Understanding the Innovation of Utilizing Universal Design for Learning in Integrated STEM Classrooms by Early Adopters

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Academic Abstract

Integrated STEM education and Universal Design for Learning (UDL) have been often theorized as compatible. However, there has been little research done to understand how UDL is used in real-world integrated STEM classrooms. Our study aimed to understand how current practicing educators in integrated STEM classrooms combine these teaching methodologies. This was done through a combination of interviews and document analysis of lesson plans, and supplementary information. To evaluate what elements of UDL were used in the documents, researchers developed a UDL codebook based off of the 31 checkpoints in the Center for Applied Special Technology (CAST) UDL guidelines. The goal of the study was to understand how the adoption of UDL could spread across all integrated STEM educators. Therefore, our study viewed the use of UDL in an integrated STEM classroom as an ‘innovation' and analyzed our results through Diffusion of Innovation theory. Specifically looking to providing understanding to the ‘innovation' through Rogers 5 Attributes of innovations. The study found that all except two UDL checkpoints were proved to be compatible within integrated STEM classrooms, and were categories developed to explain how the participant achieved these checkpoints. The findings also show that not all UDL checkpoints occur at the same frequency. Through Diffusion of Innovation theory, our study showed that Integrated STEM educators believe that UDL is automatically adopted by educators using Integrated STEM teaching methodologies. They expressed problems associated with implementing some UDL checkpoints, and providing overall themes of complexity when implement UDL in an Integrated STEM classroom.

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Public Abstract

Integrated STEM education and Universal Design for Learning (UDL) are two teaching methodologies that have been often theorized to be compatible. However, there has been little research done to understand how UDL is used in real-world integrated STEM classrooms. The study aimed to understand how current practicing educators in integrated STEM classrooms combine these teaching methodologies. This was done through a combination of interviews and document analysis of lesson plans, and supplementary information. To evaluate what elements of UDL were used in the documents, researchers developed a UDL codebook based off of the 31 checkpoints in the Center for Applied Special Technology (CAST) UDL guidelines. The goal of the study was to understand how the adoption of UDL could spread across all integrated STEM educators. Therefore, our study viewed the use of UDL in an integrated STEM classroom as an 'innovation' and analyzed our results through Diffusion of Innovation theory, which conceptualizes an innovation spread through a population. The study found that all except two UDL checkpoints were proved to be compatible within integrated STEM classrooms, and were categories developed to explain how the participant achieved these checkpoints. The findings also show that not all UDL checkpoints occur at the same frequency. Through Diffusion of Innovation theory, our study showed that Integrated STEM educators believe that UDL is automatically adopted by educators using Integrated STEM teaching methodologies, but when discussing the implementation of specific UDL checkpoints themes about the complexity of the innovation emerged.

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I would like to dedicate this project to a few people. First and foremost, I would like to thank my wife, Courtney Steger, and my dog "Faye". Both of you were there constantly there for me throughout everything. Every problem, every setback, every idea, and you were there to help me through. Even though only one of you were able to share ideas back with me, I can't express what you mean to me and how really lucky I am to have you. I would like to dedicate this project to myself in third-grade. Struggling because of a disability is never easy, and overcoming those challenges may have been even harder. I hope you would be proud of where we are now, and the work done in this project. I hope these findings help students like you.

Finally, I would like to dedicate this project to my mom, Christine Steger. You being a selfless teacher, never let me give up. Even after heartbreaking failures when I had already given up on myself. You must have spent countless hours reading with me, helping me trip through every word in countless books, never wavering in your belief in me. You made me want to go into teaching, and I will forever be grateful for you.

All of you saw potential in me, and this project is for you.

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1.1. BACKGROUND

Students with disabilities who are enrolled in general education classrooms are more than twice as likely to continue into post-secondary education compared to their segregated peers (Rojewski et al., 2015). To address these student's needs, teachers utilize inclusive teaching practices. Universal Design for Learning is considered an inclusive teaching practice that provides a framework aimed at minimizing barriers and optimizes learning for all students based on scientific evidence (CAST, 2018). Universal Design for Learning (UDL) is a well-documented teaching methodology that addresses the needs of all learners. Access STEM (2007) a conference of disability education professionals proposed to use UDL in concert with Science, Technology, Engineering, and Mathematics (STEM) education models to effectively reach both traditional and non-traditional learners.

The use of UDL in STEM teaching methodologies or other more traditional teaching methods have to be shown success in the classroom through educational research studies. The success of UDL being tested in different teaching methodologies has been done through: qualitative analysis of improvement in skills, confidence and academic performance from both an participants and outside perspective (Basham, Meyer, et al., 2010; Dymond et al., 2006); testing through improvements based on pre-post testing before and after the intervention of UDL methods (Coyne et al., 2012; Dalton et al., 2011; Hall et al., 2015; Katz, 2013; King-Sears et al., 2015; Lieber et al., 2008; Marino, 2009); and a combination of qualitative and quantitative analysis (Marino et al., 2014; Rappolt-Schlichtmann et al., 2013). There has also been extensive literature documenting the compatibility and complementarity of these two teaching methodologies, albeit limited understanding of if and how these two methodologies are integrated and applied in real classroom settings.

Various publications have provided extensive detail regarding “how” to integrate STEM and UDL, which have similar methodologies and could be used together in an effort to make STEM classes more accessible to all learners ("Access STEM Building capacity to include students with disabilities in science, technology, engineering, and mathematics fields. Seattle," 2007; Basham & Marino, 2013; Goeke & Ciotoli, 2014; Hwang & Taylor, 2016; Israel et al., 2015; Marino et al., 2010; Moon et al., 2012). A few studies have tested the implementation of STEM and UDL through models and researcher designed curriculum (Basham, Israel, et al., 2010; Basham & Marino, 2013; Dunn et al., 2012; Gonzalez & Fryer, 2014; Villanueva & Di Stefano, 2017), while no research to our knowledge has been done analyzing the compatibility of STEM and UDL in real world classrooms based on real classroom problems and factors. The question becomes how can they be combined in real-world settings to promote STEM learning that is accessible to all learners?

Understanding the real-world combination of these two methodologies is complicated. Part of the difficulty arises from the widely used but poorly defined term STEM education, and the ambiguity of UDL implementation. STEM education in its basic form is an acronym used for Science, Technology, Engineering, and Mathematics. Integrated STEM is one of the many methods of teaching STEM subjects. Integrated STEM relies on the interconnected nature between STEM subjects and attempts to develop lessons that force students to draw multiple content areas while developing their personal and academic skills (Bybee, 2013). These ambiguous factors in previous studies make it difficult to analyze, compare, and execute follow-up studies. Another problem with the literature to date is the all-or-nothing approach to examining the methodology in a classroom. For example, Universal Design for Learning is a teaching methodology with loosely defined principles that could be interpreted and executed in many ways. According to CAST (2011), Universal Design for learning is defined as providing students with multiple means of representing information, multiple means of engaging with that information, and multiple means of expressing an understanding of that information. But, within each of these elements' educators are allowed flexibility in how they reach those goals. This flexibility makes it difficult to understand the combination of how these two methodologies are used in classrooms.

1.2. STATEMENT OF THE PROBLEM

There has been a great deal of literature explaining the plausible compatibility of combining STEM and UDL teaching methodologies. The bulk of the literature is based in preliminary research including practitioner's wisdom and literature reviews to explain "how" to integrate STEM and Universal Design for Learning teaching methodologies ("Access STEM Building capacity to include students with disabilities in science, technology, engineering, and mathematics fields. Seattle," 2007; Basham & Marino, 2013; Goeke & Ciotoli, 2014; Hwang & Taylor, 2016; Israel et al., 2015; Marino et al., 2010; Moon et al., 2012) Researchers have begun developing models, case studies and exploratory studies to discover more about the innovation (Basham, Israel, et al., 2010; Basham & Marino, 2013; Dunn et al., 2012; Gonzalez & Fryer, 2014; Villanueva & Di Stefano, 2017). A few empirical research studies have been conducted on the combination of the two teaching methodologies of STEM and UDL. However, these classrooms were designed not by practicing educators but by researchers who are experts in both the field of UDL and STEM education (Basham & Marino, 2013; Izzo & Bauer, 2015; Malian, 2011; Marino, 2010; Marino et al., 2010; Street et al., 2012). The question becomes, if STEM and Universal Design for Learning (UDL) teaching methodologies have theoretical similarities, what changes and adaptations are made by educators in order to fit the needs of an Integrated STEM classroom? To our knowledge, there has been no research investigating what aspects of UDL are being used in integrated STEM classrooms.

1.3. PURPOSE OF THE STUDY & OVERALL APPROACH

In order to understand how these methodologies are actually interpreted and executed, researchers need to investigate how Universal Design for Learning is actually used in integrated STEM classrooms. The purpose of this study is to understand the potential for widespread adoption of Universal Design for Learning by educators already utilizing Integrated STEM education methods through Diffusion of Innovation theory. By evaluating lessons and capturing the perspectives of the portion of the population of Integrated STEM educators trained in UDL and who claim to be using it in practice in their classrooms, researchers can evaluate what principles of Universal Design for Learning are being utilized and what are left out. Evaluating the rationale behind the decisions made by the educators to include or leave out elements of UDL can provide insight into the priorities of the population.

This study used Diffusion of Innovation Theory (Rogers, 2003) to analyze the nature of the innovation of using UDL in Integrated STEM education classrooms. Rogers (2003) defines innovation as "an idea, practice, or object that is perceived as new by individuals or a unit of adoption" (Rogers, 2003, p. 11). Our goal is to provide an understanding of the actions and perspective of the early adoptive portion of the population's use of the innovation. We can then use Roger's five attributes of innovations (Rogers, 1995) to asses the data for the potential adaptability and dissemination of the innovation. Providing understanding about the innovation, in this case, the use of UDL in Integrated STEM classroom, is the first step in understanding what may aid or hinder the adoption of this innovation by this or any population of educators.

1.4. RESEARCH OBJECTIVES & QUESTIONS

Our research questions are based on a overarching question with subsequent follow-up and sub questions. The research questions for this project are as follows:

If Integrated STEM and Universal Design for Learning (UDL) teaching methodologies have theoretical similarities, what changes and adaptations are made by educators in order to fit the needs of their Integrated STEM classroom?

