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DESIGNING AND IMPLEMENTING ARGUMENTATION THROUGH DIGITAL PLATFORM: A FRAMEWORK FOR BEGINNING 3RD-6TH SCIENCE EDUCATORS

by

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A capstone submitted in partial fulfillment of the requirements for the degree of Master of Arts in Education: Natural Science and Environmental Education.

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CHAPTER ONE

Introduction

Introduction and Project Question

In reflecting upon my time as a middle school STEM (science, technology, engineering and math) teacher in an urban district, three ideas stand out in my mind: the importance of enhancing students' argumentation skills, the growing role of technology in the classroom, and the challenge of accommodating an increasingly diverse student body. A cursory review of the literature suggests that the broader community of educators face similar challenges and highlights the need for practical solutions to address them. To this end, I conceptualized a capstone that will help bridge this gap between research and practice by aiding teachers in their design and implementation of argumentation—drawing upon best practices in lesson design, classroom technology use, and supporting diverse learners. Ultimately my capstone will explore the question: *How can 3rd - 6th grade educators design and implement science argumentation through a digital medium?*

In Chapter 1, I share my personal observations surrounding this need and contextualize them within the broader literature base. This chapter concludes with a brief overview of the framework I designed with the goal of better preparing science teachers for rich discourse within their science classrooms.

Personal Observations

Over the course of my four years teaching upper elementary and middle school STEM, my teaching practices have evolved substantially to account for a notable shift in educational pedagogy. My first two years as a teacher involved helping to establish a charter school within a high-needs community with historically underperforming schools. The school we created held strict guidelines for behavior (including *when* and *how* students were allowed to communicate with one another), a model which lent itself to many successes and failures. Apparent benefits included tranquil classroom environments that encouraged students to complete work independently and with few distractions. As a result, low-performing students improved significantly in core subjects, and school-wide data suggested a narrowing achievement gap. Despite these laudable improvements in student performance, the strict behavioral expectations and the emphasis on quiet complacency detracted from learning in other ways. The environment made it feel impossible to allow students to guide their own inquiry or ask critical questions. Open dialogue between students felt daunting and often resulted in chaos. Though the students were fully capable of thoughtful discourse, teachers were ill-equipped to guide them through the process.

If one were to observe my current classroom, they would see a very different picture, one filled with discussion, rebuttals, inquiry--an *organized* chaos. Students are aware of the guidelines to the practices of scientists and engineers and are able to utilize those to drive discourse and engagement. My district utilized an online-based curriculum and because of the pandemic, I was also routinely utilizing all features of google classroom in order to implement instruction for distance learning. With more training in student-driven inquiry and discourse under my belt, I feel better prepared to facilitate this process. Nevertheless, it took significant trial-and-error--not to mention patience--to arrive at this stage. I often hear from colleagues who avoid argumentation practices for a variety of reasons, among them concerns about managing behaviors and maintaining engagement. Additionally, many have expressed a lack of explicit training in this style of teaching and inadequate resources to support the process. It is difficult to find argumentation tools or guidelines that are flexible and can be adapted to fit the unique context of one's classroom, school, community and environment. Many existing resources are specific to certain scientific principles/phenomena, which may not be relevant to curriculum or appropriate for the student population. Finally, colleagues have noted the challenges of supporting students with varying abilities and learning needs through the process of argumentation.

In my current position, English language learners (ELLs) comprise a significant portion of the student population. Varying levels of cognitive academic language proficiency (CALP) can interfere with students' oral and written argumentation, leading to frustration and disengagement. In working with a large population of ELLs, I have seen the frustration that a lack of language plus content knowledge can bring. Many are confused about the argumentation process and are not seeing how each of the steps of the framework are connected to each other.

With the pandemic occurred and students and teachers quickly adapting to online learning, there has been a large shift in instruction. Many of us have never received instruction in online learning, or even how to utilize simple system functions for curriculum online. My students were using technology before the pandemic and even with me implementing this curriculum, I never had to attend to a professional development to learn how to use it. This global challenge brought many of the traditional educational landscape’s deficiencies to the surface, including need for more critical thinking and argumentation, the need for technology to be utilized within classes and the need for equitable practices across an increasingly diverse population.

Rationale

My experiences as an upper elementary and middle school STEM teacher and my observations from the field engendered the idea for this proposed capstone project: a framework for 3rd - 6th grade science teachers to guide the implementation of student argumentation via digital platforms. It was shaped by the belief that argumentation should not be avoided in science classrooms because of lack of experience or clarity surrounding its practices. Three critical assumptions undergird this project. First, argumentation represents a vital practice in science education by teaching students to think critically about different scientific phenomena and their evidence, but many teachers lack the tools and training to design and implement it effectively. Second, in the wake of a global pandemic temporarily closing schools nationwide, districts are increasingly reliant on technology and virtual platforms to deliver learning. Though one can expect in-person schooling to resume eventually, educational trend forecasters suggest that virtual platforms will remain a critical avenue for teaching moving forward (Ally, 2019). Even before the pandemic, technology played a significant role in many classrooms, especially science. Lastly, American classrooms are increasingly heterogeneous in terms of student characteristics, and data forecasts suggest that student populations will continue to diversify, especially with respect to English language abilities (Hussar and Bailey, 2020). Thus, educators require support in accommodating argumentation practices to meet the needs of diverse learners.

Argumentation in Science Education

Argumentation can be defined as a discursive activity occurring in the context of a controversial issue when contrasting statements are used to support discordant claims (Leitão, 2000; Toulmin, 1958). Within science, argumentation involves generating arguments by extrapolating evidence to support or refute claims (Jiménez-Aleixandre & Erduran 2007). Recognizing the important role of scientific argumentation in developing students' critical thinking skills, the National Research Council included argumentation as a foundational skill within Next Generation Science Standards in (NGSS) established in 2013 (NGSS Lead States, 2013). Developed collaboratively with input from key cross-disciplinary stakeholders, these standards provide K-12 science educators with guidance related to content and practice, in order to best prepare students for college and careers. According to the NGSS, middle school students (grades 6-8) must be able to use evidence and reasoning to construct arguments that support or refute a claim (related to a scientific phenomenon). Science knowledge is built upon making these connections;

instilling argumentation skills in students is crucial to increasing scientific literacy and central to scientific practices (NRC, 2012).

