolio
- Access to technology (iPad or Chromebook)
- Screencasts for students to review (from Lesson 2)
- Screencast Rubric
- Screencast Checklist (one per student)

- Pencils (one per student), and
- Clipboards, if needed
- Screencast Sentence Frames (1 per student)
- Screencast Sentence Frame Anchor Chart
- Anchor Chart: Features of a Model Screencast (from Lesson 1)

Teacher Instructional Steps

1. Review students learning from Lesson 2.
    a. Students should explain the audio/visual expectations of a screencast.
    b. Students self-assess their own screencast according to the rubric.
2. State the learning objective. Now that students have focused on the audio/visual expectations of a screencast, they will focus their attention on the content of the screencast.
3. Review how the rubric works with students.
    a. Ask students to describe what the numbers on the rubric mean and what score they are aiming to achieve.
    b. Identify the categories in the rubric.
4. Hand out materials to students
    a. Screencast checklist, pencils, and clipboards, if needed
5. Introduce content categories on the checklist with students one category at a time. Audio/visual categories include: Introduction, Presentation of Learning, and Conclusion. For each category:
    a. Read each requirement on the checklist
6. After introducing each category, play a model video for students to watch intently focusing on that specific aspect of the video.

a. Students should check off each of the requirements that they see in the model video. Explain to students that they will have to pretend that it is their own video because each of the requirements start with an I statement. Students may also add their own additional notes or thoughts to this checklist.

7. Students discuss with partners what they checked off on their checklist.
8. Check in before moving on. Do students need a brain/body movement break before moving on?
9. Create and model an About Me screencast using the Screencast Sentence Frames
   a. Explain to students that an About Me video should teach others about you. It can include your interests and people or things that are important to you. This video should help people get to know you.
   b. Following are possible ways to create a teacher About Me model screencast using the drawing and audio recording features of a screencast. Content will be specific to facts about teacher/student.
   c. Drawing:
      i. Draw pictures of pets using a drawing tool. Include a text box with the pet's name. Remind students to not block pictures with labels.
      ii. Draw music symbols with a stick girl dancing because you like to dance.
      iii. Draw a blue sky because your favorite color is sky blue.
   d. Audio Recording
      i. Recording should take place away from general background noise. Remind students of audio expectations from Lesson 1 (no background noise, engaging voice, no distractions or interruptions, no feedback)

ii. Bring students attention to the Screencast Sentence Frame Anchor Chart.

iii. Introduction: "Hi. My name is Jojo and this video is all about me. I will talk about the things in my life that I love and explain some of my favorite things."

iv. Content: "I have two pets that are small and cute. I love to cuddle with them before bedtime. I love to dance because it makes me feel happy. Zumba and hip-hop are my favorite types of dance. My favorite color is blue because it calms me down and makes me feel happy. There are a lot of shades of blue. The shade I like is the color of the sky."

e. Conclusion: "I hope after watching you learned something about me. Thanks for watching!"

10. Model self-assessment using the Screencast Checklist using their own simple screencast.

a. Read each category aloud and the expectations for an advanced score (4).

b. Watch your own screencast example for each category. Think aloud for each category i.e., "Let's see, did I stay on topic? Yes, I talked about three different things about me. Did I explain my thinking with evidence? You bet! I didn't just say I have two dogs, I told the audience their names and a little bit about them.

c. Using the rubric, give yourself a score for each category and complete the Screencast Self-Assessment Tool.

11. Students create an All About Me screencast video.

a. Release students to create their screencast video. They should include a drawing with labels and a recording using the Screencast Sentence Frame Tool. As they work, should complete the Screencast Checklist.

i. Students should work independently in different areas of the room, away from each other. Access to earbuds would also help subside background noise.

b. When finished, students can complete the Screencast Self-Assessment Tool.

12. Close the lesson by having students share, in partners, their self-assessment. Students may watch each other's screencast videos and discuss whether they agree on the self-assessment scores.

Screencast Sentence Frame Tool

Introduction:

Hi. My name is ________________________________ and this video is about

____.

I will talk about ____

____.

Conclusion:

I hope after watching you learned____

____.

Thanks for watching!

Lesson 4: Digital Portfolio General Peer Feedback

Standards

- ISTE: 7a Students use digital tools to connect with learners from a variety of backgrounds and cultures, engaging with them in ways that broaden mutual understanding and learning.
- ELD: A. Collaborative 2. Interacting with others in written English in various communicative forms (print, communicative technology, and multimedia)

Lesson Objective

Students will be able to connect with other learners and add to their own learning by providing feedback regarding content and audio/visual quality on their peer's digital portfolio post that is respectful, provides helping comments, creates conversation, and is appropriate and on topic as measured by the Peer Commenting Rubric.

Length of Lesson

45 minutes

Assessment

Students will comment on the content and audio/visual quality of peer's screencast videos using the online digital portfolio. Students will complete Peer Feedback Self-Assessment Tool.

Resource Materials

- Projector
- Access to technology (iPad or Chromebook)
- Access to Digital Portfolio
- Screencasts for students to review
- Peer Commenting Rubric Options for display:
    - Large rubric on display

    - Rubric placed in class digital portfolio
    - Printed rubric for each student
- Peer Commenting Self-Assessment Sentence Frame Tool
- Peer Commenting Sentence Frames; Options for display:
    - Large on display
    - Placed in class digital portfolio
    - Printed for each student
- Commenting on Seesaw Digital Citizenship Poster & Lesson (see link)

Teacher Instructional Steps

1. State the objective. This lesson's goal is to add comments to a peer's post. regarding content and audio/visual quality that is respectful, provides helping comments, creates conversation, and is appropriate and on topic.
2. Discuss purpose of a digital portfolio/blog
    a. Explain to students that one of the benefits of a digital journal or blog is that others can see it and give feedback; It makes journaling interactive between many people.
    b. Explain how a digital journal or blog allows students to reflect on their learning. This way students can think about what they have learned and thoughtfully share that learning to others.
    c. Explain that students will add posts about the learning they do every day allowing peers to learn from each other. Emphasize the communication and collaboration of this online dialogue.
3. Review rubric
    a. Briefly review how a rubric works from Lessons 2 and 3.

b. Read the requirements for each category of the rubric.

c. After reviewing each category, play a model video for students to watch intently focusing on that specific aspect of the video.