1. How is the innovation of utilizing Universal Design for Learning in Integrated STEM education classrooms being implemented in real-world classrooms?
    a. In what ways do adopters meet Universal Design for Learning checkpoints?
    b. What challenges do adopters encounter when implementing Universal Design for Learning?
    c. At what frequency does Universal Design for Learning checkpoints occur in the data?
2. What do patterns of the adopter's implementation say about the adoption of the innovation?
3. What do the actions and decisions of the adopters say about the innovation through Rogers (1995) five attributes of innovations?

2. CHAPTER TWO: LITERATURE REVIEW

2.1. STEM EDUCATION

STEM education is a term developed in the 1990s by the National Science Foundation (NSF); It was originally called "SMET" for the same acronym of "Science, Mathematics, Engineering, and Technology" (Sanders, 2008). The idea of STEM originally developed from the separate courses of Science, Technology, Engineering and Mathematics holding similarities in teaching methodology and content areas. Since its inception STEM has evolved to hold many meanings to educators worldwide, making “STEM” into a buzzword in education that is interpreted in many different ways. According to Bybee (2013), there are seven definitions of STEM education that are all current models for educational curriculum and practice: i) STEM means just science education, ii) STEM means a combination of math and science education, iii) STEM means science education with the incorporation of technology, engineering or mathematics, iv) STEM means four separate disciplines, v) science and math are connected by one technology program, vi) STEM means coordination between teachers across disciplines, vii) STEM means a seamless integration across disciplines. STEM education teaching methods also include Engineering Design/ Build projects and the utilization of technology both as learning tools and as lecture material (Howland et al., 2012). Scherer et al (2017) conducted a systematic review wherein they found that educators in Agriculture, Food, and Natural Resource Education fields use one of the following methods for teaching STEM education in classrooms: problem-based learning, multiple instructional methods, hands-on activities, inquiry-based learning (discovery or scientific), competition, experimental and learning. According to this review, many lessons were also designated as unspecified in their instructional methods (Scherer, 2017). As Scherer's et al (2017) review indicates, the definition of STEM education within research and practitioner's wisdom as well as the associated teaching methods are still vague and not universally applied. For the sake of research in the field, educational studies need to include explicit details including the teaching methods, student engagement, and terminology for their definition of "STEM". With this information, connections can be drawn and findings and new research can develop.

2.2. PROBLEMS FACING STEM STUDENTS WITH DISABILITIES

Students with disabilities face a plethora of problems when participating in STEM courses. STEM teaching methods can cause difficulty because they vary in their challenges for students with different needs. Inquiry-based instruction can present problems for a student who has problems remaining on task. Remaining on task during group work can prove difficult for students with high incidences disabilities, specifically those with learning disabilities and ADHD (McGrath & Hughes, 2018). On the flip side of the spectrum, Integrated STEM approaches such as problem-based learning or discovery education are unstructured, relying on independent research and group communication to solve the problems. This could be problematic for students who struggle with social skills, unclear schedules, or communication issues. Students with autism, communication disorders, or are struggling with their peers may face challenges (Gobbo et al., 2018). The relatively quick transition from the representation of material to activities in STEM education lessons provides little time to digest information. This could cause problems for students who may require longer to process information because of cognitive overload (Gonzalez, 2016).

Teachers also have expressed difficulties with the inclusion of students with disabilities in classrooms. One of the most influential barriers for students in STEM education is the comfort level of educators teaching students with disabilities. In an examination of 323 science teachers, Alston et al. (2002) found that most teachers held misconceptions about the abilities of students with learning disabilities. The researchers found that teachers often misunderstood what these students needed to be successful in their classroom and they attributed the misunderstandings to a lack of preparation to teach students with disabilities (Alston et al., 2002). The present unease in teaching students with special needs is still expressed by educators today. According to Spektor-Levy (2017), teachers express the interest of including students in their science classrooms but feel a lack of training to teach all learners. The positive experience of being supported by the instructor and classmates has a tremendously positive effect on all students' STEM career interests, with or without disabilities (Dunn et al., 2012). Yet, low expectations and a lack of proper accommodations by teachers act as a key barrier that prevents students from succeeding in STEM fields ("Access STEM Building capacity to include students with disabilities in science, technology, engineering, and mathematics fields. Seattle," 2007)

2.3. UNIVERSAL DESIGN FOR LEARNING (UDL)

Connell et al. (1997) coined the term Universal Design and identified seven principles that need to be addressed when creating a structure: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, size and space in approach and use. In its original meaning, Universal Design included all types of disabilities (i.e., physical and mental) and mostly focused on building construction flaws that limited people with disabilities from an entrance. Rose & Mayer (2002) further refined these principles and developed the term Universal Design for Learning, which is still used today. Universal Design for Learning shifts the focus from physical limitations to limitations within a classroom setting. The goal of UDL is to focus on the end result of the lesson and not pre-specify how those outcomes are reached. Rose & Mayer (2002) defined UDL as providing instruction with multiples means of representation, engagement, and assessment.

Multiple means of representation is defined as providing multiple methods of stimuli in order for students to understand and retain lesson material (Rose & Meyer, 2006). The typical methods for introducing information to students is through a variety of media including a textbook, websites, pictures, graphics, and video. Multiple means of strategic engagement are defined by Rose & Meyer (2006) as providing multiple methods to strategically engage individuals in the classroom. This would include the process and participation of the lesson along with the lesson 'hook'(Rose & Meyer, 2006). The final principle for UDL is multiple means of expression, which is defined as how students can express the information they have understood. According to Rose & Mayer (2002) assignments can be designed in different ways that are more conducive to the learner's needs to allow more students the opportunity to demonstrate mastery, comprehension or application. They went on to say assessments can come in the form of final projects, papers, repeating lessons, multimedia demonstrations, or final products (Rose & Meyer, 2002). The Center for Applied Special Technology (CAST) articulated and expanded upon these core principles into a checklist guideline format. This allows researchers and educators to reevaluate their curriculum based on achievable objectives ("*CAST Universal Design for Learning Guidelines version 2.0.*," 2011). CAST has continued to update the website udlguidelines.cast.org, but as of 2018 the 31 UDL checkpoints remain the same (CAST, 2018)

2.4. THE INNOVATION OF COMBINING STEM AND UDL TEACHING METHODOLOGIES

In 2008 The Reauthorization of the Higher Education Opportunity Act that allowed students with disabilities better access to post-secondary education by encouraging curriculum development through the principles of UDL. Since then, there has been a stream of educational studies and application publications attempting to merge the principles of UDL within a classroom, including extensive work in the STEM fields. Connections between STEM education and UDL can be drawn through UDL's models of multiple means of representation, engagement, and assessment.

2.4.1. *Providing Multiple Forms of Representation*

Students learn in different ways by comprehending and understanding different media more efficiently than others. In order to do this, an educator must provide multiple forms of stimuli to allow the learner to understand content through a preferred medium (CAST, 2018). Educators combining STEM education and Universal Design for Learning teaching methods such as the use of demonstrations, models, modeling of process, watching videos, databases of information, pictorial representations, animations and, 3-D videos (Israel et al., 2015; Izzo, 2012; Marino, 2010; Marino et al., 2010). Outside of visual and kinetic representation of information providing options for displaying information through auditory representation is done in concert with other forms or representation (King-Sears et al., 2015). How the material is represented is also important through both UDL and STEM education. Clear organization of information through the use of low-tech methods such as graphic organizers and strategy sheets are common in classrooms using STEM and UDL (CAST, 2018; "*CAST Universal Design for Learning Guidelines version 2.0.*," 2011; King-Sears et al., 2015; Marino, 2010).

The guidelines for representation in the CAST (2011) handbook for conducting UDL instruct educators to draw from multiple backgrounds, highlight patterns, and emphasize big ideas between content areas. Key teaching methods in STEM education including discovery-based education, problem-based education, and interdisciplinary STEM education all rely on drawing connections between subject matter and learner backgrounds. This has been accomplished through a technique used within both STEM education and UDL to accomplish optimal organization called scaffolding of material. Scaffolding of material involves overlapping related chunks of information, which allows for generalization between different content and lessons (CAST, 2011). Scaffolding between subject matter is highlighted in the interdisciplinary nature of STEM education (Bargerhuff, 2013; Basham, Israel, et al., 2010; Hwang & Taylor, 2016) and scaffolding of materials has been proven effective in both UDL and STEM teaching methods (Basham & Marino, 2013; King-Sears et al., 2015; McCleery & Tindal, 1999).

2.4.2. *Providing Multiple Forms of Strategic Engagement*

Similarities have been drawn between strategic engagement and STEM education as well. CAST (2018) explains that providing options for recruiting interest maintains student's engagement. STEM education provides multiple methods for engaging in coursework through the development of the lesson 'hook'. Scientific inquiry strategies are used within STEM education as a method for engaging student's attention. Scientific inquiry strategies have been shown to engage both students with disabilities and students without disabilities (Bargerhuff, 2013; Palincsar et al., 2001). A suggested method in CAST (2018) for increasing strategic engagement of students is to provide relevant value and authenticity to the lesson content. This is done in STEM through the use of real-world problems and real-world design challenges (Basham, Israel, et al., 2010; Dunn et al., 2012; Hwang & Taylor, 2016). Student intrinsic motivation in the subject matter can be increased by drawing personal connections from the students to the material (Izzo, 2012; Marino et al., 2014)

Courses like architecture, computers, and astronomy provide opportunities to use STEM subject matter outside the restrictions of science and mathematics state-mandated testing (Israel et al., 2015; Izzo, 2012; Marino et al., 2010). According to Hehir et. al (2013). students with disabilities enroll in CTE programs at a disproportionately high rate. Students with high incidence disabilities make up approximately 17 % of students in CTE classrooms. In cities, vocational schools up to 30% of the student body in CTE classrooms had needs defined by the Individuals with Disabilities Education Act (IDEA) (Hehir et al., 2013). CTE classrooms can serve to benefit and hinder the learning of students with learning disabilities. In a quantitative study observing 30 CTE classrooms, Casale-Giannola (2011) noted that CTE classrooms have the opportunity for differentiated instruction, active learning, real-life connections, cooperative learning and relationship development. However, CTE classrooms can also hinder the learning of students with learning disabilities due to weak basic skills and poor teacher training (Casale-Giannola, 2011). By using real-world problems facing an industry, classroom subjects are put in situations students may face in their future careers, further increasing awareness in how subject matter is used in the real world (Goeke & Ciotoli, 2014; Gonzalez & Fryer, 2014; Hwang & Taylor, 2016). Engagement in STEM courses can be improved through the use of peer-led learning. Peer-lead learning has been shown to have a positive impact on both students with and without disabilities in STEM courses through direct instruction or dialog circles ("Access STEM Building capacity to include students with disabilities in science, technology, engineering, and mathematics fields. Seattle," 2007; Bargerhuff, 2013; Street et al., 2012).