The Shift to Digital Learning

During the global pandemic, schools in the United States turned to technology as a means of educating students. With most schools having physically closed their doors, educators must identify feasible, effective, reliable, and equitable methods for migrating learning to virtual platforms. Most formalized research on digital learning during the COVID-19 pandemic has yet to be disseminated. However, findings released in March 2020 suggest that 47.9 million US school children were affected by pandemic-related school closures (Fishbane & Tomer, 2020). This has catalyzed educational researchers, curriculum developers, and educational technology consultants to quickly mobilize in order to meet the demand and support this digital learning boom. It is estimated that the corporate E-learning sector will grow by approximately $38 billion from 2020 to 2024 (Tamm, 2020). Even before the COVID-19 global pandemic, a movement towards digital learning in science education was well underway. In 2002, the US Department of Education emphasized the importance of integrating technology in all K-12 classrooms. This sentiment was echoed by the National Academy of Sciences in 2017 when they recommended that STEM educators adapt their classrooms to stay current with technology and prepare students for an industry and economy in which technology lies at the forefront. Despite the increasing prevalence of technology in K-12 classrooms and the nationwide shift toward digital learning, there are several factors that preclude successful implementation. Barriers to digital learning can include lack of access to technological means (e.g., computers, internet, etc), incompatible systems, lack of student engagement, and limited adult oversight for students learning at home. Additionally, lack of educator training and expertise in how to utilize virtual platforms remains a significant obstacle (Bailey, 2016). This capstone project responds to this call-to-action, by seeking to better prepare teachers to effectively implement argumentation practices over a digital medium.

Diversity Considerations

Student populations in schools across the country are becoming increasingly more diverse. K-12 schools are continually rising in the number of ELL students (National Center on Education Statistics, 2015). Having taught in a diverse school and a school in which 90% of the student population is Latinx has afforded me with some insight into issues that arise with trying to implement science curriculum as is. Some issues include: students often do not have enough background knowledge on science concepts, there are not enough accommodations for ELL students, and the phenomena may not be relevant to the student population. Therefore, it is essential that schools continue to provide attention to this population in terms of professional development and resources to support all learners (Doran, 2017). The framework I provided includes guidance for English Language Learners. Response to Intervention (RTI) helps with the early identification of students with learning and behavioral needs through a multi-tiered approach. Through tiers of 1) high quality classroom instruction, 2) targeted interventions, and 3) intensive interventions, teachers can have their content be accessible to all learners. My argumentation framework will include support for students whose first language is not

English, that can be used for a variety of students as well. Historically, most of the research on instruction of English Learners has focused on English language proficiency, with limited emphasis on instruction of specific subjects, such as science (Lee, 2005).

Overview

As previously noted, the purpose of this capstone project is to equip 3rd - 6th grade science educators with foundational knowledge and guidelines to begin rolling-out argumentation in their online classrooms. Chapter two reviews the extant literature exploring the use of student discourse (e.g., argumentation) in STEM, considerations for virtual learning, and accommodations for multilingual students. Chapter three describes the framework development process, including an overview of each component that will be included in the permanent product. The framework will ideally enable science teachers to seamlessly incorporate argumentation into their classrooms and curricula, while enacting best practices in teaching argumentation, using technology in STEM, and creating an accessible and inclusive classroom environment. Chapter four emcompasses reflections from the project, including limitations and future directions.

CHAPTER TWO

Literature Review

Introduction

A type of pedagogical discourse, argumentation helps endow students with the critical conversational, written, and thinking skills to understand the world around them (Jiménez-Aleixandre, & Erduran, 2008). Despite extensive research exploring the need for argumentation as a core competency in classrooms around the world, educators infrequently implement argumentation due to its challenges (Osborne, 2010). Barriers with implementing argumentation across science classrooms include difficulties establishing a classroom culture that values argumentation, creating sound argumentation lessons, and managing student behavior and engagement during argumentation (Henderson et al., 2018). Limited teacher training and support related to this pedagogical approach further precludes implementation of argumentation in science classrooms (Henderson et al., 2018). Beyond understanding the science content, teachers must be equipped to structure, moderate, and evaluate the argument while meeting the unique learning needs of *all* students. Moreover, the unique and unprecedented context of the COVID-19 global pandemic created a new set of challenges, as educators learned to adapt to school closures and the transition to online distance learning. Forced to migrate instruction to a digital platform, despite limited preparation or training in this domain, has further complicated the implementation of traditional pedagogical approaches, such as argumentation. Additionally, changing demographics within schools in the United States demands that teachers be prepared to adapt their instruction to make it accessible for diverse students, particularly English language learners and students with disabilities. There is a need in education for more guidance and support for science teachers in the implementation of online argumentation for diverse learners (McNeill et al., 2016).

The purpose of this chapter is to provide an overview of the literature that forms the theoretical and conceptual base of the question *How can 3rd - 6th grade educators design and implement science argumentation through a digital medium?* This chapter will open with a discussion of the relevant research demonstrating the importance of discourse within education and highlighting the need for scientific argumentation skills to be practiced consistently in 3rd -6th grade science classrooms. Next, this chapter will address advancements in educational technology and implications for distance learning in the intermediacy of the COVID-19 global pandemic, including a discussion of technology-specific barriers. Additionally, this chapter will review how the diversification of US classrooms poses unique challenges to the implementation of argumentation and relevant diversity considerations. Finally, the chapter concludes by reviewing the role of teachers in supporting student argumentation, such as how to provide accommodations and feedback.