4. Project and introduce sentence frames. Explain that students can add comments using these as a guide

5. Model Feedback

    a. Choose 3-5 student posts to model, with a think aloud and sentence frame, how to give quality feedback while projecting for students to see. As you're posting feedback, ask students to score your comments using the rubric. Explain to students that sometimes "it's not what we say, but how we say it," so it's important to use a kind and respectful voice.

        i. Helping Comment: "Name of student, I like the way that you added labels to your text because it helps me to read your drawing better."

        ii. Helping Comment: "Name of student, thanks for sharing your learning. Next time, it would be helpful if you take your picture from directly above so that we can clearly see the image."

        iii. Create conversation: Name of student, wow, I didn't realize there was so much to know about _________________. Where did you learn all of that information?

6. Teacher models scoring on a rubric using their own simple screencast and Self-Assessment Tool.

    a. Read each category aloud and the expectations for an advanced score (4).

   b. Watch your own screencast example for each category. Think aloud for each category i.e., "Let's see, did I use the student's name? Yes. Was my voice kind and positive? You bet! For the respectful category, I give myself the score of 4, because I used the student's name and my voice sounded very nice."

7. Allow 15- 20 minutes for scaffolded practice of giving feedback. Using the rubric and sentence frames, students add comments to peer's post.
   a. If able, set digital journal to require approval of comments. As students complete comments, individually conference with students as they post to provide feedback. As the class works, bring students' attention to quality comments that meet expectations.
   b. When students finish, they should self-assess their screencast using the Peer Commenting Rubric and Self-Assessment Tool.
8. Close the lesson by having students share, in partners, their self-assessment. Students may read each other's feedback and discuss whether they agree on the self-assessment scores.

Peer Commenting Rubric

	4- Advanced	3- Proficient	2- Approaching	1- Beginning
Respectful	• Name of student • Positive feeling tone	• Mostly Positive feeling tone	• Attempts a positive tone	• Comment is negative or mean
Helping Comments	• Specific, detailed compliment about something your peer did well AND/OR • Specific, detailed comment about an area your peer can improve their post	• Mostly specific Compliment something your peer did well AND/OR • Mostly specific comment about an area your peer can improve their post	• Attempts specific Compliment something your peer did well AND/OR • Attempts specific comment about an area your peer can improve their post	• Compliment or area of improvement is general
Creates Conversation	• Connects and adds to the learning in detail AND/OR • Asks open questions to prompt a conversation	• Connects and adds to the learning in some detail AND/OR • Asks questions to prompt a conversation	• Attempts to connect and adds to the learning AND/OR Attempts to ask questions to prompt a conversation	• Does not connects to learning or ask questions to prompt a conversation
Appropriate Content/On Topic	• Appropriate language • On topic	• Mostly on topic	• Attempts to be on topic	• Inappropriate language AND/OR • Off topic

Peer Commenting Sentence Frames

Helping Comment:

(name of student) _____________________, I like the way you (specific and detailed)

______________________________________, because (reason why you like it)

____.

Helping Comment:

(name of student) _____________________, thanks for sharing your learning about

______________________. Next time try (specific and detailed)

____, because (reason why it would help)

____.

Create Conversation:

(name of student) _____________________, thanks for sharing your learning about

______________________. I was most interested about (specific and

detailed)______________________________________. (Ask a question that cannot be answered

yes or no) ____.

Peer Commenting Self-Assessment Sentence Frame Tool

For the respectful category, the score I give myself is ___________, because _________________

____

____.

For the helping comments category, the score I give myself is ___________, because ___________

____

____.

For the creating conversations category, the score I give myself is ___________, because _______

____

____.

For the appropriate comments/on topic, the score I give myself is ___________, because

____

____

____.

PART 2 – METACOGNITION

Lesson 5: Introduction to Metacognition

Standards

- CCSS.ELA-LITERACY.L.2.6 Use words and phrases acquired through conversations, reading and being read to, and responding to texts
- ELD: C. Productive 12. Selecting and applying varied and precise vocabulary and language structures to effectively convey ideas

Lesson Objective

Students will be able to define the word metacognition.

Length of Lesson

45 minutes

Assessment

Students will draw a picture representing their understanding of metacognition.

Resource Materials

- Sticky notes

Teacher Instructions

1. State the objective. Today students will learn a new word and how it can help them with their learning.
2. Introduce and define metacognition
   a. Generate excitement over learning a very adult term that is studied by many scientists in the real world.
   b. Break the word down for students as you practice saying it aloud (meta-cog-nition)

c. Define metacognition as someone's thinking about their own thinking. Have students repeat this definition aloud.

d. Connect students to times they've thought about their own thinking. Here is an example think aloud that might occur in the class:

    i. Teacher: "Have you ever thought: "What was I thinking?" or "I better think about what I just did!" These are just some of the times that your brain is thinking about its own thoughts. I notice that I do this ALL the time when I'm solving a math problem. Sometimes I just know the answer without even thinking it seems. Let's try, what's 2 + 2?"

    ii. Students: "4"

    iii. Teacher: "See, it's like your brain didn't even have to think about that. Most of the time though, I have to really think about how to solve a problem. When I'm thinking about how to solve a problem, that's metacognition."

3. Brainstorm examples of metacognition with students. The following are possible examples:

    a. Problem solving behavior on the playground.

        i. Thinking about why you said or behaved a certain way.

        ii. Was that a smart choice? Did that strategy work?

    b. Planning and developing a piece of writing from beginning to end.

    c. Using reading strategies to become a better reader.

        i. Asking questions.

            1. I wonder why...?

            2. Why is the character...?

        ii. Monitoring for comprehension.

1. Do I understand what I just read?
2. What strategy can I use to help me understand better?

d. Planning how to solve a math problem

i. Should I use addition or subtraction?

ii. Does my answer make sense?

iii. What are some other strategies I can use?