2.4.3. *Providing Multiple Forms of Action and Expression*

The final principle for UDL is multiple means of expression or assessment, which is defined as how students can express or demonstrate mastery in a subject (CAST, 2018).

Educators in a STEM classroom have allowed students to utilize multiple forms of media to express understanding. Some of these media include speech, text, drawing, illustration design, film music, visual arts, video, social media web-based tools, and storyboard (Bargerhuff, 2013; Izzo, 2012; Marino et al., 2014).

CAST (2018) also states that accomplishing the goal of providing students with multiple options for expression involves using a variety of strategies to solve problems. A few teaching methods within STEM that utilize multiple methods of problem-solving include engineering and design-based learning, which both focus on allowing autonomy to student's problem solving (Basham & Marino, 2013; Marino et al., 2010). These methodologies include providing examples of solutions to problems while allowing students to develop and test their own. Researchers into the innovation of utilizing UDL in STEM classrooms have also made note of STEM classrooms' ability to accomplish other objectives including providing flexible assessments (CAST, 2018), allowing for methods for timely progress monitoring (Basham & Marino, 2013; Izzo, 2012), and reinforcement of self-management strategies (King-Sears et al., 2015).

2.5. DIFFUSION OF INNOVATION THEORY

Diffusion of Innovation theory is based on the stages of change that occur within a community when an innovation is introduced. Rogers (2003) defines innovation as "an idea, practice, or object that is perceived as new by individuals or a unit of adoption" (Rogers, 2003, p. 11). Diffusion of Innovation theory discusses that there are different factors that are involved in an innovation being adopted. Rogers (2003) hypothesized that there are four main elements to Diffusion of Innovations theory. The four main elements consist of (1) the innovation (2) the communication channels within the population about the innovations (3) how long is the time of diffusion among the population (4) the social system within the population (Rogers, 2003). Rogers (2003) also explains the general stages of how an innovation is generated, the general stages each member of member of the population will take when deciding to adopt the innovation, and factors about the adopters themselves that could increases the likelihood of the innovation being adopted. Rogers (2003) determined that there were 5 variables that determined the rate of adoption of an innovation: (a) the perceived attributes of the innovation, (b) the different types of innovation decisions, (c) communication channels of the social system, (d) the overall nature of the social system, (e) the extent of a promotional effort by change agents.

The focus of this study is to evaluate how integrated STEM educators utilize Universal Design for Learning in their real-world classrooms. Diffusion of Innovation theory Can be used by researchers to investigate the disconnect between the practical application of innovations and the theoretical compatibility of innovations. This can be accomplished through evaluation of the innovations through Rogers (1995) five attributes of innovations that influence the rate of adoption: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. “Relative advantage is the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers, 2003, p. 212). Although Rogers (2003) focuses on the monetary advantages of an innovation, educational research has switched the focus to the specific pedagogical advantage of an innovation over its predecessor. Benette and Benette (2003) discussed the relative pedagogical advantages of educational instructional technology, but the idea holds true for teaching methodologies as well. "Most instructional technologies are so flexible and can be put to so many uses that it is impossible to identify their intrinsic value. Rather, the value of the technology will depend on the ways in which it is used" (Bennette and Benette, 2003, p. 56). Therefore, in order to determine the relative advantage of a teaching methodology, it is important to identify how it is perceived as useful by the adopters. “Compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." (Roger, 2003, p. 224). Compatibility of the innovation is broken down into three sections (1) the population's values and beliefs about the innovation, (2) the innovations compatibility with previously introduced ideas, and (3) the compatibility with the population's needs. In the field of education, the educator's beliefs and values about an innovation affect the rate of adoption either positively or negatively. The innovation needs to be compatible with the teacher’s previous teaching methodologies, but not so similar that it is not considered an innovation. An innovation that is too similar can appear to offer no advantages over to its predecessor and won’t be adopted (Hahn 1974). An innovation must also fit the needs of the educator in order to be accepted by the community. “Complexity is the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003, p. 242). The rate of adoption for innovations that are perceived as complex are reduced compared to innovations that are easier to understand. This means that educational teaching methods that are perceived as too complex are less likely to be adopted “Trialability is the degree to which an innovation may be experimented with on a limited basis” (Roger, 2003, p. 243). This characteristic means that if an innovation is easier to try for a short time, the innovation is more likely to be adopted by the population. In educational systems, in order for educators to try a new teaching methodology, it can require a great deal of time and effort to learn the basic implementation, which can reduce the likelihood of adoption of the innovation. “Observability is the degree to which the results of an innovation are visible to others” (Rogers, 2003, p. 244). This characteristic means that if an innovation is readily available and widely introduced to an individual, the innovation is more likely to be adopted. In education social systems there is increased evidence that diffusion has a higher success rate when it is spread through personal interactions or in small groups (Dancy & Henderson, 2010; Prince et al., 2013).

There is extensive previous work explaining that STEM education and Universal Design for learning methodologies hold theoretical compatibilities ("Access STEM Building capacity to include students with disabilities in science, technology, engineering, and mathematics fields. Seattle," 2007; Basham & Marino, 2013; Goeke & Ciotoli, 2014; Hwang & Taylor, 2016; Israel et al., 2015; Marino et al., 2010; Moon et al., 2012) but there is no research that has been done to examine what this innovation looks like in Integrated STEM classrooms while being exposed to all of the factors of a real-world situation. Fully describing the innovation itself and how it is used in the field today is an essential first step in promoting the spread of UDL into all integrated STEM classrooms.

3. CHAPTER THREE: METHODOLOGY

3.1. RESEARCH DESIGN

This study utilized a qualitative research design for collecting and analyzing data. Qualitative studies rely on a diverse set of methodologies and steps. These studies focus on the analysis of phenomenon through text, images, lived experiences, interviews and first-hand observations (Creswell & Creswell, 2017). Qualitative analyses are meant to examine the whole picture of a phenomenon through words and actions of those who live the phenomenon. In this study, I analyzed what elements of Universal Design for Learning were used in Integrated STEM in real-world classrooms, along with the decision-making rationale behind what elements of UDL included or excluded in the classrooms. The inclusion and exclusion of UDL elements in Integrated STEM classrooms, along with the decision-making perspective of the educators require qualitative analysis to understand the entire workings of the phenomenon.

3.1.1. *Research Questions*

The research questions for this project are as follows:

If Integrated STEM and Universal Design for Learning (UDL) teaching methodologies have theoretical similarities, what changes and adaptations are made by educators in order to fit the needs of their Integrated STEM classroom?

1. How is the innovation of utilizing Universal Design for Learning in Integrated STEM education classrooms being implemented in real-world classrooms?
    a. In what ways do adopters meet Universal Design for Learning checkpoints?
    b. What challenges do adopters encounter when implementing Universal Design for Learning?

c. At what frequency does Universal Design for Learning checkpoints occur in the data?

2. What do patterns of the adopter's implementation say about the adoption of the innovation?
3. What do the actions and decisions of the adopters say about the innovation through Rogers (1995) five attributes of innovations?

3.2. THEORETICAL BASE FOR THE PROJECT

This research not only focuses on what is currently being done in the fields of combining Integrated STEM education and Universal Design for Learning methodologies but the potential for adoption of UDL methodologies to all Integrated STEM classrooms. This project analyzed what elements of Universal Design for learning are used in Integrated STEM in real-world classrooms, along with the decision-making rationale behind what elements of UDL are included or excluded in the classroom. To develop a study completely framed in a theoretical background, this project focused on Diffusion of Innovation theory, specifically better understanding the use of UDL in Integrated STEM classrooms as an Innovation. The project's framework, including sampling and interpreting of results, was be framed using Diffusion of Innovation theory

Defining innovation: The project interpreted the use of Universal Design for Learning in real-world Integrated STEM classrooms as an innovation. By viewing the phenomenon as an innovation, researchers evaluated the individual elements of UDL being present or absent in Integrated STEM lessons and the teacher's rationale behind the decisions to include or leave out through Rogers' (1995) five attributes of innovations that influence the rate of adoption. This allowed researchers the opportunity to better understand the innovation and its potential for adoption.

Population selection: The attractiveness of using Diffusion of Innovation Theory is the ability to better understand the elements of an innovation from the perspective and actions of the early adoption portion of the population. Researchers aimed to study teachers who have completed graduated coursework training in Integrative STEM teaching methods and inclusive practices including UDL and who currently use these practices in their real-world classrooms. This focuses the project on the early adopter portion of the target population of integrated STEM educators, who consist of educators currently teaching UDL through Integrated STEM methodology. The completion of the Integrated STEM courses demonstrates a knowledge of Integrated STEM teaching methods. To make sure the participants were truly adopters of the Integrated STEM teaching methodologies, researchers evaluated their lesson plans through a rubric designed to evaluate Integrated STEM lesson plans. The sample population has also taken a course in inclusive practices including UDL to complete their degree. This means that the population for this study has the training necessary to adopt the innovation of utilizing UDL in Integrated STEM classrooms and therefore could articulate what elements of the innovation they adopted or chose not to adopt.