Student Discourse

Student discourse is the driving mechanism behind language acquisition, student engagement and student achievement. The ability to engage in discourse (i.e., spoken or written language) is fundamental to the ability to understand concepts, both in the classroom and in the world at large (Lemke, 1990). Discourse utilizes language as a means to sense-making, in addition to facilitating communication with different people in various contexts (Michaels, 1991). Moreover, pedagogical theorists and scholars have underscored discourse as a cornerstone of learning (Michaels, 1991). This is based on the understanding that learning is not something that occurs in isolation but comes from our social and cultural experiences (Stephenson, 2001). As education has transformed, the need for theoretical frameworks that are able to incorporate these changes is vital for the future of education. Vygotsky (1978) emphasized “the dominant role of social experience in human development” (p. 22). From his perspective, learning and teaching were collaborative.

Given its significant role in learning, a large body of literature has examined the benefits of classroom discourse, which encompasses a vast array of pedagogical strategies, techniques, and approaches. For example, Sampson, Grooms and Walker (2009) found that students who participated in Argument Driven Inquiry (ADI)—a discourse-based instructional model—exhibited better critical thinking skills and a greater grasp of scientific language. By giving students opportunities to practice discourse in the classroom, they are better equipped to construct meaning in the world around them.

Argumentation

A subtype of pedagogical discourse, argumentation—which seeks to generate evidence-based explanations—has been shown to benefit learning in numerous ways (Kim & Roth, 2018). Van Eemeren and Grootendorst (2004) defined argumentation as a “verbal, social and rational activity aimed at convincing a reasonable critic of the acceptability of propositions justifying or refuting the proposition expressed in the standpoint" (p. 1). In other words, argumentation is an activity aimed at justifying a standpoint, by putting forth evidence in order to convince others (Van Eemeren, Grootendorst, & Henkemans, 2002). Argumentation—the goal of which is to advance understanding through a process of establishing or validating a conclusion—is distinct from the ideas of an "explanation", statements to describe natural phenomena and an "argument", which is providing or supporting an explanation (Sampson & Clark, 2011). Argumentation may serve various functions, including persuasion (Van Dyke, 2001), social conversation (Baker, 2002; Van Eemeren, 1985), and interpersonal dialogue (Leitao, 2000). Argumentation models have been utilized in negotiations, decision-making, legal reasoning, and knowledge representation (Bentahar et al., 2010). Argumentation represents a powerful tool for educators across disciplines, as it can be applied to any topic or domain involving critical reasoning (Habermas, 1984).

The educational benefits of argumentation have been well-documented across disciplines, among which include increased content knowledge, better conceptual understanding, improved ability to offer explanations, and enhanced ability to organize information (Means & Voss, 1996). These findings held true, regardless of the manner (i.e., written vs. oral), medium (i.e., traditional vs. digital), or format (e.g., individual vs. group) used to implement the argumentation process (Baker, 2003; Venville & Dawson 2010; Zohar & Nemet 2002). Though argumentation has strong evidence for its utility across disciplines, many scholars have explored its role in science curriculum as an inquiry-based tool to develop students' critical thinking skills (Osborne, 2010).

Science Argumentation

Argumentation has become a central component of science education in the last decade. as the National Research Council (NRC; 1996) emphasized the importance of inquiry in science learning, urging that students should "actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills" (p. 2). To this end, the NRC included the practice of argumentation within the Next Generation Science Standards (NGSS), established in 2013. These new standards catalyzed a major departure from previous science classroom instruction by integrating three dimensions for student expectations: disciplinary core ideas, cross-cutting concepts, and science and engineering practices (NGSS Lead States, 2013). Whereas traditional classrooms previously focused on "core ideas" (i.e., domain-specific content knowledge), the NGSS emphasized a greater emphasis on the behaviors and practices of scientists and engineers (e.g., engaging in argumentation) (Pruitt, 2014). These practices of scientists and engineers were added for students to engage with science on a deeper level.

Recent research has highlighted the critical role of argumentation in science pedagogy (Mork, 2012; Osborne et al., 2019; Özdem Yilmaz et al., 2017; Simon et al., 2006). Jiménez-Aleixandre and Erduran (2008) articulated five skill areas enhanced through the integration of argumentation in science classrooms. This theoretical framework highlights the contributions of argumentation to science learning in the form of higher order cognitive processing, scientific literacy, enculturation in scientific culture, and critical thinking. This theory states that argumentation involves public reasoning, epistemic criteria, talking and writing science and reflection about themselves and the world. It is connected by evidence and reasoning for why the evidence matters.

Other researchers have recognized the benefits of argumentation within science education to include helping students learn to evaluate evidence, reflect upon it, and think critically about scientific claims (Bathgate et al., 2015). Kim and Song (2006) found that middle school students who performed open-ended inquiry tasks improved on their experimental methods in science. Despite substantial research underscoring the benefits of argumentation, consistent implementation across classrooms in the United States fails to keep up. Science Argumentation has been proven to benefit students significantly and has been brought forth by many different frameworks.

Theoretical Frameworks in Science Argumentation

Despite the long-established benefits of argumentation, there is little consensus about how to design and implement it in the classroom. Numerous existing frameworks related to argumentation in science education are available within the literature. On the one hand, this multitude of frameworks allows educators the flexibility to select an approach that aligns with their scientific argumentation philosophy. On the other hand, not all frameworks have the same degree of empirical support and educators may have difficulty selecting the most appropriate framework. Moreover, this lack of parsimony obscures educational scholars' ability to evaluate and synthesize findings across studies of science argumentation. Much of the current works draws from one relating to the importance of discourse in the construction of scientific knowledge (Erduran et al., 2004;

Toulmin, 1958) and from building upon sociocultural perspectives highlighting the importance of social interaction and language in learning (Vygotsky, 1978)

Toulmin's (1958) theoretical framework, known as *Toulmin's Argument Pattern* (TAP), has been pivotal for scholars exploring scientific discourse, largely due to its simple conceptualization of an argument and its main components. The parsimony of this framework, with its narrow focus on claim, evidence and justification, make it easily accessible and understandable for educators with limited experience using argumentation in science classrooms. Another distinctive feature of Toulmin's theoretical framework is the emphasis on the procedural interpretation of argumentation (i.e., providing adequate evidence and justification) rather than obtaining a single "correct" conclusion. TAP encompasses six components which are seen as best practices among many researchers. The *Claim* represents the statement being supported or refuted, the *grounds* represent the facts or evidence used to support the claim, the *warrant*t represent the scientific reasoning behind the grounds, the *backing* represents facts that support the warrant, the *rebuttal* represents refuting of the claim with evidence, and the *qualifier* represents situations in which the claim is not true (Bell & Linn, 2000; Driver et al., 2000; Erduran et al., 2004; Jiminez-Aleixandre et al., 2000). TAP has been used primarily among those who define argumentation as a form or in written argumentation but is rarely used when it is implemented for argument strategy or goals (Rapanta, 2019). TAP has been shown to produce strong connections between science and reasoning (Duschl & Osborne, 2002), is relatively simple to use/understand (Erduran, Simon & Osborne, 2004), and has an adaptable structure. Conversely, critics of TAP cite its difficulty to implement in real time (Simon, Erduran, & Osborne, 2006) and the inflexibility of its analytical “pattern” which can impede organic discourse.