4. Students draw a picture on a sticky note representing metacognition

a. For example, pictures of students thinking about how to solve a problem in a thought bubble

5. Close the lesson by reviewing objective. Have student “think, pair, share” the meaning of metacognition.

Lesson 6: Metacognitive Planning in Mathematical Problem Solving

Standards

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.CONTENT.2.OA.A.1 Represent and solve problems involving addition and subtraction.
- ELD 1.B: Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language.

Lesson Objective

Students will be able to make sense of a story problem and make a plan for solving it using the I Can Be a Problem Solver Checklist Tool.

Length of Lesson

45 minutes

Assessment

Teacher will observe students solving using the tool and take annotated notes (see notes in lesson plan). Students will check off a list as they move through the problem-solving process.

Resource Materials

- Projector
- I Can Be a Problem Solver Checklist Tool
    - Large tool on display
    - Tool placed in class digital portfolio
    - Printed tool for each student
- Story Problem Teacher Modeling
- Story Problem Student Practice

- Access to technology (iPad or Chromebook)

Teacher Instructional Steps

1. Review sticky notes from Lesson 1. Review the meaning of metacognition: thinking about our thinking.
2. State the objective. In this lesson, students will think about how to solve mathematical problems, by thinking about the problem and making decisions to help solve.
3. Review the I Can Be a Problem Solver Tool. Review the “Ask” questions with students by reading aloud and having them repeat back. Cover the remaining sections.
4. Model using the tool with mathematical story problem. Read the story problem aloud to students and model using a think aloud.
    a. “Is there anything in this problem that confuses me? Should I reread it to make more sense of it?”
    b. “What is this problem asking me to find out? The last sentence asks, how many gumballs does Logan have left? That must be what I have to figure out. The solution statement will be, Logan has _____ gumballs left.”
    c. “What information does the problem give me? Well, I know that Logan started with 28 gumballs and I know that he gave Mason 5 gumballs.”
    d. “How can I solve this problem? I know that Logan gave Mason gumballs and the problem asks how many are left, so I think I’m supposed to use subtraction.”
    e. “What strategy do I want to try to solve this problem? Do I need to use manipulatives, can I draw a model, or can I show with notation how I mentally solve this problem? I think I will draw two tens and eight ones since he starts with 28 gumballs. Then I will cross out 5 ones since he gave five to Mason.”

5. Review whole group, the “Ask” questions of the checklist for the story problem that students will complete in partners.
    a. Ask each question, allowing students to think about response before answering.
    b. Students share their response with a partner.
    c. Have all students respond aloud together.
    d. Repeat back the correct response and correct any misconceptions.
    1. Students work in partners to solve a story problem using the “Ask” questions of the I Can Be a Problem Solver Checklist. Allow students 15-20 minutes to solve. As students work together, the teacher observes students and takes annotated notes to formatively assess students. The following questions can guide your note taking.
        a. Are students making sense of the problem?
        b. What actions do students take to make sense of the problem?
        c. What questions are students asking themselves during the problem-solving process?
        d. What errors are students making during the problem-solving process?
6. Close the lesson by reviewing objective. Have student “think, pair, share” the questions in the ask section of the I Can Be a Problem Solver Checklist.

I Can Be a Problem Solver Checklist

Ask:

- ❑ Is there anything about this problem that confuses me?
- ❑ What is the problem asking me to find out? What will my solution statement be?
- ❑ What do I already know? What information does the problem give me?
- ❑ How can I solve this problem? What strategy will I use to solve?

Decide:

- ❑ Am I on the right track?
- ❑ Is there another, more efficient strategy I can use? Is there another strategy that makes more sense to me?
- ❑ What should I do next?
- ❑ Is my strategy working?

Check

- ❑ Where was I most successful?
- ❑ What were some of my challenges?
- ❑ Is there something I would do differently when solving a similar problem?

Story Problem 1

Logan had 28 gumballs. He gave 5 to Mason. How many gumballs does Logan have left?

Logan has __________ gumballs left.

Story Problem 2

Logan had 68 gumballs. He gave 49 to Mason. How many gumballs does Logan have left?

Logan has __________ gumballs left.

Lesson 7: Metacognitive Monitoring in Mathematical Problem Solving

Standards

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.CONTENT.2.OA.A.1 Represent and solve problems involving addition and subtraction
- ELD 1.B: Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language.

Lesson Objective

Students will be able to make sense of a story problem and monitor their plan for solving.

Length of Lesson

45 minutes

Assessment

Teacher will observe students solving using the tool and take annotated notes (see notes in lesson plan). Students will check off the list as they move through the problem-solving process.

Resource Materials

- Projector
- I Can Be a Problem Solver Checklist Tool
    - Large tool on display
    - Tool placed in class digital portfolio
    - Printed tool for each student
- Story Problem Teacher Modeling
- Story Problem Student Practice

Teacher Instructional Steps

1. State the objective. In this lesson, students will use metacognition to think about how to solve mathematical problems focusing on how they monitor their strategy to make sure they're on the right track or decide if they should solve using another strategy.
2. Review Ask questions of I Can Be a Problem Solver Checklist Tool from Lesson 2 by completing a think aloud with new story problem.
    a. Read the story problem aloud to students.
    b. "Is there anything in this problem that confuses me? Should I reread it to make more sense of it?"
    c. "What is this problem asking me to find out? The last sentence asks, how many crickets are left in the tank? That must be what I have to figure out. The solution statement will be, there are _____ crickets left in the tank."
    d. "What information does the problem give me? Well, I know that at first there were 26 crickets in the tank and Toni ate 5."
    e. "How can I solve this problem? I know that Toni ate 5 crickets and the problem asks how many are left, so I think I'm supposed to use subtraction."
    f. "What strategy do I want to try to solve this problem? Do I need to use manipulatives, can I draw a model, or can I show with notation how I mentally solve this problem? I think I will try to count back 5 from 26 on my fingers."
3. Review the I Can Be a Problem Solver Tool. Review the "Decide" questions with students by reading aloud and having them repeat back. Cover the remaining "Check" section.
4. Model using the tool with mathematical story problem. Read the story problem aloud to students and model using a think aloud.

   a. "What should I do next? I could try to show how I counted back by ones on my fingers using a number line"
   b. "Is my strategy working? My strategy worked, but I wonder if it will work with larger numbers?"
   c. "Is there another, more efficient strategy I can use? Is there another strategy that makes more sense to me? This make sense for me, but there might be a more efficient strategy. I'll try another strategy and compare the two."