Understanding the innovation: Through Diffusion of Innovation theory, researchers can better understand the characteristics of the innovation that affect its rate of adoption. Rogers (1995) theorized that there are five factors about an innovation that affect its rate of adoption, these include: (a) relative advantage, (b) compatibility, (c) complexity or simplicity (d) trialability (5) observability. By examining the findings through these 5 factors, the reaserchers were able to determine factors that encourage or fail to encourage the spread of this innovation within the Integrated STEM education community.

3.3. ROLE OF RESEARCHER

I am a 25-year-old, white, male, who grew up in a working middle-class household. I am a master's student, working as a graduate research assistant in the Agricultural, Leadership, and Community Education department at Virginia Tech. My experiences with Integrated STEM education and Inclusive classrooms are derived from personal and educational experiences. To highlight one point of experience is personally being diagnosed with a High Incidence Disability, Dyslexia and ADHD. I was diagnosed in 3rd grade and throughout my tenure in grade school, I became familiar with forms of inclusion from the perspective of a student. Another example of my personal experience is through my master's work in an educational program. My degree focuses around developing Integrated STEM education classrooms through the agricultural medium. I have also worked as a Graduate Intern at Wake Forest University's Learning Assistance Center and Disabilities Services, helping work with students with disabilities in a post-secondary setting one on one to help reach their academic goals.

I naturally view this investigation through the perspective of a teacher and as a student. While every student's needs are different, I have felt the struggles of being in a class where lectures are not geared toward my needs. I have also instructed students with disabilities and understood the burden of redeveloping curriculum to fit the needs of all learners. I believe that teachers have the power to create environments conducive to all learners. I believe in the constructivist theory that states the environment created around students provides the opportunities for learner development. But, if those opportunities are skewed towards particular learning style, the minority of students will suffer.

3.3.1 *Epistemology and Ontology of Researcher*

Pragmatism: This study was designed around the researcher's beliefs about the field of educational and educational research through pragmatism. The purpose and design of this research study were chosen based on the usefulness perceived by educators and researchers in the field. Stressing the usefulness of a study to the field is derived from the educator's pragmatic beliefs. Blake (2003) wrote about the application of the ethos of pragmatism in educational research by saying that understanding of the meaning and practices of educational ideas comes from focusing on their reflexive thinking though actual experimentation. This allows researchers to reduce the amount of "educational rubbish" in the field. The research designed in this study is derived from my belief that there are too many educational studies in the field of combining UDL and STEM without substantial explanation and reflection of educational practices. The clarification and screening methods are aimed to provide clarity and usefulness for future researchers and educators in this field.

3.4. TARGET POPULATION AND SAMPLE

The target population for this study is current teachers utilizing integrative STEM teaching methodologies in their classroom. This project used a purposeful sample of teachers that have completed coursework and training in Integrated STEM education methods through a graduate-level STEM Education Certificate Program with an elementary level concentration. Teachers created a STEM education portfolio with copies of Integrated STEM lessons they had designed for their current classrooms in a required course for the STEM education certificate program. If a teacher did not have access to their STEM education portfolio, the researchers asked to review Integrated STEM lessons that they were willing to share, along with any supplemental information the teacher was willing to provide, including pictures and videos that they had used to document the lessons execution

In 2012, the code of Maryland Regulations (COMAR)13A.03.06 required the use of UDL guidelines in the development of curriculum, instructional materials, instruction, professional development, and student assessment. This means that our educators are trained in both Integrated STEM education and at least familiar with Universal Design for Learning by teaching in the state of Maryland. Therefore, they are prime candidates to evaluate how an educator chooses to use UDL in an Integrated STEM classroom. Our sample population is made up of teachers currently or previously teaching at the Elementary levels in public school systems, through Integrated STEM teaching methods. By examining trained teachers in Integrated STEM education settings, researchers can evaluate the presence or absence of UDL principles, the educator's rationale behind their decisions and perspectives to better understand the innovation and its potential for adoption by the remainder of the target population. There are 24 teachers currently in the alumni database for the STEM Education Certificate Program.

3.5. RECRUITMENT

All 24 teachers in the database were contacted and invited to participate in our researcher study. The director of the program sent an introduction email to all graduates of the STEM Education Certificate Program. Researchers then sent a formal email invitation to the potential participants, explaining the nature of the project and what would be required of them. This study conducted 2 rounds of recruitment. The first round of recruitment occurred in May of 2018. Because the participants are practicing educators, a May recruitment conflicted with standardized testing in the state of Maryland. We conducted a second round of recruitment in late June. Of those 24 teachers, 5 volunteered to participate. The official IRB approved email, consent forms and interview guilds are found in Appendix C, D, and E.

3.6. DATA COLLECTION

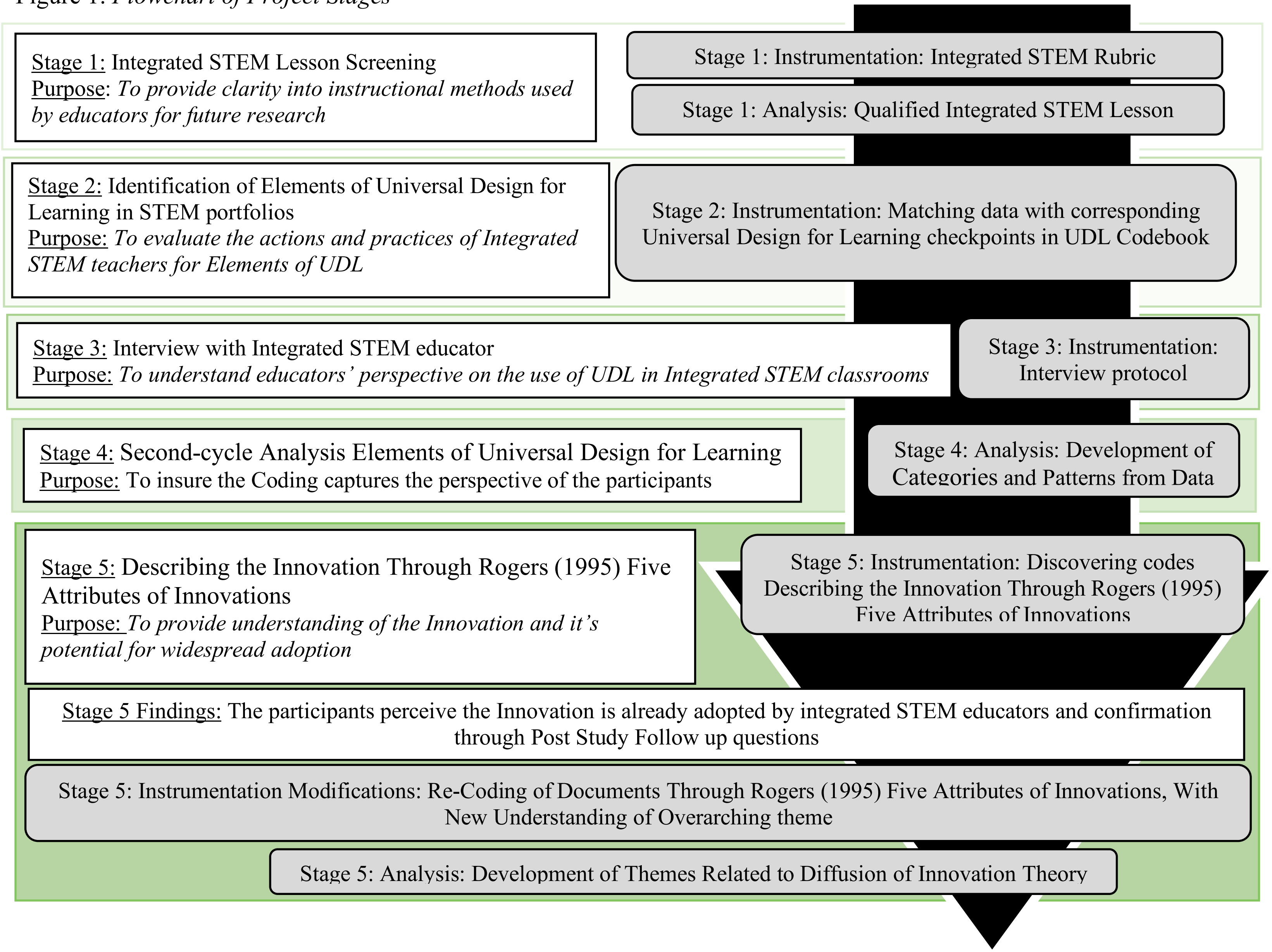
Qualitative data was collected through a document analysis of Integrated STEM lesson plans and a 45-minute interview with the creator of the Integrated STEM lesson plans about the lesson's execution, educator's perspective on the innovation, and the educator's decision making rationale for including or not including elements of UDL. Two weeks prior to starting document analysis, the researcher contacted the participant and asked which of the lessons in the portfolio have been used in their classroom, making it clear the researcher will only be looking for lessons that they have taught. Two pieces of data were collected from each participant in the study. Participants were asked to allow the researchers access to view their Integrated STEM lesson plans in their portfolios or provide alternate integrated STEM lessons for document analysis and participate in a 45-minute.

Each teacher's STEM portfolio was personalized to their classroom needs and had different material included based on the teacher. However, included in all these STEM portfolios are a collection of integrated STEM lessons. Additionally, supplemental materials were found in the portfolios that provided additional insight for document analysis including: personal notes on the lesson plans, post-lesson reflections, lesson revisions, case studies about students of interest in their class (a student with an ESOL barrier and a student with an emotional/ behavioral barriers), assignment responses, and pictures and videos of the lesson's execution. Of the 5 teachers in the study, 3 provided access to their STEM portfolio, 1 provided access to an extensive lesson plan, and 1 provided access to an entire month-long Integrated STEM unit. The data sources for the study included 22 lesson plans. One interview was conducted for each of the participants. In total there were 67 supplemental documents in addition to the lesson plans in the STEM portfolios.