Another component of the science argumentation framework involves engaging with the language of science. Lemke’s (1990) work on the language of science reflects how to adopt practices for talking, reading and writing.

Despite differences in frameworks, there are core principles that apply to argumentation. Social-cultural perspectives on argumentation have been formed primarily by Vygotsky (1978). This dictates learning about science in a communal manner to make meaning of content. The basis of Toulmin’s model is resounding across researchers as the basis of claim, evidence and reasoning is used within argumentation. Many of these frameworks suggest how the implementation of science argumentation is necessary to having students think critically, although there are many barriers to implementation as well.

Barriers to Science Argumentation

The need for argumentation is seen as a significant component of science education, yet it is not implemented consistently. Much time in science classrooms is spent learning content with little time provided for the practice of argumentation for a multitude of reasons, including lack of classroom management techniques, lack of clarity surrounding frameworks for argumentation, lack of support for diverse learners, difficulty controlling the classroom discussion (Mork, 2012). Creating strong argumentation also requires motivated and well-prepared students (Henderson et al., 2018). Most of these barriers relate to limited understanding of argumentation in science and limited pedagogical techniques necessary to do so (McNeill & Knight, 2016; Osborne et al., 2019; Sampson & Blanchard, 2012). Teachers require a tool to facilitate the integration of argumentation into their instructional practices, enabling them to move toward the socially complex aspects that argumentation demands (McNeill et al., 2016). This is further complicated by the dearth of resources demonstrating how students should engage with these practices (Pruitt, 2014). Moreover, Cazden (2001) found that teachers' self-efficacy and degree of confidence about implementing discourse directly affects their willingness to utilize argumentation within their classes. As the educational landscape continues to evolve in a rapidly changing era, it is vital that educators and scholars address a growing gap in the literature: how to implement argumentative practices in a digital environment. In order to see more argumentation among science classrooms, there needs to be solutions to the barriers seen. Barriers seen are lack of clarity surrounding the frameworks, lack of supports for diverse learners, limited understanding of argumentation and its practices.

The Shift to Digital Learning

The digital world, and access to it, has been expanding rapidly, and with ongoing technological advancements, the educational landscape will continue to change. Education is shifting from teacher-centered to student-centered approaches (Mcknight et al., 2016). Additionally, in the midst of a global pandemic, which has upturned all traditional forms of education, digital learning lies at the forefront of instructional practices. Digital learning confers a number of benefits, including access to a wider range of educational resources, the ability to more easily differentiate instruction and accommodate for unique student needs (Marr, 2020), the efficiency of communication and feedback, and the possibility to allocate teacher time in a more sustainable manner (Mcknight et al., 2016). Online learning can help make education more readily available to those who lack access to educational materials. Digital learning makes it easier to share curriculum, as digital copies are generally cheaper than physical books. Finally, online education can provide a more immersive experience and facilitate the data-driven decision-making process (Marr, 2020).

Importance of Technology for 2f1st Century Learners

The US Department of Education office of Educational Technology emphasized the importance of technology for 21st century learners in their 2017 Technology Plan update *Reimagining the Role of Technology in Education* (US Department of Education, 2017) . Benefits of e-learning includes collaboration, resource sharing, flexibility, instant feedback and reusability (Khamparia and Pandey 2017). Gormley and McDermott (2014) stated that literacy in the 21st century not only includes the ability to read books, but includes a student's ability to gather and analyze information from the internet, audio, multimedia and text files. In order to access new careers—which will inevitable entail utilizing technology to enhance critical thinking, problem solving, collaboration, and communication skills—students must master the ability to navigate information through various types of mediums (American Association of School Librarians, 2007; Luterbach & Brown, 2011). Additionally, in 2019, Forbes came out with 10 skills needed for the future of work and among the top ten were critical thinking skills, technology skills, diversity, and cultural intelligence. Not only this, but students today are exposed to visual stimuli consistently, therefore education needs to keep pace with engagement in terms of simulations (Nicolaou et al., 2019). The future of education and the job market demands that students master argumentation skills within a digital medium. However, a critical first step involves supporting and empowering educators to blend argumentation and technology in a manner that is accessible to a variety of learners.

Pandemic and Distance Learning

As the COVID-19 pandemic spread across the world in 2020, it challenged educational systems to rise to the proverbial occasion with respect to distance learning. Nothing of this magnitude has occurred in the United States in recent history, with the closest being the closure of schools in New Orleans after Hurricane Katrina. Hurricane Katrina taught important lessons that are resounding now, notably, that educators must quickly mobilize new systems, while keeping tabs on concerns related to equity, given evidence that disadvantaged students suffer more than affluent students in the wake of a crisis. As more students continue to learn online due to various factors, advancements in technology will continue to be on the rise.

Advancements in Technology

Recent advancements in Information Communication Technologies (ICTs) has brought to light the need to rethink teaching and learning practices. Notable developments in this arena include better access to the internet, increases in classroom technology use, and the introduction of immersive technologies (e.g., virtual, audiovisual and augmented reality). Research has underscored the potential for new technological advancements in the form of biometrics (i.e., recognizing physical or behavioral traits used for engagement of students), augmented reality (i.e., real world learning experiences), and multi-touch surfaces (i.e., ability to stream directly from surface of work station; Purdue University, 2020). Audiovisual media advancements have recently been shown to support technology-enhanced learning (Klippel et al., 2019). As technology continues to advance, there will be more avenues for students to access rigorous and engaging educational materials. Within these advancements, also comes various types of barriers in technology.