5. Review whole group, the "Decide" questions of the checklist for the story problem that students will complete in partners.
   a. Ask each question, allowing students to think about response before answering.
   b. Students share with their response with a partner
   c. Have all students respond aloud together.
   d. Repeat back the correct response and correct any misconceptions.
6. Students work in partners to solve a story problem using the "Ask" and "Decide" questions of the I Can Be a Problem Solver Checklist. Allow students 15-20 minutes to solve. As students work together, the teacher observes students and takes annotated notes to formatively assess students. The following questions can guide your note taking.
   a. Are students making sense of the problem?
   b. What actions do students take to make sense of the problem?
   c. What questions are students asking themselves during the problem-solving process?
   d. What errors are students making during the problem-solving process?

7. Close the lesson by reviewing objective. Have student "think, pair, share" the questions in the "Decide" section of the I Can Be a Problem Solver Checklist.

Story Problem 3

There are 26 crickets in Toni's enclosure. Toni ate 5 of them. How many crickets are still in the tank?

There are ___________ crickets still in the tank.

Lesson 8: Metacognitive Evaluating in Mathematical Problem Solving

Standards

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP6 Attend to precision.
- CCSS.MATH.CONTENT.2.OA.A.1 Represent and solve problems involving addition and subtraction
- ELD 1.B: Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language.

Lesson Objective

Students will be able to make sense of a story problem and evaluate their plan for solving.

Length of Lesson

45 minutes

Assessment

Teacher will observe students solving using the tool and take annotated notes (see notes in lesson plan). Students will check off the list as they move through the problem-solving process.

Resource Materials

- Projector
- I Can Be a Problem Solver Checklist Tool
    a. Large tool on display
    b. Tool placed in class digital portfolio
    c. Printed tool for each student
- Story Problem Teacher Modeling

- Story Problem Student Practice

Teacher Instructional Steps

1. State the objective. In this lesson, students will use metacognition to think about how they solved a mathematical problem.
2. Review teacher story problem from Lesson 3.
3. Review the I Can Be a Problem Solver Tool. Review the “Check” questions with students by reading aloud and having them repeat back.
4. Model using the tool with mathematical story problem from Lesson 2. Read the story problem aloud to students and model using a think aloud.
    a. “Where was I most successful? I was most successful when I showed how I counted back by ones on my fingers. This let me check my answer for accuracy.”
    b. “What were some of my challenges? When I used larger numbers, counting back by ones was more difficult.”
    c. “Is there something I would do differently when solving a similar problem? I think I will try another strategy I saw by counting back by tens and ones.”
5. Review whole group, the “Check” questions of the checklist for the story problem that students completed in partners in Lesson 3.
    a. Ask each question, allowing students to think about response before answering.
    b. Students share with their response with a partner.
    c. Have students share responses with partner.
    d. Call on students to share aloud to the class.
6. Students work in partners to solve a story problem using the “Ask,” “Check,” and “Decide” questions of the I Can Be a Problem Solver Checklist. Allow students 15-20 minutes to

solve. As students work together, the teacher observes students and takes annotated notes to formatively assess students. The following questions can guide your note taking.

a. Are students making sense of the problem?
b. What actions do students take to make sense of the problem?
c. What questions are students asking themselves during the problem-solving process?
d. What errors are students making during the problem-solving process?

7. Close the lesson by reviewing objective. Have student “think, pair, share” the questions in the “Check” section of the Problem-Solving Checklist.

PART 3 – MATHEMATICAL ARGUMENT

Lesson 9: How to Explain Your Thinking Using a Model

Standards

- CCSS.MATH.PRACTICE.MP4 Model with mathematics.
- CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
- CCSS.MATH.CONTENT.2.OA.A.1 Represent and solve problems involving addition and subtraction.
- ELD: C. Productive 9. Expressing information and ideas in formal oral presentations on academic topics.

Lesson Objective

Students will be able to justify their mathematical thinking using a model that is organized and easy to read, is detailed, and includes labels. A model is any visual that supports a student's mathematical thinking including a picture of how manipulatives were used, a drawing of the story problem, a strategy such as a number line or other diagram, or an equation that includes how students used abstract numbers to solve the problem.

Length of Lesson:

45 minutes

Assessment

Students will complete a story problem. They will show how they solved the problem using a model.

Resource Materials

- Projector
- Story Problem
- Explain Your Answer Anchor Chart
- Explain Your Answer Sentence Frame
- Explain Your Answer Rubric
- Explain Your Thinking Self-Assessment Tool
- Access to Technology (i.e., iPad or Chromebook)

Teacher Instructional Steps

1. State the objective: Explain that the best mathematicians prove their answers are correct and use some sort of model to show others their thinking.
2. Introduce and review Explain Your Answer Rubric.
    a. Review what a rubric is the contents of a rubric (categories, scores, expectations).
    b. Go through each category and discuss the requirements of an advanced score.
        i. After reviewing each category, look at the model problem response and have students focus intently on the specific aspect of the response.
    c. Project and read story problem to students.
3. Discuss the story problem with students. Ask questions from the planning phase of the I Can Be a Problem Solver Checklist Tool (Lesson 6).
4. Model solving a story problem with a think aloud. See teacher think aloud as an example to support modeling this practice.
    a. Teacher: “Think about how we can use a model to show evidence of our thinking. Manipulatives are also great tools to solve problems we’re thinking about.”
    b. Give students a minute to think about how they will show their math.

   c. Teacher: “Watch as I solve and think about what’s in my brain. First, I draw and label 22 Legos. I draw them in groups of tens and ones. Then I draw and label 23 Legos also in groups of tens and ones. The problem asked how many altogether so I count how many ten groups there are in all: 10, 20, 30, 40. Then I add the 2 and the 3 to make 5. 40 and 5 makes 45. I am going to give you some time to work quietly on the problem. You can use the same model that I did or use another model. You can also use manipulatives or an equation as long as you can accurately explain how you solved and why that strategy works.”