3.7 INSTRUMENTATION AND DATA ANALYSIS

Qualitative data collection and analysis was conducted in five stages, (Figure 1) with data sources including lesson plans, supplemental information and interview transcript. First, lesson plans from each participant provided were scored on the adapted Integrated STEM rubric (Appendix A). All lessons that scored lower than an average score of 1 on the adapted integrated STEM rubric were excluded from document analysis. All qualifying data provided by the participants were coded for Universal Design for Learning Checkpoints. An interview was scheduled where participants were asked about elements of UDL not discovered in their provided materials. Both the provided documents and interviews were then recorded with the participants perspective in mind and used to create categories within the Adapted Universal Design for Learning Codebook (Appendix B). All collected data were coded for and interpreted through Rogers (1995) five attributes of innovations that influence the rate of adoption.

Figure 1: *Flowchart of Project Stages*



3.7.1. *Stage 1: Integrated STEM Lesson Screening*

All lessons were evaluated based on their alignment with integrated STEM education principles. The purpose of this section is to clarify what methodology of STEM education was used for the lessons.

3.7.1.1. Stage 1 Instrumentation: Integrated STEM Rubric

These lessons were evaluated on a rubric adapted from the Integrated Agriculture Education (IAE) rubric (Appendix A) designed by Robinson (2017). The rubric designed by Robinson (2017) was created to evaluate and guide educators to incorporate integrated STEM mathematics principles into their lessons. The original rubric was designed to evaluate both lesson plans and video of the lesson's execution. Our adapted rubric was changed to evaluate only lesson plans highlighting the use of integrated STEM principles within a lesson. The adapted rubric consists of 12 questions, that highlight the 5 characteristics of integrated STEM lessons found in Robinson's (2017) systematic review of STEM literature. These characteristics include: (1) utilization of two or more subject areas within a context; (2) coursework produced should be practical and/or authentic; (3) making strategic effort to promote critical thinking and problem-solving skill development; (4) methods are student-centered; and (5) technology is utilized consistently (Robinson, 2017). The adapted rubrics provide a score of 0 through 3 for each element of integrative STEM Education classrooms. The adapted rubric was piloted by 2 trained educators in Integrated STEM education on lessons provided by one of the participants. The lesson was scored originally by the researcher and then piloted by the 2 trained integrated STEM educators. The results were compared and the overall average scores between the researcher and other educators differed by only (0.083 and 0.16) on a 0-3 scale. Any rubric items with discrepancies were revised based on score and pilot's comments. When the rubric was finalized, it was used for the remainder of the data collection.

3.7.1.2. Stage 1 Analysis: Qualified Integrated STEM Lesson Selection

All lessons from each participant were evaluated on the adapted Integrated STEM rubric. If the combined average for the selected lesson was lower than 1, it was considered only a general STEM lesson and was excluded from the study. All qualified lessons moved on to stage 2 of the document analysis. The result of our screening methods is found in Appendix F. All 22 lessons provided by participants had an average STEM rubric score higher than 1 and therefore qualified for the study.

3.7.2. *Stage 2: Initial Coding of Elements of Universal Design for Learning in Documents*

To evaluate what elements of Universal Design for Learning were implemented in the qualified lessons and supplemental information, we used an adapted version of the CAST (2011) v.2 guidelines (Appendix B) as a codebook to inform the qualitative analysis of the lesson plans and the transcripts of the interviews. Basham and Garder (2010) proposed methods to evaluate and measure the implementation of UDL into a curriculum or program. One method they believed to be effective is using CAST's guidebook as checkpoints for an evaluation. Since Basham & Garder's publication, CAST has revised their guidebook to provide a more in-depth guide to UDL implementation. This method was used to evaluate implementing of UDL in other STEM curriculum (Marino et al., 2014) and is widely cited as a guide to implementing UDL principles into any curriculum (Basham & Gardner, 2010; Gonzalez & Fryer, 2014; Marino, 2010; Marino et al., 2014; Villanueva & Di Stefano, 2017). Because UDL has many forms of implementation, the CAST UDL guidelines have provided a systematic guide to help evaluate the strengths and weaknesses of educators' use of UDL.

According to the CAST UDL guidebook, in order to help educators reach the 3 main principles of UDL (providing multiple means of representation, engagement, and expression), the guidelines provide 9 sections that inform each of the 3 objectives. Within those 9 sections, the guideline provides 31 checkpoints that inform educators whether they have met the goals of the 9 sections. we used the 31 total checkpoints to identify what elements are used in Integrated STEM classrooms, by adapting the UDL guidebook to a UDL codebook (Appendix B). Codebooks are used as a method of informing qualitative analysis, by refining how researchers evaluate the data. For each of the 31 checkpoints, the codebook contains an explicit definition taken from the CAST UDL Guidelines or a summarizing sentence explaining the meaning of the checkpoint, along with a list of "implementation examples" taken directly from the original CAST UDL Guidelines.

Each qualified lesson including supplemental information, was coded for pedagogical purposes and practices by matching the corresponding pedagogical purpose behind each CAST UDL guideline checkpoint. The data was interpreted based on the total available information provided.

3.7.3. *Stage 3: Data Collection: Interview with Integrated STEM educator*

To gain a better perspective on the implementation of the innovation, we conducted an interview with the participants. The goal of the interview section was to provide insight into answering our research questions from the perspective of early adopters of the innovation. The interview section sought to remove the ambiguity of the document analysis and provide educational practitioners' insights into the decisions and rationale about what elements of UDL were not included in the material available for document analysis. This further provided insight into understanding the innovation with questions aimed at informing Rodgers (1995) 5 attributes of an innovation that influence the rate of adoption.

3.7.3.1. Stage 3 Instrumentation: Interview protocol

The 45-minute interview consisted of 4 sections (Appendix E), These sections consisted of standard and customized questions for each interview. The first part of the interview provided the participant with insight into the investigation of this research project. Part 1 consisted of one question aimed at identifying if the educator applies a conscious effort into using Universal Design for Learning in their Integrated STEM classroom. This question provided insight into the rational and decision-making process of the educator, as to whether they had adopted or failed to adopt Universal Design for Learning in their classroom.

Based on the educator response to part 1, part 2 had 2 version of questions, both seeking to provide insight into Rogers (1995) five attributes of innovations that influence the rate of adoption: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. The questions were designed to specifically target responses towards each of the attributes while allowing the participant to elaborate on their rationale. If the participant said yes in part 1, we proceeded to ask questions from part 2A which has the educator expand upon their rationale for using UDL in their classrooms. If the participant said no in part one, we proceeded to part 2B, which has educators expand upon why they do not perceive they use UDL. Both part 2A and part 2B have questions aimed at informing Rogers (1995) five attributes of innovations that influence the rate of adoption. Follow up questions were asked for clarification and elaboration to provide further insight into the 5 attributes. The interview question (Appendix E, question 2Aa, 2Ba) was targeted to gain the perspective of the educator on what are the Relative advantages of using the innovation or how the adopter perceives the Innovation as better than the idea that superseded it. The interview question for Compatibility aimed to provide context into that educator's experience with students with disabilities in their integrated STEM classroom, demonstrating a need for the innovation (Appendix E, question 2Ab, 2Bb). Complexity was investigated by a combination of targeted interview questions and interview specific UDL checkpoint questions investigating rationale behind problems faced when implementing a UDL checkpoint by the participants (Appendix E, questions part 4). The targeted interview questions focus on the educator's perceived beliefs on the difficulty of implementing UDL in an Integrated STEM classroom (Appendix E, question 2Ad, 2Bd). The Interview specific questions were designed to identify what checkpoints of UDL were not utilized and evaluate why. The targeted questions aimed at Trialability sought to evaluate the educator's perception of how other educators could try this innovation on a trial basis (Appendix E, questions 2Ae, 2Be). The targeted questions for Observability aimed to evaluate the educator's perception of how other educators could observe this innovation within their community (Appendix E, question 2Ae). A question also focused on whether the use of UDL in an Integrated STEM classroom would be recognizable to someone without formal training (Appendix E, question 2Aea, 2Aeb, 2Bf).

Part 3's interview questions were designed to investigate UDL checkpoints that cannot be evaluated by document analysis of the integrated STEM lesson plan and supplemental material alone. These questions aimed to evaluate checkpoints # 6.1, 6.2, 6.4, 9.1, 9.2, 9.3 (Appendix B) focus on goal setting and self-regulation that required data collection via specific questions on the educator's classroom teaching practices. Part 3 consist of 2 questions asked at every interview. If the participant responded that they utilize the checkpoint in questions 3a or 3b, we either moved on to the next question or asked an elaboration question to clarify their original response. If the participant responded that they do not utilize the checkpoint in questions 3a or 3b or indicated that there were difficulties with that UDL checkpoint implementation, researchers asked a follow-up question aimed at having the educator expand upon the problems they faced with that checkpoint.

Part 4 transitioned into questions aimed at UDL checkpoints not found in the participant's specific integrated STEM lessons and supplemental material. These questions were customized based on results from what UDL checkpoints were seen in the document analysis. These questions were designed around UDL checkpoints that were not easily identifiable in the document analysis of the documents alone. This part includes specific questions designed to remove some of the ambiguity of researcher document analysis and provide further insight into the actions of the participant as a whole. These checkpoint questions were formed before the start of each interview. Each interview's questions were therefore customized based on the availability of the pedagogical purposes found in the data corresponding to each UDL checkpoint. Each of the selected part 4 questions were aimed at evaluating if and how a UDL checkpoint was utilized. If the participant's response indicated that the requirements for the checkpoint were significantly met, the researcher proceeded to the next checkpoint. If the checkpoint was not met, however, the researcher asked a follow-up question to investigate the decision-making rationale of the participant. Follow-up questions were only asked for checkpoints that not satisfy the requirements of the checkpoint, or for further clarification. Participants interview responses were transcribed verbatim. These transcripts were used as data for the remainder of the project.

3.7.4. *Stage 4: Second-Cycle Analysis for Elements of Universal Design for Learning*

The purpose of this stage of analysis was to use insights into participants perspective from interview data to refine initial Universal Design for Learning codes found in STEM portfolios and discover new codes based on a more complete understanding of the participants perspective and motivations behind their actions. The UDL codes found in both the original and second cycle data analysis were refined using the understanding from adopters perspective in their interview. Using the interview to refine all of the codes found for each participant ensured that the researcher's codes matched the pedagogical purpose the adopter sought to achieve. These refined codes from both the first and second-cycle analysis sorted into the corresponding UDL checkpoints in the Codebook. The researcher then analyzed all codes for each of the 31 UDL checkpoints in the guidebook individually. All examples found in each checkpoint were categorized based on similarity in how the examples achieved the UDL checkpoint. These examples were then compiled into categories.

