Annotated Bibliography

Chahine, Iman. (2013). The impact of using multiple modalities on students' acquisition of fractional knowledge: An international study in embodied mathematics across semiotic cultures. The Journal of Mathematical Behavior. 32. 434–449. 10.1016/j.jmathb.2013.04.004.

This study was conducted to investigate the impact of using curriculum that employs multiple modalities on the performance of 5th grade students. The performance was based on the concept of unit, fraction equivalence, and fraction comparison. The sample included five schools and eighteen fifth grade classrooms that were randomly assigned to multimodal (experimental) and monomodal (control) curriculum groups. Data was collected by tests, interviews, and classroom observations. The results of the study did align with the hypothesis that using multiple modalities would help facilitate the understanding of basic math (fraction) concepts. "Experiencing fraction concepts as embodied in various modalities within relevant situations enabled RNP students to build broader conceptualization of what fractions mean thus seeing fractional knowledge from a wider context. RNP students flexibly adjust their understanding of fractions thus transforming concepts into skills accentuated by the use of multiple modalities" (14). "Additionally, by exposing the students to various modes of representations, teachers can understand students' misconceptions and idiosyncratic algorithms, which emanate from problem solving driven by rule memorization and mechanical procedures" (15). These results align with our own research question and findings. We focused on understanding the unique strategies students would share and reflect with each other when solving a problem. This ties to the article in the sense that effective learning does happen through

conversation and different ways of thinking. If student thinking is only done through memorization and procedure then we as educators also can't really understand the misconceptions our students have with math since their thinking is not shared. I would argue that the more participation we have amongst all students the better chance we can find ways to connect with our students. By having greater connection and rapport with our students we can also see more engagement, motivation, and confidence within our students.

Educator's Voice, 2015, Critical thinking and problem solving for the 21st century learner inquiry based learning: Preparing young learners for the demands of the 21st century., pp. 16-24. Volume VIII.

In this article by Educator's Voice, the study was conducted in a secondary level classroom on the premise of gamifying the math lesson. Gamification within the classroom allowed for an interactive process of discovery that focused on teaching higher order thinking skills. The "lesson was taught multiple times to diverse learners in varied contexts 7th-, 11th- and 12th grade students and college students enrolled in a graduate-level course". Derek Stoll, one of the writer's of this article, introduced the topic of functions as machines and dynamic puzzles. The idea for this lesson was to create an environment where "exploration, collaboration, levels, and storytelling" would take place. "One of the first things you can do to gamify your lesson is to create a dilemma or problem (or situational interest) that catches and holds your students' interest and immediately immerses students in the learning. It doesn't have to be an especially difficult or troubling situation, but it should engender sufficient situational interest". There was another rule also implemented and that had to do with students not erasing any

of their responses. This allowed for a learning environment conducive to risk taking in which collaboration and a growth mindset was instilled by allowing the students to work together and progress throughout the learning process. During the lesson, students were to analyze patterns they noticed with different math machines located throughout the classroom. Once the students identified and analyzed their pattern findings they were to share their findings with the entire class. Regardless of the learners' experience with, knowledge of, or interest in mathematics, all reported gaining a greater understanding and appreciation for mathematics in general and functions in particular. In essence, I think the rule they implemented with students not erasing their responses was key to allowing students to work collaboratively and not be afraid of making mistakes. This makes me realize the importance of being able to deliver quick feedback to students and allow students to give each other feedback. This idea of gamifying a lesson is closely related to the use of desmos and how it works. I believe that desmos has the same properties or components of gamifying a lesson allowing the teacher to manipulate the responses and sharing them with everyone while keeping the responses anonymous. One thing I find difficult however is the ability to have students share their own individual ideas compared to following an idea from their group or peers. One thing that has helped is creating group roles to keep students accountable. By creating group roles I have also noticed students keeping each other accountable and allowing more scholars to speak up one way or another. Overall, this idea of gamifying a lesson by creating a no judgment space is key but also hooking the students at the beginning is also very important. I think that to be able to create a story or hooking a large group of audience with a story requires some deep intentional planning. Something I find takes a lot of patience and experience.