5. Teacher models scoring on a rubric using their own strategy model.
   a. Read each category aloud and the expectations for an advanced score (4).
   b. Think aloud for each category i.e., “Let’s see, did I show a model of my strategy that showed step by step how I solved? You bet! For the justify my answer category, I give myself a 4 because I used detail like why I made my choices and used labels and wrote clearly in my model and my explanation.”
6. Students use a strategy to solve example story problem. Students should create a screencast video of their mathematical problem solving.
   a. Give students 15-20 minutes to solve problem on their own. Monitor students as they solve. Pay attention for students who may need prompting to get started.
   b. When students finish, they should self-assess their screencast using the Show Evidence category of the Explain Your Thinking Rubric.
7. Complete a strategy gallery walk.

a. Students leave their work where it is and quietly walk around and look at how others have solved. They can find examples of students that solved similarly and those that solved using a different strategy.
b. Ask them to think critically about questions they have about the work of others.
c. Give students a few minutes to view other's work. Once they've circulated call students back to their seats. During the gallery walk, the teacher should identify 2-4 students who used different strategies and clearly modeled their strategy to present to the whole class.

8. Strategy share out.
    a. Have selected students share their strategy models for the whole class. Have students pay attention to how their peers modeled their strategy in a detailed, step-by-step way.
9. Close the lesson by reviewing objective. Have student "think, pair, share" the most important aspects of explaining their thinking with a model.

Explain Your Thinking Rubric

Category	4- Advanced	3- Proficient	2- Approaching	1- Beginning
Labels	• All work is labeled	• Mostly labeled	• Some labels	• No labels
Show Evidence	• Model is detailed and step-by-step	• Model is detailed	• Model is present	• Model is hard to understand or missing
Explain/Justify	• Explanation is detailed and clear • Explanation includes reasoning of all steps for solving	• Explanation is clear • Explanation includes reasoning of some steps for solving	• Explanation is difficult to understand • There is little reasoning included	• Explanation is missing parts or missing
Presentation	• Work is neat, organized, and easy to read	Work is mostly neat, organized, and easy to read	Work is sloppy, but readable	• Work is unable to read

Explain Your Thinking Self-Assessment Tool

For the labels category, the score I give myself is __________, because ________________

____

____.

For the show evidence category, the score I give myself is __________, because __________

____

____.

For the explain/justify category, the score I give myself is __________, because ______

____

____.

For the presentation category, the score I give myself is __________, because ________

____

____.

Story Problem 4

Avery has 22 Legos. Jackson has 23 Legos. How many Legos do Avery and Jackson have all together?

Show Evidence (model, drawing, equations, etc):

Explain:

First I ____.

Then I____.

Then I ____That gave me the answer ____________________. I used this strategy because ___________________

____.

Lesson 10: How to Explain Your Thinking in Writing

Standards

- CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
- CCSS.MATH.CONTENT.2.OA.A.1 Represent and solve problems involving addition and subtraction
- ELD: C. Productive 9. Expressing information and ideas in formal oral presentations on academic topics.

Lesson Objective

Students will be able to justify their mathematical thinking using a written/oral explanation.

Length of Lesson:

45 minutes

Assessment

Students will complete a story problem. In addition to using a model, students will explain how they solved the problem using a written/oral explanation.

Resource Materials

- Projector
- Model Problem Response
- Story Problem
- Explain Your Answer Anchor Chart
- Explain Your Answer Sentence Frame
- Explain Your Answer Rubric
- Access to Technology (i.e., iPad or Chromebook)

Teacher Instructional Steps

1. Review Lesson 1. Discuss with students how they used a model to show their strategy for solving a word problem. Students should call to mind that students used different strategies to solve and met the expectations of an advanced model according to the Explain Your Answer Rubric.
2. State the objective. In this lesson, students will add on to their explanation by adding a written explanation to their model.
3. Review the model of your strategy. Consider briefly reviewing think aloud from Lesson 1
4. Model how to explain your thinking in writing. See teacher think aloud as an example to support modeling this practice.
    a. Teacher: “Now we’re going to practice explaining our thinking. Sometimes we explain aloud in a recording in our screencast and sometimes we will write our explanation down. Today we will practice writing our explanation.”
    b. Introduce Explain Your Thinking Sentence Frame.
    c. Teacher: “Here’s how I would explain my thinking: First, I drew 22 Legos. I draw them in groups of tens and ones because that’s easier for me than counting by ones. Then I drew 23 Legos in groups of tens and ones because that’s how many Legos were added. Then I counted all my tens first because I can keep that in my head easily and there were 40. Then I added the 2 and the 3 to make 5. Then I added my tens and ones; 40 and 5 makes 45. That makes 45 in all. I added them altogether because the problem asked how many Legos there were altogether. I know that altogether is a signal to add.
5. Teacher models scoring on a rubric using their own strategy explanation.

   a. Read the explain/justify category aloud and the expectations for an advanced score (4).
   b. Review your written explanation example. Think aloud a score for your written explanation i.e., “Let’s see, is my explanation detailed and clear? You bet! Does my explanation include a reasoning for all of the steps for solving? Yes!” Complete the Self-assessment accordingly.
6. Students review their strategies and models from Lesson 1. Students should refresh their memory on how they solved the problem. They should think about the strategy they used, why they used that strategy, and how they solved step-by-step.
7. Practice explaining your thinking aloud
   a. Have students first think about their response.
   b. Students then share their response with a partner. Listen in as students share with each other. Listen for a model student explanation.
   c. Share out, or have a student share, a model explanation.
8. Release students to work independently to complete their explanation in writing. As students work, conference with individuals to provide scaffolded support. When done, students should self-assess according to the rubric.
9. Complete gallery-walk.
   a. Students leave their work where it is and quietly walk around and look at how others explained their strategies.
   b. Ask them to think critically about questions they have about the work of others.

c. Give students a few minutes to view other's work. Once they've circulated call students back to their seats. During the gallery walk, the teacher should identify 2-4 students who clearly explained their strategy in writing to present to the whole class.