Similarly, any problem that was expressed by a participant when asked about a specific UDL checkpoint in the interview was documented. These problems were not formulated into themes across the 5 participants, but serve to report all of the challenges faced by the adopters in this study. Researchers also developed a graphic representation of the total number of examples found in each of the 31 UDL checkpoints. The graphic representation of example found does not serve as a basis for qualitative analysis, but is intended to provide insight into the trends of adopters.

3.7.5. *Stage 5: Describing The innovation Through Rogers (1995) Five Attribute of Innovations*

3.7.5.1. Stage 5: Analysis: initial coding and analysis describing the innovation through Rogers (1995) Five Attributes of Innovations

To frame the findings of our study we used Rogers (1995) five attributes of innovations that influence the innovation's rate of adoption. Each attribute of the innovation was evaluated with the summation of all of the data collected. Interview transcripts and collected data were coded for examples of each of the Five attributes of Innovation. Once the data was coded, these codes were collected together based on what factor the codes were describing.

All of the codes in each factor were looked at to develop themes about each of the five attributes. When analyzing the codes found for Compatibility, the researcher evaluated how the early adopters perceive the innovation as compatible with their existing classrooms, along with documenting if there was a need for the innovation in Integrated STEM classrooms. When analyzing the codes found for Complexity, the researcher analyzed the data focusing on the perceived difficulty in using the innovation. The researcher also evaluated if participants thought that the innovation required additional effort on the part of adopters to utilize the innovation. When analyzing the codes found for Trialability, the researcher analyzed the adopters perception on how difficult the innovation is to use on a short-term basis. When analyzing the codes found for Observability, researchers analyzed codes based on what adopters perceive is observable about using the innovation compared to the remainder of the population of integrated STEM educators.

During this first-cycle analysis a theme emerged that affected how all of the codes were interpreted. The participants consistently expressed that if a teacher was using Integrated STEM education, then they were naturally using Universal Design for Learning. The researcher continued with the coding process for each of the Rogers (1995) five attributes of innovations that influence the innovation's rate of adoption. Upon closer examination in the coding methods listed above, the theme was widespread throughout the interviews. It soon became clear that this finding altered the interpretation of our original codes and therefore the data needed to be with the understanding of this finding.

Because this finding was not part of our targeted questions, but showed up constantly during interviews, after this cycle of data analysis we sent two follow up email to the participants with a question:

1. From your perspective, if a teacher using your definition of Integrated STEM Teaching methodology in their classroom, are they automatically using Universal Design for Learning as well?
2. Is any additional effort needed on the part of the teacher to Implement Universal Design for Learning in Integrated STEM Classrooms?

Three participants responded all in agreement. Yes, if a teacher is using Integrated STEM they are automatically using Universal Design for Learning.

These follow up responses confirm our original finding and guided the second-cycle analysis. The 3 participants expressed that additional effort is needed in order to utilize UDL in an integrated STEM classroom, which supports our continuing analysis method to understand the 5 attributes that affect the adoption of an innovation.

3.7.5.2. Stage 5: Second-cycle Coding of Documents Through Rogers (1995) Five attributes of innovation

The lessons, supplemental documents, and interview transcripts were using the methods described in stage 2. This time, the data was coded with the understanding that the participants viewed the innovation as already applied in integrated STEM classrooms, leading to the need for the researcher to determine whether the excerpt still fell within the scope of the study. This required our researchers to ask two questions about the excerpts.

The first question was, were the participants talking about UDL being adopted by Integrated STEM teachers? Or were they talking about both teaching methodologies being adopted by teachers not currently using either teaching methodology? The later, both methodologies' being adopted into a non-Integrated STEM classroom, changes the population in the study. This according to Diffusion of Innovation theory changes the population being discussed from Integrated STEM educators to all educators moving these responses outside the scope of our study.

The second question researchers had to decipher prior to data analysis was, "were the participants discussing the benefits and problems about UDL being used in integrated STEM or for just Integrated STEM teaching methodology?" Because these two teaching methodologies are so closely linked in the perspective of the participants, participants would use Integrated STEM and Universal Design for Learning as synonyms. This would make the benefits and challenges of each teaching methodology indistinguishable from one another and would make it difficult to understand UDL's use in Integrated STEM Classrooms. Once the researcher had deciphered that the participant was discussing Universal Design for Learning's use in integrated STEM classrooms, the researcher continued with the original coding method.

3.7.5.3. Stage 5: Analysis: Development of Themes Related to the Diffusion of Innovation Theory

Once the lessons, supplemental documents, and interviews were coded for Rogers (1995) five factors of innovations that influence the innovation's rate of adoption, each of the codes was grouped based on what factor each code represented. Each group of codes corresponding to the five attributes was analyzed separately. The remaining codes were looked at as a group and themes were developed to represent the attribute as a whole.

3.8. ESTABLISHING CREDIBILITY

Establishing credibility of qualitative analysis is derived from explaining the uniqueness of the study and enhancing the chance of replication in other settings. By clearly explaining the personal interpretation of data through a reflection of the researcher's bias, values, and personal experience, the applicability of the study is wider reaching (Creswell & Creswell, 2017). In Creswell (2017) they list methods for increasing the credibility of a qualitative analysis. In this study, I implemented multiple strategies to increase the credibility of the findings. (1) Triangulation of data- this study included multiple forms of data, including participant interviews along with a document analysis of Integrated STEM lesson plans. (2) Member checking- the researcher provided multiple opportunities for dialog about the ongoing research with the participants of the study. Member checking was completed through email follow up questions, and confirmation of themes and categories found as result of this study (3) Peer examination- the overall results and reports were reviewed by an advisor and advisory committee. Researchers UDL coding methods were refined by through discussion with an expert debrief in UDL and other inclusive teaching practices (4) Clarification of the researcher's bias- the researcher explained their biases, views and personal experience with the phenomenon, (Creswell & Creswell, 2017).

3.8.1. *Advantages and limitations of Document and Interview Analysis*

Document analysis such as analyzing lesson plans has advantages and disadvantages in qualitative research. Document analysis of lesson plans provides the words and opinions of the participants. Lesson plans that are implemented often have hours of personalized work associated with them. Document analysis provides convenience to the researcher as well, being time efficient and saving the time of transcription. There are disadvantages to document analysis as well. Not all of the participants will be comprehensive in their lesson plans and responses. The lessons may be incomplete or not authentic. This method also requires researchers to find the elements of UDL in Integrated STEM education throughout the lesson which may not be in obvious locations (Creswell & Creswell, 2017). Transcripts of interviews about the execution of the lessons help strengthen the value of the document analysis but only provide a glimpse through the teacher's experience teaching the lesson. Interviews can depend on the wording of the questions asked and the willingness of the participant. An important limitation of this type of investigation is the subjectivity and inherent bias expressed in the interviewee's interpretation of what happens in the classroom. This inherent bias limits the generalizability of the findings within the field of research.

3.9. RESEARCH PERMISSION AND ETHICAL CONSIDERATION

Research permission and ethical considerations need to be taken before, during and after the study to protect the integrity of the participants and the study. Necessary steps for gaining research permission have been formatted to the subject of this study (Creswell & Creswell, 2017):

1) The research objectives were articulated in writing prior to the study so that they are clearly understood by the participant (including a description of how data will be used).

2) Written permission to proceed with the study as articulated and received from the participants through an email confirmation and signing of the IRB consent form.

3) A research protocol was filed with the Institutional Review Board.

4) The participants were informed of all data collection devices and activities.

5) Written interpretations were made available to the informants about their lesson plans and responses.

6) The informant's rights, interests, and wishes were considered first when choices were made regarding reporting the data.

7) The final decision regarding informant anonymity rests with the informant. No personal information was included in the analysis, interpretation, or reporting of the data.

4. CHAPTER FOUR: RESULTS

4.1 PARTCIPANTS' EXPERIENCE

Our participants discussed their experiences teaching a variety of students targeted by the Universal Design for Learning teaching methodology. Our participants have experience teaching in Integrated STEM classrooms with students with a verity of disabilities including Non-readers, autism spectrum disorder, non- communicative, Fragile x, other genetic disorders, language barriers, learning disabilities, hearing impairments, severe behavior and emotional issues, and students with mental health or trauma-related backgrounds

4.2 RESULTS: ACTIONS OF ADOPTERS FOR EACH UDL CHECKPOINT

Table 1 represents the collection of categories of how integrated STEM educators used each of the 31 UDL checkpoints. Table 1 also provides explicit examples of how the integrated STEM educators implemented each of the UDL checkpoints.