Barriers in Technology

The numerous advantages of educational technology notwithstanding, several barriers often preclude their successful adoption and sustained use in educational settings. Common barriers to educational technology include inadequate educator training and expertise, lack of engagement and buy-in from both teachers and students, and lack of access and funding. The US Department of Education and educational leaders nationwide recognize the shift needed to implement technology in schools, but many are falling short in their training for educators. While many schools are taking the initiative to increase the amount of money dedicated to technological devices, less than 20% of educators have the training and skills deemed necessary to be considered *technology integrated* (Pittman & Gaines, 2015). Therefore, teachers will also need guidance and training on how to maximize student engagement online by capitalizing on opportunities for collaboration and critical thinking (Brunk, 2008; Honey, Culp, & Spielvogel, 2005).

Lack of teacher and student buy-in is another notable barrier to the implementation of technology in the science classroom. Until recently, many educators have experienced online learning as a “foreign environment”. Many educators feel greater ease in a face-to-face education, while others appreciate how online learning creates flexibility and enables modifying instruction for individual needs more efficiently (Davis & Snyder, 2012). Often, educators who possess good instructional skills within a face-to-face format find it difficult to effectively guide learning and discussion in a digital medium.

Despite ICTs being lauded for their ability to increase the reach of instruction and accommodate diverse learners, there are significant disparities in who has access to ICTs. For example, indigenous people across the globe, who are already the most affected by achievement disparities, are the least likely to access ICTs (Resta & Laferriere, 2015). ICTs are expensive, as is broadband connectivity, a necessary prerequisite for most digital learning (Resta & Laferriere, 2015). When supply is limited, educators are challenged to maximize ICT-use to its fullest potential so that all students can reap some of the benefits. Whether the burden is on families, schools, or communities to supply the ICTs, many students in diverse and economically disadvantaged communities lack the privilege to fully benefit from this type of instruction. Acknowledging inequities with technology access is a crucial step to narrowing the gap.

Equity and Diversity Considerations

With schools in the US becoming increasingly diverse, educators must thoughtfully address equity and diversity considerations in order to successfully implement online science argumentation. Contemporary US classrooms are composed of students who vary with respect to race/ethnicity, socio-economic status, ability status, and

English language proficiency, among other identity markers (National Center for Education Statistics: U.S. Department of Education, 2007). The US Department of Education found that in 2016, 13.4% of pre-K-12 students had an identified disability and 9.6% were English language learners (National Center for Educational Statistics, 2009). As ELLs and students with disabilities account for over 20% of the entire student population, educators must take these groups into account when delivering online argumentation instruction. Pre-service teacher education programs do not always prepare teachers to understand the nuances of teaching in diverse classrooms (Green, McKenzie, & Rose, 2016). As populations continue to shift and as technology continues to advance, teachers will have more challenging demands in terms of their diverse learning community (Martin & Smolcic, 2019).

English Language Learners

In order to accommodate the diverse set of learners, students whose first language is not English need to be considered. The population of English language learners (ELLs) in US schools is on the rise, with students increasingly attending school who speak little-to-no English (Oroco & Tordova, 2009). Because argumentation is grounded in discourse, language skills (i.e., reading, speaking, writing, and listening) are essential in order to participate. For example for a student to be able to question their own argument or that of another student, they must be able to adequately communicate their perspective to others. Moreover, science involves a unique set of vocabulary with specific language requirements for accessing the content and engaging in the argumentative process (González-Howard & McNeill, 2016). This poses a challenge for students with limited cognitive academic language proficiency (CALP; González-Howard et al., 2017). On the other hand, discourse has been found to be extremely beneficial for ELLs because it provides multiple moments to develop and practice English skills while conceptualizing scientific content (Gonzalez-Howard & McNeill, 2016). The benefits of providing opportunities for students to engage in discourse is not only seen within students with proficiency in English, but is seen as a tremendous path to academic success for multilingual learners. Although, student centered learning requires a large teacher role in preparing for those student outcomes.

Teacher Role

Even though argumentation is a key component of science education, activities containing argumentative practice are not frequently found in science classrooms, one factor is pertaining to the teacher's role (Mork, 2012). Teachers both benefit and are challenged by the NGSS, as it is now tied towards performance expectations instead of concrete knowledge. Deep engagement in argumentation does not occur spontaneously, but is driven by a teacher's role in the creation and implementation of the process (Boyer, 2016; Duschl & Osborne, 2002). Creating a shift of focus on argumentation in a classroom not only provides new guidelines for students, but a change in framework for teachers as well. If a teacher is ill-prepared to design and implement argumentation, the students will also be confused by the framework, especially if it is within a new digital medium. Research by Osborne, Erduran and Simon (2004) concluded that in order to have argumentation implemented in science classrooms, there needs to be pedagogical strategies and guidance for teachers. More guidance will be needed if shifting to online forums as well if a teacher is not adept in technology. The guidance for teachers first starts with designing the appropriate lessons for argumentation.

Designing Argumentation

A critical first step to the effectiveness of argumentation in science classrooms involves designing structure and guidelines for the learners. Structure and context are necessary elements for humans to make sense of new procedural and content knowledge. Just as teachers struggle to implement argumentation without an adequate framework, so too do students struggle to participate in it (Berkland, 2011). After introducing students to the structure for the argumentation to unfold, teachers are responsible for defining the key components of the argumentation process. For example, within most argumentation frameworks, this includes the *claim*, the *evidence* and the *rationale* behind a phenomenon. Phenomena can be difficult for students to understand if they have no schema in which to place it. Lemke emphasized how sociocultural and contexts within a community are needed for students to construct meaning (Lemke, 2001). Therefore, teachers selecting a phenomenon that is relevant to the student population would help student investment and understanding in the science concepts. Finally, teachers are responsible for creating an *instructional plan* that outlines the phenomenon to be explored and provides a wealth of evidence for students to evaluate and utilize to support their claims. Hands on examples and simulations offer deeper conceptual knowledge with science (Smetana and Bell, 2011). Therefore, engagement in these types of activities for students to obtain evidence is vital. The Learning Design Group (2015) at the Lawrence Hall of Science collaborated to create an argumentation toolkit for science educators that can guide them through identifying evidence that supports or refutes claims and also identifying convincing evidence. The toolkit outlines key components of argumentation including student interaction, claims, reasoning, and evidence. After designing the structure needed for argumentation, the implementation is to follow.