10. Strategy share out.

    a. Have selected students share their strategy models for the whole class. Have students pay attention to how their peers modeled their strategy in a detailed, step-by-step way.

11. Close the lesson by reviewing objective. Have student "think, pair, share" the most important aspects of explaining their thinking with a written explanation.

Lesson 11: Classroom Mathematical Norms

Standards

- CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
- ELD: B. Interpretive 5. Listening actively to spoken English in a range of social and academic contexts

Lesson Objective

Students will be able to listen, ask questions, and critique the mathematical thinking of a peer according to the classroom mathematical discussion norms: treat each other with respect, give each other time to think, participate in discussion, speak loudly and clearly, listen and repeat speaker's ideas, explain why you agree or disagree, remember that it is ok to make mistakes and revise our thinking.

Length of Lesson

45 minutes

Assessment

Students will write on a sticky note which mathematical norm is most important to them and why.

Resource Materials

- Mathematical Norms Anchor Chart (Kazemi & Hintz, 2014, p. 22)
- Teacher Example and Student work from Lessons 1 and 2

Teacher Instructional Steps

1. State the objective. In this lesson, students will learn how to have a respectful discussion about mathematics including thinking critically about each other's reasoning and agreeing and disagreeing with peers.
2. Review the Mathematical Norms Anchor Chart with students. Read each statement aloud and have students repeat orally. Discuss each by asking students the meaning of each. Consider modeling the expectations for each norm. See example think aloud.
   a. "Treat each other with respect at all times. Boys and girls, what do you think it means to treat each other with respect at all times when a student is sharing their mathematical thinking?"
   b. Students may respond with not goofing off and listening to their peers.
   c. Have students model what it looks like to not meet this expectation as you share your thinking from the example from Lessons 1 and 2. Students should act uninterested, interrupt, goof off, and move around.
   d. Have students model what it looks and sounds like to meet this expectation by sitting quietly and listening attentively.
3. Teacher explains her solution from the problem in Lesson 1 and 2 calling to mind the norms.
4. Two or three students can also orally share their explanations with the class. During this exercise, the teacher should support students in asking questions, having students repeat ideas, and agree or disagree with the students' reasoning. This will be more formally addressed in the next lesson.
5. Facilitate a discussion regarding how the class adhered to the mathematical discussion norms of the classroom, by going through each statement and checking off those that were successful and those that could use more practice. See example think aloud.

   a. "Class, thank you for participating in our mathematical discussion. Can we look at our list of norms and see how well we followed the norms? Did we treat each other with respect at all times?"
   b. Students respond.
   c. "Can you give an example of how we did or did not treat each other with respect at all times?"

6. Close the lesson by reviewing objective. Have student "think, pair, share" the mathematical norm that is most important to them and why. Students should write their response on sticky note and add to the anchor chart.

Lesson 12: How to Question a Peer's Argument

Standards

- CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
- ELD: B. Interpretive 5. Listening actively to spoken English in a range of social and academic contexts

Lesson Objective

Students will be able to listen, ask questions, and critique the mathematical thinking of a peer by using questions from the Critiquing the Arguments of Other's tool.

Length of Lesson

45 minutes

Assessment

Students will be able to ask questions of their peers. Teacher will make observations and take annotated notes based on student questioning using the Critiquing of Other's tool and well as listening to student discussions.

Resource Materials

- Mathematical Norms Anchor Chart
- Critiquing the Arguments of Others Tool

Teacher Instructional Steps

1. Review Lesson 3 Mathematical Norms. Read over the Mathematical Norms Anchor Chart. Remind students that in order to have successful mathematical discourse or conversation, students must feel safe to share.

2. State the objective. In today's lesson, students are going to think critically about the explanation of their peer's solution. They will ask each other questions and then have to answer others to justify their mathematical thinking and reasoning.
3. Introduce tool. Read questions from the Critiquing the Arguments of Others Tool aloud in parts. Have students repeat back questions orally. Have students practice asking questions with their partners.
4. Model the Critique
    a. Using the teacher model from the Lessons 1 & 2, bring a student up to ask questions from the strategy category. Students may also turn these questions into restated statements or compliments. Here are some example responses:
        i. "What strategy did you use to solve the problem? "I used a model to add groups together."
            1. "I noticed that you drew a model using tens and ones."
        ii. Why did you decide to use that strategy? "I used a model so that I could count the Legos by tens and ones."
            1. "I think the strategy to use tens and ones is an efficient strategy compared to counting by ones."
        iii. Does that strategy always work? "I don't have any examples when it hasn't."
        iv. Did you try any other strategies? "No, I didn't."
    b. Using a student model from Lessons 1 & 2, bring a student up to make statements from the "Think Critically" and "Compare and Contrast Strategies" categories. Here are example responses:
        i. I wonder why you added the tens (20+ 20) first.

1. I like how you used your knowledge to add 20 and 20. That was different than counting by tens.

ii. I noticed that that you didn't draw a model.

iii. I have a question about how you would model this.

iv. I think I'd like to try your strategy on a similar problem.

v. What is similar about our strategies?

vi. What is different about our strategies?

5. Practice using the Critiquing the Arguments of Others Tool whole group. Bring two-four students up to explain their model and strategy. Elicit questions from the rest of the students according to the Critiquing the Arguments of Others Tool.
   a. At some point, during small group instruction, partner students to use the Critiquing the Arguments of Others Tool. Provide teacher guidance and support.
6. Close the lesson by reviewing objective. Have student "think, pair, share" at least one question from each category of the tool.
   a. After this lesson, students may critique and ask questions as peer feedback directly on screencast videos.