Table 3: *Actions of Adopters for Each UDL checkpoint*

Provide Multiple Means of Representation: [a]	Definition and examples of implementation:[b]	Categories of How UDL was used in Integrated STEM classrooms [c]	Examples [d]
1. Provide options for perception	"To reduce barriers to learning, it is important to ensure that key information is equally perceptible to all learners by: 1) providing the same information through different modalities (e.g., through vision, hearing, or touch); 2) providing information in a format that will allow for adjustability by the user (e.g., text that can be enlarged, sounds that can be amplified)"		
1.1 Offer ways of customizing the display of information	"Display each source of information in a flexible format so that the following perceptual features can be varied"-Pg. 14	1.1.1Access to built-in accessibility software on laptops 1.1.2 Teacher will read aloud/ record reading of class materials 1.1.3 Find identical resources (videos) in different language	1.1 Access to build in accessibility software (Examples: text to speech, online articles, search engine tools, closed captioning
1.2 Offer alternatives for auditory information	"To ensure that all learners have access to learning, auditory options should be available for any learning material, including emphasis, presented aurally."-Pg. 15	1.2.1 Access to built-in accessibility software on laptops 1.2.2 Find identical resources (videos) in different language 1.2.3 Teacher will read aloud/ record reading of class materials	

[a] The official title of the UDL checkpoint according to the CAST 2011 guidelines
[b] Either an explicit definition of the UDL checkpoint from the CAST 2011 guidelines or a summarizing definition
[c] Categories of how our participants reached these checkpoints
[d] Explicit examples found in the data that correspond to the categories

1.3 Offer alternatives for visual information	"To ensure that all learners have equal access to visual information, it is essential to provide non-visual alternatives."-Pg. 15	1.3.1 Access to built-in accessibility software on laptops 1.3.2 Find identical resources (videos) in different language 1.3.3 Teacher will read aloud/ record reading of class materials	
2. Provide options for language, mathematical expressions, and symbols	"Learners vary in their facility with different forms of representation – both linguistic and non-linguistic. Vocabulary that may sharpen and clarify concepts for one learner may be opaque and foreign to another… inequalities arise when information is presented to all learners through a single form of representation. An important instructional strategy is to ensure that alternative representations are provided not only for accessibility, but for clarity and comprehensibility across all learners."		
2.1 Clarify vocabulary and symbols	"To ensure accessibility for all, key vocabulary, labels, icons, and symbols should be linked to, or associated with, alternate representations of their meaning"- Pg. 16	2.1.1 Students will practice matching word with representation 2.1.2 Teachers provide context to new vocabulary through guided critical thinking/ guiding questions related to students 2.1.3 Use of organizers to develop categories 2.1.4 Students discover new vocabulary through context 2.1.5 Vocab is explicitly given prior to lesson	2.1.1 examples match in picture forms, flashcards 2.1.2 Relate word to background, culture, future carriers 2.1.4 Students identify, and develop their own or group definitions, discussion or research, apply and store vocabulary 2.1.5 Content first teaching 2.1.5 Explicitly giving, discussing vocab or asking about vocab

2.2 Clarify syntax and structure	"To ensure that all learners have equal access to information, provide alternative representations that clarify, or make more explicit, the syntactic or structural relationships between elements of meaning"-Pg. 17	Questions and Document analysis failed to reveal evidence of meeting these two checkpoints	
2.3 Support decoding of text, and mathematical notation, and symbols	"To ensure that all learners have equal access to knowledge, at least when the ability to decode is not the focus of instruction, it is important to provide options that reduce the barriers that decoding raises for learners who are unfamiliar or dysfluent with the symbols."-Pg. 17		
2.4 Promote understanding across language	For ESOL students providing linguistically options for students to learn in their primary language greatly increases understanding.	2.4.1 Students develop understanding through situational context 2.4.2 Use of organizers and worksheet 2.4.3 Supplementary assistance 2.4.5 Match new word with alternate representation	2.4.3 Use of Aids, resource teachers, helpers, peer helpers – develop plan, find resources 2.4.5 picture, drawing, hands-on videos, videos in native language
	"Providing alternatives, especially for key information	2.5.1 Use of Graphic organizers 2.5.2 Hands on activity	2.5.2 Dissection

2.5 Illustrate through multiple media	or vocabulary is an important aspect of accessibility"- Pg. 18	2.5.3 Interactive Technology 2.5.4 Visual representation 2.5.5 Text based representation 2.5.6 Audio representation 2.5.7 Guest speakers and demonstration 2.5.8 Discussion based learning 2.5.9 Engaging hook 2.5.10 use of multiple subjects 2.5.11 Direct explanation 2.5.12 Students personal research	2.5.3 Simulations, group blogs, websites 2.5.4 Video, pictures, maps, power points, Graphs 2.5.5 Books, articles, provided notes 2.5.6 Reading materials aloud 2.5.8 Critical thinking questions, class discussion, predictive questions, reflective questions, background, highlight points of clarification, highlighting points of view, group debates, group exploration, discovering vocab 2.5.9 Real world problems, real jobs, interesting story 2.5.10 Same topic in English, Social studies, science, math 2.5.12 Part of design process
3. Provide options for comprehension	"Constructing useable knowledge, knowledge that is accessible for future decision-making, depends not upon merely perceiving information, but upon active "information processing skills" like selective attending, integrating new information with prior knowledge, strategic categorization, and active memorization. Individuals differ greatly in their skills in information processing and in their access to prior knowledge through which they can assimilate new information. Proper design and presentation of information – the responsibility of any curriculum or instructional methodology - can provide the scaffolds necessary to ensure that all learners have access to knowledge."-Pg. 18-19		

3.1 Activate or supply background knowledge	"barriers can be reduced when options are available that supply or activate relevant prior knowledge, or link to the pre-requisite information elsewhere"-Pg. 19	3.1.1 Evaluating personal understanding 3.1.2 Critical thinking questions about background 3.1.3 Background through graphic organizers 3.1.4 Scaffolding information from previous lessons	3.1.1 Brainstorming, modeling how it's done 3.1.2 Class discussion 3.1.3 Anchor charts, sos challenges, gluing in notebooks
3.2 Highlight patterns, critical features, big ideas, and relationships	"one of the most effective ways to make information more accessible is to provide explicit cues or prompts that assist individuals in attending to those features that matter most while avoiding those that matter least."- Pg. 19	3.2.1- Demonstration or modeling of information 3.2.2 Use of graphic organizer to highlight patterns and highlight key features 3.2.3 Repeating and highlighting predictable lesson pattern 3.2.4 Highlight critical ideas through discussion	3.2.2 Anchor charts, sos challenges, gluing in notebooks 3.2.3 Problem solving process, design challenge format, stations, classroom schedule, calendar, stating the purpose, engendering, design, injury, observe, experiment, observe, state and finish unit with similar project, practice, scaffolding, time constraints 3.2.4 Critical thinking questions, class discussion, guiding questions, facilitation (aids or teacher) scaffolding of lessons
3.3 Guide information processing,	"Well-designed materials can provide customized and embedded models, scaffolds, and feedback to assist learners who have very diverse abilities	3.3.1 Visualization of material 3.3.2 Gradually introducing material to students through scaffolding of lessons	3.3.1 Demonstration or modeling, visualization, guest speakers, hands-on experiments, pictures, ppts, graphs

visualization, and manipulation	in using those strategies effectively"-Pg. 20	3.3.3 Direct explanations 3.3.4 Information processing through highlighting steps 3.3.5 Manipulation of info through questions 3.3.6 Guiding information through organizer	3.3.2 Series of lesson layout, (GIP), calendar of layered lessons, starting and ending unit with same experiment 3.3.3 Aids or teachers helping support students 3.3.4 Design based lesson, Problem based learning, Inquiry based lesson, reminding through poster around classroom, guiding the lesson, work stations, directed exploration 3.3.5 Teachers questioning, Critical thinking, discussion, Questions before and during representation to refine focus, prompt questions, preface and focus of incoming information 3.3.6 Data collection charts, observation recording sheet
3.4 Maximize transfer and generalization	"Supports for memory, generalization, and transfer include techniques that are designed to heighten the memorability of the information, as well as those that prompt and guide learners to employ explicit strategies."-Pg. 20	3.4.1 Critical thinking questions 3.4.2 Application of lesson outside lessons original context 3.4.3 Differentiating points of view of material	3.4.1 Predictive and reflexive thinking. Scaffolding questions back to a point of understanding 3.4.2 Starting and ending unit on similar projects, apply to other real-world problems, adding additional variables to problem.

		3.4.4 Application of content outside STEM subject	3.4.3 Different speakers, different aspects in stations, other subjects
II. Provide Multiple Means for Action and Expression:			
4. Provide options for physical action	"It is important to provide materials with which all learners can interact. Properly designed curricular materials provide a seamless interface with common assistive technologies through which individuals with movement impairments can navigate and express what they know – to allow navigation or interaction with a single switch, through voice activated switches, expanded keyboards and others"- Pg. 22		
4.1 Vary the methods for response and navigation	"To provide equal opportunity for interaction with learning experiences, an instructor must ensure that there are multiple means for navigation and control is accessible."- Pg. 22	4.1.1 Adaptions for hand written Responses 4.1.2 Adaptions instead of physical response 4.2.1 Speech to text software built into computers	4.1.1 Using audio recorder instead of writing 4.1.2 Substituting physical expression for visual (computer simulations) use of group support (peer support)
4.2 Optimize access to tools and assistive technologies	"It is critical that instructional technologies and curricula do not impose inadvertent barriers to the use of these assistive technologies."- Pg. 23	4.2.1 Speech to text software built into computers 4.2.2 Active support	4.2.1 Larger computer screens, zoom capabilities, word prediction software, scanner to iPad. 4.2.2 Use of for supplemental help aids, dictating response on a recorder, use of phone as personal scanner to iPad
5. Provide options for	"There is no medium of expression that is equally suited for all learners or for all kinds of communication. On the contrary, there are media, which seem poorly suited for some kinds of expression, and for some kinds of learning. It is important to provide alternative modalities for expression, both to the level the playing field		

expression and communication	among learners and to allow the learner to appropriately (or easily) express knowledge, ideas and concepts in the learning environment." – Pg. 23		
5.1 Use multiple media for communication	"Unless specific media and materials are critical to the goal (e.g., learning to paint specifically with oils, learning to handwrite with calligraphy) it is important to provide alternative media for expression" – Pg. 23	5.1.1 Physical expression 5.1.2 Audio expression 5.1.3 Written expression 5.1.4- Visual expression 5.1.5 Student observations	5.1.1 Develop models, hands on, physically build designs, dioramas 5.1.2 Group discussion, critical thinking questions, explanation of understanding, presentations, group debate, making a song 5.1.3 Experiment results report, prediction/ results, daily STEM notebooks, Persuasive writing, pre/ posttest, essay format, mathematical understanding, develop an advertisement 5.1.4 Maps, posters, draw/ label, home video, pictorial, computer simulation, ppt, charts
5.2 Use multiple tools for construction and composition	"Unless a lesson is focused on learning to use a specific tool (e.g., learning to draw with a compass), curricula should allow many alternatives" -Pg. 24	5.2.1- Tools for physical expression 5.2.2 Physical tools to express understanding 5.2.3 Computer software used for expression	5.2.1 Project materials, activity, hands on, prototype 5.2.2 Pencil, poster, STEM notebook 5.2.3 Online discussion board, ipad. Speech to text, recorder, word, google maps, voiceover, ppt, laptops, spell check, dictation services, enlarged computer screens, hearing aids