Fedeli, Laura, December 3, 2022, Participation and feedback as motivational triggers: Insights from online students' approach to learning., J*ournal of E-Learning and Knowledge Society,* Vol. 18, No. 1 (2022), pp. 1-10.

In Participation and Feedback as Motivational Triggers (Fedeli, 2022) the article discusses the importance of collaborative learning activities that foster motivation. In this study, the author is primarily interested in understanding how active student participation can be a motivational challenge as well as how both professor and peer feedback can be a key promoting aspect. The study was conducted through the use of two qualitative case studies during the pandemic. It took place during a three year science degree program at the University of Macerata, Italy. The research was on how professors could better serve and motivate their students during their hands-on workshops while learning virtually. Some key findings that took place in the study included how hands-on activities helped the students develop high level transversal skills that also played a role with their use of digital interaction and collaboration tools. Since it was the first time these students were experiencing both online and in person learning, they were motivated the most when being enrolled in the Instructional Technology course. The reason for their motivation was that the digital tools used in the course would help them with their participation in the online activities. Furthermore, to supplement their use of the digital tools the students felt that the hands-on activities allowed them to develop high level transversal skills as well as professional skills. The results given include students feeling they acquire deeper reflection when meeting in person, talking directly, and getting to know each other better. The study also mentioned how feedback amongst students was something they needed to learn how to develop. However, when students

provide feedback to each other, are more reflective on their learning, and are given assessments more often they are capable of getting so much more out of their learning. In essence, providing feedback is one way students can have more participation with each other and learn how to be more open to making mistakes. The other part of the results included students' decision on whether or not the professor should keep any part of the online course design. Most students would maintain the section of the course with group activities but a large portion of the students would also like to continue having the group activities in both an online setting as well as in person. Students argued that the online tools would provide immediate feedback from the professors by monitoring student activity closely. This would result in more active participation and greater achievement in the course. I think these results are important to consider now that we are integrating more technology into our classrooms and specifically into math. Today, I use multiple software tools such as websites and other resources to allow my students to learn but this study makes it clear that it is still important for students to learn collectively by engaging with each other and discussing their thinking with each other. The idea is how I can better supplement my students' thinking and pattern construction with technology. I think that within the last few years education has shifted dramatically. There are a lot of new technologies that can be used and new ways of teaching and learning but we must stick to the basics and focus on specific intentional teaching and learning. For me, as a teacher I am struggling with finding the time to not only be intentional with my teaching but also provide immediate feedback. I think that by taking this course and continuing to gain more experience I will find a nice balance in building intentional lessons as well as providing feedback. I also think that this article connects with many common themes in

effective math learning. Providing feedback can happen in so many different ways and one way is through the use of Desmos which is similar to the idea of gamifying lessons. Something else that comes to mind when I think of feedback is differentiation and grading. My team at my school site is struggling with creating lessons that suit all different math levels within the classroom. The struggle is that our math classes have students enrolled and testing at polar math levels. What I think will be useful is in creating lessons that continue to have a lot of discussion and active participation through movement and swapping of ideas. I also think that by providing formal assessments more often I can allow for students to know where they stand in the course and to be willing to provide more feedback to each other.

National Council of Teachers of Mathematics (NCTM). (2014). Principles to Actions: Ensuring Mathematical Success for All. Effective Teaching and Learning, (17-24).

In the article, Principles to Actions, the author differentiates lower level demand math tasks with higher level demand tasks and gives evidence as to why high level tasks are so important for learning in all grade levels. "To ensure that students have the opportunity to engage in high-level thinking, teachers must regularly select and implement tasks that promote reasoning and problem solving. These tasks encourage reasoning and access to mathematics through multiple entry points, including the use of different representations and tools, and they foster the solving of problems through varied solution strategies (17)". The author also argues that these tasks provide an insight into student sense of identity which leads to increased engagement and motivation in mathematics. Lower level demand tasks are considered memorization or procedural tasks without connections. Higher level demand tasks are procedures with connections or what is considered to be