Critiquing the Arguments of Others

Strategy Talk

- ✓ Explain your evidence.
- ✓ What strategy did you use to solve the problem?
- ✓ Why did you decide to use that strategy?
- ✓ Does that strategy always work?
- ✓ Did you try any other strategies?
- ✓ Did you try a strategy that didn't work?
    - o Why did you try that strategy?
    - o Why didn't it work?

Think Critically

- ✓ I wonder why...?
- ✓ I noticed that...
- ✓ I have a question about...
- ✓ I think...

Compare and Contrast Strategies

- ✓ What is similar about our strategies?

What is different about our strategies

Summative Assessment Metacognition & Mathematical Arguments Post-Assessment

Give students a mathematical story problem to solve that meets mathematical content standards. Problems that lend themselves well to multiple strategies for solving are best. Have students create a screencast solving the problem. They should solve only on the screencast using the drawing, text box, and recording tools. Students should record as they draw and complete the problem for the most authentic representation of their thinking. After completing the screencast video, students provide feedback on a peer's post in the online digital portfolio. Finally, students should self-assess their screencast, mathematical arguments, and peer feedback,

Tools for Assessment:

Metacognitive Thinking -I Can Be a Problem Solver checklist

Mathematical Arguments- Use the Explain My Thinking Rubric to assess students' ability to make mathematical arguments.

Peer Feedback/Critiquing the Arguments of Others- Peer Commenting Rubric

Self-assessment- for each of the above, match student's self-assessment, with teacher assessment.

CHAPTER FIVE

PROJECT RECCOMMENDATIONS

The Common Core State Standards for Mathematics (CCSSM) require students in kindergarten through 12^{th} grade to demonstrate understanding of mathematical process skills. These process skills are highlighted in the eight Standards for Mathematical Practice (SMPs). One of these SMPs is to “construct viable arguments and critique the reasoning of others.” The problem teachers face is how to develop instructional tools and strategies to support these cognitive abilities. This project is designed for elementary teachers providing instructional strategies and tools that might support students in their ability to make mathematical arguments. This project includes three major areas of development. Screencast technology tools were used to communicate mathematical arguments and metacognitive thinking. Metacognition strategies are then developed to support students in their ability to make those arguments. Lastly, tools and strategies were created to teach students how to make higher-level mathematical arguments. This chapter includes lessons learned, educational implications, project implementation plans, limitations of this project, future research, and project suggestions for unit development.

Lessons Learned

My math instruction has improved tremendously due to the creation of this project, and more importantly, the process of creating it. The development of this unit was a long process. More than anything, I was reminded of the time and attention to detail it takes to plan a quality unit of study. Some specific lessons in this vein include the need for backward planning, the level of detail needed for each lesson, and developmentally appropriate chunking of lesson activities.

I originally laid out an outline for the unit of study. This outline included lessons I have implemented in the past without the level of planning that this unit required. Once the outline was created, I began writing each lesson. In this process, I found myself constantly asking myself "what is it that I want my students to be able to do?" This is where the Understanding by Design Framework (Wiggins & McTighe, 1998) became an apparent need in my unit design. Using this framework allowed further development of each unit beginning with the end in mind. This also led to the importance of including standards, objectives, assessment, and resource materials for each lesson.

As I began creating the instructional steps for each lesson, I wrote in a way that made sense to me and the implementation plan according to how my classroom runs. It was not until someone else read a lesson that I realized I needed much greater detail in the instructional steps. In this realization, I went back and tried to write each lesson so that any teacher would be prepared to implement the plan versus someone who has spent countless hours researching and thinking about the unit topics. These changes included the addition of examples for teacher think-alouds and overall more information to support what each lesson activity might look like in a classroom.

Lastly, the creation of this unit helped me to break lessons down into developmentally appropriate chunks allowing adequate time for students to practice with each learning objective. I learned through the process that in my zealousness to create innovative and meaningful lessons, I jump right in and move too fast. The revision process of this unit helped me to slow down the unit timeline and chunk lessons more appropriately for the learning needs of my primary elementary students.

This unit contains 12 lessons all surrounding one Standard for Mathematical Practice. I passionately believe that this practice will support students' deep understanding of the content standards so 12 lessons dedicated to the concept is well worth it. However, this is 12 lessons that have only sparingly touched on any mathematical content standard.

I believe the best instruction is created based on the individual students in your classroom. In the past, I have used curriculum that were made for whole group instruction and were very generalized. Granted, these curriculum all included strategies for differentiation, but they were developed to disseminate information to all students rather than learn about students' individual strengths, weaknesses, and learning styles and to teach accordingly. This unit supports teachers in their ability to individualize instruction based on the needs of their students. That being said, I learned that building a unit based on individualized instruction is difficult. A unit must be created so that any teacher can implement in their own classroom. My teaching style may vary drastically from another teacher's and so the unit I design must address the teaching style of all those who may implement this unit in their classrooms. Perhaps the best unit is one that supports teachers in creating individualized instruction by creating tools, strategies, and structures, but leaves room for teachers to personalize for their own needs and the needs of their students.

Lastly, I learned the importance of using research to create tools. The tools that I created for the unit morphed and shifted the more and more research I read. I had a general idea of what the tools would look like based on my experience with instructional tools when deciding on this project, but it was in the research that these tools were adapted and completed for use with students. I also found that in sharing these tools, teachers implementing this unit responded most to the research based tools such as the "I Can Be a Problem Solver Checklist" and the

"Critiquing the Arguments of Others Tool." These tools were an adaptation from the research of Wilson and Clarke (2004). They were used in quantitative studies that explored metacognition and mathematical arguments with students. The changes made were to address the younger aged students than that of the research population. In sharing my unit, teachers commented on the clarity of the statements used and the organization of the tools.

Educational Implications

This project builds off the body of research that supports the use of metacognitive strategies in all content areas, specifically in this case, mathematics (Carr & Jessup, 1994; Van der Stel & Veenman, 2010). The tools created in this area, while adapted from the research, are appropriate and can be used with primary elementary aged students (King, 1991). Screencast technologies might serve as a means of collecting real time student think-alouds. The use of technology builds on the work of Artzt and Thomas (1992) and the use of think-alouds to assess metacognition.