Implementing Argumentation

After establishing the structure and plan for the argumentation session, teachers should position themselves to moderate the argumentation process through the delivery of probing questions and timely feedback (Hand & Norton-Meier, 2017). Specifically, teachers during this phase might challenge the correctness of a statement, rephrase the question, compare responses to other available claims, or extend the range of responses (Mork, 2012). Reasons for teacher intervention include inaccuracy of content, narrow range of topic, or lack of engagement (Mork, 2012). These steps of questioning and feedback are essential to promoting students' conceptual understanding (Hand & Norton-Meier, 2017). Moreover, they help to further arguments and find counterpoints (Mork, 2012). Though it may sound simple, many teachers struggle to shift into this student-centered role, having grown accustomed to the more traditional teacher-centered pedagogical style (Martin & Hand, 2009). In fact, Martin and Hand (2009) found that teachers on average required 18-months to fully transition into this new stance of delivering questioning and feedback while students themselves drive the discussion. Moreover, research suggests that pre-service teachers have more difficulty providing quality questioning and feedback compared to teachers who have more experience implementing argumentation (Erduran, Ardac & Yakmaci-Guzel, 2006). An important component of the implementation comes with how to maintain student engagement.

Teacher and Peer Feedback

An added challenge for science teachers implementing online argumentation is keeping students engaged and guiding peer feedback amongst students. Research suggests that many students exhibit negative attitudes towards science, which can make it difficult for science teachers to engage students even using standard practices (Osborne & Collins, 2001). Moreover, most teachers report lacking adequate classroom management strategies for a traditional learning format. Compared to traditional teacher-centered pedagogical styles, argumentation can invite more behavioral dysregulation from students if behavior is not adeptly managed. Strategies for managing student behavior during argumentation might involve reminding students of behavioral norms and providing appropriate redirection, without jeopardizing the organic flow of discourse. With less traditional oversight, online learning also presents new challenges with respect to maintaining student engagement and managing student behavior. To this end, greater guidance is needed for educators during this transition to online platforms, particularly for teachers with lower technological savvy and self-efficacy. Guiding questions can help facilitate students into robust conversation. One of the most important components of this is accommodating for a diverse set of learners.

Accommodating Diverse Learners

Science can be extremely difficult for students whose first language is not english. Science language is not used in casual conversation and many times science language can have multiple meanings in different contexts or can be abstract, making it hard to grasp (Fang, 2004). Sandoval (2005) talked about providing appropriate evidence may be a struggle for students, while Bell and Linn (2000) expanded on that notion talking about how students may not be able to explain the reasoning for their evidence.

Findings from Steele (2007) and Zembylas and Isenbarger (2002) found that problems in memory, language, attention and processing skills were the most common characteristics among special education students therefore, the following were recommendations to implement for science instruction: 1) Modify the curriculum (adapting readings/ matching to comprehension level/ text to speech, 2) Adjust the length of assignment, 3) Teach science in inquiry approach (based on science practices and less on specific science content), 4) Use auditory, visual and tactical functions, and 5) Repeat instructions in concise format and have students repeat back. Mcginnis (2013) further emphasized the need to teach science in an inquiry student-centered approach in opposition to content teacher-centered approach modified suggestions for students who receive special education services. In addition, English Language Learners will find challenges within the language of science, therefore they will also need specific language supports. This includes providing sentence starters to help with organization of thoughts and providing students with a variety of data for students to use as evidence in order to support or refute claims (Simon et al., 2006). These accommodations (vocabulary support, sentence stems, auditory extensions, direct instructions, checks for understanding) help students to focus on the science and engineering practices. After designing and implementing argumentation comes assessing the student outcomes.

Assessing Student Outcomes

Researchers have also discussed the challenges of assessing argumentation in a reliable way across the argumentation process. McNeill and colleagues (2016) surveyed teachers who found that teachers felt current available assessments on argumentation did not influence their teaching of argumentation instruction. The alignment was not there. Formative and summative assessments are necessary for teachers to provide consistent feedback on the students argumentation process and to evaluate for a grade or comparison across other scientific argumentation comparisons (Henderson et al., 2018). They have found that evaluating student processes and the end product is quite difficult (Osborne et al., 2016). The quality of which is evaluated upon how well the evidence was gathered and analyzed, how the claim fits within the evidence and how well this evidence is supportive of the claim (NGSS). Erduran and Jiménez-Aleixandre (2008) codified the features of arguments to evaluate student outcomes into 5 criteria: thesis, reasoning structure, observational evidence, explanatory evidence and conclusion. They used these features of an argument to pose questions when scoring students upon the argumentative process. When in the design portion of this process, an educator should create a rubric to later assess students on their claim, evidence, reasoning, discourse in online discussion and ability to create a counter argument.

Summary

Chapter 2 reviewed literature relevant to the research question: *How can teachers moderate middle school science argumentation through a digital medium?* Findings support the notion that argumentation is a vital component of science education.

Moreover, the literature underscores the critical role of ICTs in the future of education and the importance of endowing students with technological literacy to prepare them for contemporary careers. Additional themes represented in the literature include obstacles of designing and implementing online argumentation within increasingly diverse classrooms (i.e., larger proportion of ELL students and students with disabilities) and challenges of regulating student engagement (O'Connor & Zeichner, 2011). With increasing emphasis on student-centered pedagogy (e.g., argumentation) in science and inclusive educational practices in the midst of a nationwide shift to virtual learning, there is an urgent need to support teachers with better frameworks and guidelines. The next section will outline the methods used to develop a resource for teachers to implement online science argumentation for diverse 3rd - 6th grade students.