the “doing of mathematics” which allows students to analyze, explore, and requires a considerable cognitive effort. The work collected and the examples given range from different tasks within math classes ranging from all grade levels. The tasks include how to multiply fractions and giving examples with low level demands such as memorization vs. procedures with connections which include example pictures and stories to explain the multiplying of fractions. Other tasks include solving systems of equations by using word problems compared to using procedures to solve. The results of the study indicate that “it is important to consider the prior knowledge and experiences of the students who will be engaged in the task (22)”. The results also indicate that “teachers must decide what aspects of a task to highlight, how to organize and orchestrate the work of the students, what questions to ask to challenge those with varied levels of expertise, and how to support students without taking over the process of thinking for them and thus eliminating the challenge (22)”. I think these examples and results tie things nicely to everything else I have been reading and to my research lesson. What caught my attention was specifically two things: How does higher level demand tasks promote the building of a strong sense of identity and motivation among students. The other would be how I can improve as a teacher in understanding prior knowledge and experiences of my students as well as supporting my students during their lessons without taking over the process of thinking for them. As a result of everything I am learning, I have been trying to better understand my students’ math abilities to provide them with content that pertains to their specific math level. I also think this will guide me in being more intentional with the questions I ask my students without taking over the process of thinking for them.

Zbiek, R.M., Peters, S.A., Galluzzo, B. *et al.* Secondary mathematics teachers learning to do and

teach mathematical modeling: a trajectory. *J Math Teacher Educ* (2022).

This article focused on "secondary mathematics teachers' perceptions of the experiences that contributed to their capacities to understand mathematical modeling and to facilitate students' modeling experiences" (1). Mathematical modeling (MM) is a "process that uses mathematics to represent, analyze, make predictions or otherwise provide insight into real-world phenomena" (2). The results discussed five different teacher experiences who had five interconnected knowledge schemes - math modeling as mathematics, social aspects of working together, context awareness, attention to students, and nature of curriculum. The study occurred over the course of several years and captured the wide range of experiences from the different teachers. All five teachers had different backgrounds ranging from three being public school teachers and two being private school teachers. All five teachers were American and had varying degrees ranging from no teaching degree to three of them having graduate degrees in education. The study analyzed how the five teachers developed an understanding of the doing and teaching of MM. The teachers' understanding of MM was led by different triggers within a variety of settings. Those settings included math and education courses, conferences and workshops, faculty meetings, planning and discussing math lessons, interactions with colleagues, and interaction with students as well. "Triggers prompted dilemmas that challenged teachers' sense of what mathematics is, how one does mathematics, or what teaching and being a teacher are. Teachers' resolutions to their dilemmas led to advances in their knowledge schemes and in their doing and teaching MM perspectives" (19). The advancement in teacher knowledge schemes was based on engaging in critical reflection and rational discourse to understand multiple perspectives. The results indicated that all

five schemes are interrelated and that learning from one scheme helps to learn how to facilitate MM. Some examples of teacher experiences included how they wanted their students to go through productive struggle and teamwork with challenging ideas. As a result the teacher began to strategically place teams together based on different individual strengths as well as including both atomistic and holistic approaches to MM. Another teacher experience was led by her work with an open-ended mathematics problem. Her experience was unique as she not only was a student trying to solve a MM problem but also got to see how her instructor facilitated and created a safe space for them to learn. The teachers' experiences with the different MM problems helped them better understand the importance of teacher preparation. These effective teaching practices " include the need for teachers to use and value multiple representations and various approaches (strategies and solutions), to communicate mathematically, to engage students in productive struggle, and to attend to student thinking" (21). The results indicate that teachers must go through activities and make connections with different meaning schemes that are not common in teacher education. Teachers should take PD training to better understand the meaning of MM and how to teach MM. One thing that really caught my attention in this study is the idea of productive struggle. During my own lesson preparation we came up with a lesson that was story based and purpose was to have a rich classroom discussion. We planned how to execute the lesson. I envisioned my students moving around, sharing their ideas through discussion but also with images on their whiteboard. Nevertheless, I realize that it takes time for students to really digest information and share their insight. I also connected the real world component of MM with my own lesson. MM is a way to apply math with real world examples and I believe

most of the lessons we are creating as teachers apply that concept of building engaging lessons that are reflective of the real world. One thing that is clear is that these lessons take time to prepare and unfold. As I continue to learn about MM I hope to continue to improve on creating lessons that are effective in connecting real world examples.