Mathematical justifications are widely used at the secondary level. This project engaged elementary students in making and supporting mathematical arguments using various models (Ericsson & Simon, 1998). These arguments were further supported by mathematical norms and language supports, traditionally used in other content areas, to encourage students to share mathematical thinking and critique the arguments of others (Kazemi & Hintz, 2014; Ross, Fisher, & Frey, 2009).

It is important to know while rolling out this unit, mastery for both the teacher and the students will take time. The curriculum supports all details of implementation but only time, experimentation, and reflection will truly allow for comfort and ease. Teachers must expect and accept this fact in order to support students properly. Students may need one or more lessons repeated to develop security. Embracing the idea of process over product may, in time, enhance the student product.

There are different structures that support mathematical arguments and developmental learning. One includes small group rotations where all students complete the problem at different times and class discussion takes place at the end of rotations and problem solving as well as in the class digital blog. Other classrooms opt for all students working on the problem simultaneously and then discussing orally and in blog. The format is dependent on teacher preference and comfort. Regardless, students must build stamina in problem solving. The expectation for problem solving time should be that students are working in a focused manner independently. They should use their problem-solving skills to persevere through the process allowing the teacher to work with students in the interview manner discussed before.

This unit creates a structure for the third Standard for Mathematical Practice. This structure can be used in all problem solving across the content curriculum. The time and energy put into implementing this unit will span the course of an entire school year. Also, this unit is naturally differentiated. All of the tools are meant to support all student, but it is up to the teacher to create plan for individual students based on how students are interacting with the tools.

Project Implementation Plans

Parts of this unit were implemented in my second-grade classroom. It was this instruction that led me to make reflective changes to the unit until it has evolved into this version. In collaborative mathematical conversations, my second-grade team has showed interest in implementing this unit in their classrooms. Upon successful implementation, I will share with other grade levels because many of the tools could be implemented with all elementary grade levels. I will definitely share with our district mathematics Teacher on Special Assignment. The feedback from my colleagues will definitely mean further reflections and revisions. In sum, upon further implementation, this unit will have, as many curriculum do, several editions.

Limitations of Project

This project has several limitations. The project, as is, assumes that teachers already have a developed level of comfort and skillset when using and teaching with technology. A novice with technology might have challenges implementing the screencast part of the unit. In order to implement the screencast part of the unit access to technology is required. The unit is written based on a one-to-one classroom. Classrooms that have limited access, may find the management more challenging to implement. Perhaps the greatest limitation, in my mind, is the possibility that teachers will use student screencast videos as the only assessment of mathematical arguments.

With more time, I would have added many lessons to the screencast unit. Upon finishing the unit, I realized that a certain comfort with tablet and screencast technology would be required to facilitate lesson one of this unit. Therefore, a novice tablet user would require more skill development before implementing the plan outlined in this unit.

Access to technology is a consideration in the current educational setting. Our school site is fortunate to have one-to-one tablet technology. The major use of technology is to aid teachers in collecting students' mathematical arguments. This tool helps teachers with the issue of time. It would be inconceivable to expect teachers to listen to all students' mathematical arguments for every problem that they complete. Using screencast technologies allows teachers to collect real-time thoughts from all students for any given problem. It also provides a record that can be shared and discussed after the fact with students, peers, and parents. That being said, teachers can still implement units two and three to support students in their ability to make mathematical arguments. There are other ways to assess these abilities such as conferencing with students one-on-one or in small groups or in collaborative share time with a group of students.

This leads to the risk that teachers will only use screencast technology to collect information without meeting with students in small groups or one-on-one or facilitate large group discussions. One of the greatest facilitation tools a teacher has is guided questioning. There is no substitute for working with students and asking questions to facilitate their thinking and argumentation.

Future Research or Project Suggestions

First and foremost, I aspire to design a research study for this unit. My experience with this unit and mathematical arguments give me great cause to believe in its effectiveness for student learning, but this is by no means a scientific assessment. A future study would include a systematic design that analyzes the pre-and post-assessments from this curriculum and measures for statistical significance.

Additionally, further research on student created screencasts is necessary in the educational community. These screencasts are implemented in classrooms across the country on a daily basis. Further research in this area would only serve to drive this instruction in a positive direction.

There are eight very valuable Standards for Mathematical Practice that should be embedded in mathematical units of study kindergarten through twelfth grade. A curriculum that supports all SMPs would be a great support for all teachers. This unit could serve as a foundation for the creation of others and could potentially build upon the current unit to create a curriculum.

Ideally, a classroom would utilize an online, digital portfolio to communicate their mathematical arguments to a greater audience. Students could connect online to their teacher, classmates, and family members who can be invited to connect to online student portfolios potentially creating an authentic home-school connection. This is pertinent especially when thinking of new ways to cultivate the home-school relationship and parental involvement, particularly with families that speak a language other than English in the home (Alfaro, O'Reily-Diaz & Lopez, 2014). This area could be further developed to include parent trainings.

Conclusion

The introduction provided a basis for further understanding the development of the Elementary Mathematical Arguments: A Guide to Using Metacognition and Screencast Technology to Support Students. This unit addressed the problem of providing a tool for teachers a tool to support mathematical cognitive understanding using the third SMP: making mathematical arguments and critiquing the arguments of others. Chapter two provided a literature review of past research that provided a foundation for the unit's lessons, tools, and instructional strategies. Chapter three outlined the process for creating the unit as well as provided a context for which the unit was implemented. Additionally, this methods chapter provided a list of instruments with outlined examples. The three-unit project was contained in chapter four. This project encompassed lessons, tools, instructional strategies, and assessments to aid in answering the question: What might a set of instructional strategies and tools look like to support second grade students' development of mathematical arguments, in a linguistically diverse, southern California classroom? Lastly, the concluding chapter outlined lessons learned, implications for education, an implementation plan for the project, limitations for the project, and future research or project suggestions.

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