CHAPTER THREE

Project Description

Overview

This project aims to develop a framework to support 3rd - 6th grade science educators in delivering online instruction in scientific argumentation. To that end, this project will explore the question: *How can educators design and implement 3rd - 6th grade science argumentation through a digital medium?* Argumentation lies at the root of critical thinking skills, which are essential for our changing educational landscape and represent a central tenet of science education. Though many science educators understand the benefits of teaching argumentation, the implementation of argumentation in science education is fraught with challenges and barriers. Lack of classroom management techniques, in addition to increases with technology and diversity calls for a framework for *"Designing and implementing argumentation through a digital platform: A framework for beginning 3rd-6th grade science educators."* Moreover, few science educators receive explicit training in how to teach argumentation, and few resources exist to support elementary and early middle school educators in developing and implementing argumentation instruction that fits within the context of their own classroom. The aforementioned limitations are further complicated by the transition in many districts/schools to online instruction. The goal of this project is to provide support to teachers who seek to integrate argumentation into their online instruction, but may lack the training or resources. This framework will be flexible and adaptable, such that it can align to various standards (e.g., Next Generation Science Standards (NGSS)), scientific principles, and student demographics. The final framework will assist educators in the conceptualization (e.g., selecting a scientific phenomenon, identifying claims, curating supporting evidence) and implementation (e.g., selecting a virtual platform, providing feedback, facilitating student discussion) phases. Additionally, it will provide guidelines for adapting/modifying the process for special populations (e.g., ELL students) through a website.

Rationale

To adequately prepare students for a rapidly evolving world requires that teachers adopt flexible, adaptable, and equitable approaches to teaching higher-order thinking. Above and beyond its role in the classroom, prior research has identified argumentation as an essential component in teaching students to think critically about scientific phenomena. The rationale for developing this framework is based upon three resounding facts : (1) Argumentation represents an important facet in contemporary education (Erduran et al., 2006; Mork, 2012; Osborne et al., 2019; Özdem Yilmaz et al., 2017; Simon et al., 2006); (2) technology utilization is rapidly expanding within American schools and its need is found vital (Brunk, 2008; Honey, Culp, & Spielvogel, 2005; Noeth & Volkov, 2004).; and (3) the proportion of students in the US who are English language learners (ELLs) is continuously growing (Doran, 2017). Given the increasing presence of technology in US classrooms, educators may require additional training and support to ensure its appropriate and effective use. According to the National Education Association, ELLs are the fastest growing student population in the United States, with estimates that by 2025, ELLs will comprise a quarter of the student population.

Therefore, educators likely require guidance on how to modify the argumentation process to make it accessible for those with limited English fluency. Despite the expectation that all students participate in this type of instruction, there is a dearth of literature suggesting how such practices can be adapted to meet the needs of ELL students in science classrooms (Lee, Miller & Januszyk, 2014). This project will provide educators with a research-based framework to guide the design and implementation of science argumentation online to a diverse population of students.

Description

For my project, I will create a framework for educators to use in developing and implementing argumentation in 3rd-6th grade science classrooms. This framework will include guidelines for how to select phenomena and evidence, implement argumentation online, adapt the argumentative process for ELL, and provide feedback and moderation online. The first component will provide science teachers with tools for selecting an appropriate phenomenon for the argumentation process, guidelines on generating claims based on the phenomenon, and recommendations for gathering and presenting evidence for the phenomenon. The second component will focus on design, including selecting appropriate digital mediums, maximizing student engagement, providing feedback to students, and evaluating learning gains through rubrics. The third component will focus on special student populations, with an emphasis on ELL students, and how to accommodate lessons to their needs (e.g., providing voice to text tools, sentence starters, word banks, etc.). The final component will include best practices found both within online learning and argumentative frameworks in providing feedback and moderating argumentation. The permanent product will include a framework manual website and presentation to be delivered as a professional development for teachers, in addition to a template for designing and implementing in an online classroom. This framework and its accompanying tools will be geared to early career science teachers with minimal experience implementing argumentation.

Setting and Participants

This framework is intended for 3rd - 6th grade science teachers who work with diverse learners in schools equipped with technology. The framework is intended for beginning science teachers with limited experience implementing argumentation, those wishing to refine their skills, or those seeking guidance on migrating the argumentation process to a virtual medium. This framework will be appropriate for teachers in any part of the country, as it will be designed to align with NGSS and common core standards. Moreover, it will encourage educators to select scientific phenomena that are contextually relevant to their geographic region and population. Though teachers will be the direct users of this framework, key stakeholders also include the students who will gain access to the argumentation process via virtual platforms. Learning will occur asynchronously, and can therefore take place on computers within a classroom setting, blended classroom or during remote learning. ELL students, who comprise a growing proportion of the student body, represent another group of key stakeholders. Specifically, this framework will suggest ways of accommodating students with varying English language abilities.

Framework Development Process

A multi-phase iterative process will be used to develop this framework. Phase 1 will involve reviewing middle school NGSS standards along with instructional support for English Language Learners. Phase 2 of my framework development process will involve exploring existing platforms and mechanisms for designing and implementing argumentation and/or virtual science learning within elementary and middle school classrooms. These will include the Learning Design Groups Argumentative toolkit from the Lawrence Hall of Science, among others. Phase 3 will involve cross-examining frameworks currently utilized across science classrooms, those referenced in chapter 2 will be looked at thoroughly. This phase will involve extensive research in finding a framework that can be easily shifted to an online format and can be easily adapted to meet the needs of new science teachers engaging in argumentation. Phase 4 will entail identifying what best practices on feedback and moderation are available. The final phase will involve soliciting constructive feedback from experienced professionals with both content and process expertise. This final phase will be iterative in nature, such that experts will provide input to inform refinements sequentially. Expert reviewers included two middle and high school teachers with experience using argumentation.

Design and Implementation

This framework and its accompanying manual will provide educators with strategies for designing and implementing argumentation through a digital medium with diverse learners. As an initial step, educators will be encouraged to review a checklist needed before beginning their design. Student prerequisites for argumentation include adequate content knowledge about the chosen phenomenon, sufficient experience analyzing evidence for validity, the ability to give and receive constructive feedback, 1 to 1 student computer ratio and proficiency using the chosen digital platform. Teacher prerequisites include positive, trusting relationships with students, comfort providing student feedback asynchronously through a virtual medium, and the ability to select contextually-appropriate phenomena and evidence. Once an educator deems their class ready for argumentation, they should consider the implementation guidelines articulated within the framework. Designing considerations include how to identify a digital platform, select contextually- appropriate phenomena/evidence, create a rubric and guide opportunities for student discourse. Additionally, the framework will provide guidance on how to implement for diverse learners, such as students receiving ELL instruction or special education services. The framework will also include suggestions and examples for how to provide effective asynchronous feedback on argumentation skills. Successful argumentation will result in students who are able to select and articulate a claim, back up their chosen claim with evidence and clear reasoning, engage in discourse through the online platform and address a counter argument. Moreover, effectiveness and student performance will be evaluated in accordance with the NGSS.

Summary

In Chapter three, I discussed the methods for designing and implementing argumentation in a 3rd-6th grade school science classroom. This included the rationale, description, setting and participants, framework development process, and implementation. The design derives from the the NGSS and Lawrence Hall of Science directives on providing learners with a more student centered educational approach. Chapter four will look at reflections of the project, what I learned along the way, limitations of the project, future projects and how this outline will impact the teaching profession.

CHAPTER FOUR

CONCLUSIONS

Introduction

I have been exposed to a variety of schools throughout my teaching career and have felt strongly connected to those in which students' voice and critical thinking skills are prioritized over teacher led instruction. Many of the students who I have taught, have not had those experiences and show no evidence of feeling confident in their ability to wonder, problem solve and communicate ideas effectively. Lack of support for an increasingly diverse student population, lack of understanding around how best to design argumentation lessons and a shift to digital learning has made it difficult for teachers to truly provide students with the time and opportunities to think critically about issues relevant to them. Many times curriculum is made and implemented without acknowledging that the students, and their local community, may be poorly represented within its lessons. It is through these identified challenges that I created a project that could help *3rd - 6th grade beginning science teachers to design and implement argumentation through a digital medium*. Through creating this project I have learned a lot personally and professionally, found ways in which to continue expanding students argumentation skills and identified limitations of this project.

Learnings

Throughout this process I was able to reflect on both my personal and professional growth. After implementing more argumentation in my physical classroom this year, I was able to see the benefits and wanted to see if literature supported some hypotheses I had for why it was not implemented more within science classrooms. Sifting through literature led me to the challenges of argumentation, the benefits of it and how to successfully design and implement it across upper elementary science classrooms. Concerned about the importance of argumentation and the lack thereof of implementation, I became motivated to review the reasons for abstaining from the practice and how to make it more equitable for all.

The literature surrounding the use of argumentation within education and our increasingly diverse educational landscape shed further light on the positive impacts of this tool for all (Mork, 2012; Osborne et al., 2019; Özdem Yilmaz et al., 2017; Simon et al., 2006). Furthermore, the literature states that student discourse is vital to a student's academic success (Jiménez-Aleixandre and Erduran, 2007; Lemke 1990)

In the early stages of research, I had difficulty finding studies involving online learning for this age group. There is not a tremendous amount of research currently out pertaining to the online learning of argumentation, but there has continued to be an increase.

Through this research I was able to learn about how to best support all learners in online argumentative learning through allowing the population of students and their interests to dictate the choice of the phenomena, how to find relevant phenomena through online resources, how best to provide feedback to students online and how to have students show their work through a variety of modes (videos, written, drawings ect).

Project Limitations

In order to successfully design and implement this project students need to have access to their own computer at home and strong wifi connection. The simulations utilize a lot of broadband data and do not run flawlessly without this. Students also need to be aware of the argumentation process and previewed with how this process works and its importance. This project does not include previewing the process but lays out the components once it is explained in the classroom. Argumentation is a time consuming process, put forth by teachers in order for students to drive their own learning and continue to think critically. If a teacher is not departmentalized with only teaching science there may be frustration in the amount of effort it takes to set this up for their class in the most effective way. At first glance, the limitations of this project may simply be that teachers want more structure within the design process of argumentation. Although, this was purposefully built as a framework for teachers to adapt to their specific set of students. Teaching is an art and each class, each school system is met with a variety of different students, this framework gives the teachers flexibility in implementing their own chosen phenomena in the classroom. This could be difficult for a teacher who wants everything scripted in a particular manner.

Future Projects

Argumentation has its place not only within any science education class, but within all disciplines. I feel this framework is just the start of what can be done. Not only can teachers start feeling more comfortable designing lessons based on their local context, but it can continue to drive student led discussions and classrooms. I can see this being implemented in mathematics classrooms as well. This could replace much of the rote memorization already occurring in many classrooms and could be a leading method for student assessment. Future projects could also entail more resources to find relevant context for different locations and different populations of students. When selecting my own investigative phenomena question, I found it difficult to find questions that pertained to my specific group of students. As the educational landscape shifts towards a more culturally sustaining pedagogy, there needs to be a creation of more of these resources for teachers to choose from.

This project will benefit the profession of science education in many ways. Beginning science educators will have a simple framework in which to start introducing argumentation into their classroom, current science educators will see the importance of choosing a phenomenon that is relevant to their students and all science educators will understand strategies to provide feedback to students in the context of online argumentation. I will share the results of my project by enabling my website to be used by the public and disseminating my professional development presentation to coworkers that would be able to utilize the information.

Conclusion

In this chapter I wrote about my overall learnings from this project. I looked back upon the literature review, limitations and future projects that can continue to benefit the community. This journey has been tumultuous in the time of a pandemic and also an awakening to racial inequities among school systems. I am excited to have educators try out this framework in an online format and also understand the importance of argumentation in the future of education. It is my hope that beginning educators will not only see the guide as easy to use as a supplement to their curriculum, but they will see the value in providing student discourse within their online science classrooms.

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