5.3 Build fluencies with graduated levels of support for practice and performance	"Learners must develop a variety of fluencies (e.g., visual, audio, mathematical, reading, etc.). This means that they often need multiple scaffolds to assist them as they practice and develop independence."- Pg. 24	5.3.1 Graduated levels of questioning 5.3.2 Freedom to use or reject graphic organizers 5.3.3 Deliberate grouping of students to support discussion 5.3.4 Practice of output	5.3.1 Directed critical thinking questions, increased scaffolding levels of support, encouraging a productive struggle 5.3.2 Anchor charts, use or not use 5.3.3 Group discussion with peers and aids, variation of groups based on ability level, jigsaw method with "student experts" 5.3.4 Review information
6. Provide options for executive functions	"Of critical importance to educators is the fact that executive functions have very limited capacity due to working memory. This is true because executive capacity is sharply reduced when: 1) executive functioning capacity must be devoted to managing "lower level" skills and responses which are not automatic or fluent thus the capacity for "higher level" functions is taken; and 2) executive capacity itself is reduced due to some sort of higher level disability or to lack of fluency with executive strategies. The UDL framework typically involves efforts to expand executive capacity in two ways: 1) by scaffolding lower level skills so that they require less executive processing; and 2) by scaffolding higher level executive skills and strategies so that they are more effective and developed."- Pg. 25		
6.1 Guide appropriate goal setting	"The UDL framework embeds graduated scaffolds for learning to set personal goals that are both challenging and realistic." – Pg. 25	6.1.1 Conduct one on one meeting 6.1.2 Focus on personal goal setting 6.1.3- Practice setting academic goals 6.1.4- Group goal setting	6.1.1 Use of aids to help set goals 6.1.2 Transition to middle school, developing ownership over goals, based on personal needs and wants 6.1.3 Consistent goal setting schedule, develop goals from personal reflections student rubrics, match curriculum goals, setting appropriate difficulty level of goals.

			6.1.4 Project based goals
6.2 Support planning and strategy development	"To help learners become more plan-full and strategic a variety of options are needed, such as cognitive "speed bumps" that prompt them to "stop and think;" graduated scaffolds that help them actually implement strategies; or engagement in decision-making with competent mentors."- Pg. 26	6.2.1 Guiding questioning 6.2.2 Planning through STEM lesson format methodology 6.2.3 Establishing goals of lesson early in unit 6.2.4 Use of graphic organizers	6.2.1 Predictive questioning, critical thinking, leading questioning 6.2.2 Group work, observations, group planning, group work, problem solving skills, time management, communication 6.2.3 Giving rubric at start, describing expectations
6.3 Facilitate managing information and resources	"Wherever working memory capacity is not construct-relevant in a lesson, it is important to provide a variety of internal scaffolds and external organizational aids – exactly those kinds that executives use - to keep information organized and "in mind.""-Pg. 26	6.3.1 Use of graphic organizers 6.3.2 Limit alternate places for information 6.3.3 Organization of methodology	6.3.1 Physically cut and paste into STEM notebooks, Classroom charts 6.3.2 All in STEM notebooks 6.3.3 Stations representing aspects of the problem, designated areas for experiments
6.4 Enhance capacity for monitoring progress	Educators need to provide timely formative feedback that allows learners to monitor and evaluate their progress and use the report to inform their practices moving forward.	6.4.1 Progress checks of goals 6.4.2 Displaying and adding to pervious work and questions 6.4.3- Use of rubrics to monitor academic progress	6.4.1 Once a day at morning or end of day, once a month, every quarter, direct progress reports (update parents, personal point score sheet, self-reflection). Informal progress monitoring (data binders, goal portfolios, STEM notebooks)

			6.4.2 Displayed organizers, posters students add to and pass everyday
III. Provide Multiple Means for Engagement:			
7. Provide options for recruiting interest	"Even the same learner will differ over time and circumstance; their "interests" change as they develop and gain new knowledge and skills, as their biological environments change, and as they develop into self-determined adolescents and adults. It is, therefore, important to have alternative ways to recruit learner interest, ways that reflect the important inter- and intra-individual differences amongst learners"- Pg. 28		
7.1 Optimize individual choice and autonomy	Educators should provide choices that are designed to optimize student's engagement.	7.1.1 Flexibility in lesson outputs 7.1.2 Providing choices in tools to solve problem 7.1.3 Autonomy of notetaking style 7.1.4 Freedom to explore information 7.1.5- Student derived questions	7.1.1 Rubric, choices, expression menu 7.1.2 Use of personal device, lesson materials, multiple tools 7.1.3 Choice to use of graphic organizers, draw notes 7.1.4 Research, at own pace, own questions
7.2 Optimize relevance, value, and authenticity	"To recruit all learners equally, it is critical to provide options that optimize what is relevant, valuable, and meaningful to the learner."- Pg. 29	7.2.1 Optimize personal connection to material 7.2.2 Use of Authentic tools, activities, and speakers	7.2.1 Real world problem, local problems, engaging lesson hook 7.2.2 Real hands-on resource, life like simulations, guest speakers, actual dissections

		7.2.3 Simulated career related responsibilities 7.2.4 Students develop personal ownership of the material 7.2.5 Final presentations outside of classroom	7.2.3 Mimicked career role, explore potential careers, assign group roles, becoming an expert 7.2.4 Increased responsibility, personal goals 7.2.5 To other classes
7.3 Minimize threats and distractions	"One of the most important things a teacher can do is to create a safe space for learners. To do this, teachers need to reduce potential threats and distractions in the learning environment"- Pg. 29	7.3.1- Increases motivation and engagement reduced distraction 7.3.2- Providing explicit directions 7.3.3 Strong classroom management 7.3.4 Reduction of barriers with student tools 7.3.5 Use of teacher aids to facilitate discussion 7.3.6 Adjusting grouping	7.3.1 Engaging lesson hook, real world problem, real careers, optimize level of challenge, open ended question, use of different modalities, having the students ask questions, given responsibilities (roles) 7.3.2 Review directions, clear directions, clear transitions 7.3.3 Control pacing of lessons (speed up or slow down based on need), organized classroom (schedule, classroom layout, job chart), developing relationship with student, teacher circulates room, establishing expectations, nonverbal cues 7.3.4 Barriers lead to distractive behavior. Helps prevent students from getting "stuck", organizational prompts

			7.3.6 Change members and size based on success
8. Provide options for sustaining effort and persistence	"However, learners differ considerably in their ability to self-regulate in this way. Their differences reflect disparities in their initial motivation, their capacity and skills for self-regulation, their susceptibility to contextual interference, and so forth. A key instructional goal is to build the individual skills in self-regulation and self-determination that will equalize such learning opportunities" – Pg. 30		
8.1 Heighten salience of goals and objectives	To maintain interest and engagement, educators need to provide periodic or constant reminders of goals and the value of their goals	8.1.1 One on one meetings 8.1.2 Importance of personal goals 8.1.3 Setting of academic goals	8.1.1 Direct explanation 8.1.2 To improve strengths, upcoming needs, life transitions, improve confidence
8.2 Vary demands and resources to optimize challenge	"Providing a range of demands, and a range of possible resources, allows all learners to find challenges that are optimally motivating. Balancing the resources available to meet the challenge is vital." – Pg. 31	8.2.1 Changing levels of support 8.2.2 Allowing flexibility in daily outputs 8.2.3 Varying ability level in groups 8.2.4 Focusing on achievable objectives 8.2.5 Rubrics allow for variation in demands	8.2.1 Increased aids support, different levels of questioning, giving more or less time to complete the project, added variable to increases difficulty 8.2.2 Freedom to use graphic organizers, flexibility output in personal stem journals 8.2.3 Different objectives per group. 8.2.4 Goals
	"Flexible rather than fixed grouping allows better	8.3.1 Group work	8.3.1 Jigsaw method, roles, groups based on ability level, knowledge

8.3 Foster collaboration and community	differentiation and multiple roles, as well as providing opportunities to learn how to work most effectively with others. Options should be provided in how learners build and utilize these important skills."- Pg. 31	8.3.2 Include parental assistance in community 8.3.3 Presenting for other classes in the school and community 8.3.4 Peer partners to help students facing barrier 8.3.5- Establishing positive classroom culture 8.3.6 Developing outside classroom activities	base, or age level, group brainstorming, working through problem, hands on activity, charts, group discussion, team goal setting 8.3.2 Helping, including in goals 8.3.3 Other grades, whole school 8.3.4 Peer teaching, mentorship 8.3.5 Support feelings of classroom community, sharing of personal feelings, positive reinforcement, treat students with a disability like anyone else, positive report with students 8.3.6 Summer school after school
8.4 Increase mastery-oriented feedback	Increases the focus of feedback towards mastery of content and skills	8.4.1- Reflexive questioning and observations 8.4.2- Revisiting problem in project after feedback 8.4.3- Application of knowledge to different context 8.4.4- Exploration of problem	8.4.1 Effectiveness of product, post lesson refection questions, reflection of goals, rubrics, self-evaluation rubrics 8.4.2 "Second chance learning", developing a 2nd prototype, trial and error, improvement of designs, pretest- post test 8.4.3 Generalization

9. Provide options for self-regulation	"While it is important to design the extrinsic environment so that it can support motivation and engagement (see guidelines 7 and 8), it is also important to develop learners' intrinsic abilities to regulate their own emotions and motivations… Unfortunately, some classrooms do not address these skills explicitly, leaving them as part of the "implicit" curriculum that is often inaccessible or invisible to many."- Pg. 32		
9.1 Promote expectations and beliefs that optimize motivation	Educators need to provided multiple options to promote and encourage self-regulation strategies for learners.	9.1.1- Developing relationships with students 9.1.2- Encourage reflections for next opportunity 9.1.3- Stimulate natural motivation from STEM teaching methods 9.1.4 Availability of resources 9.1.5 Provide engaging lesson hook	9.1.1 Verbal engagement on goal progress, develop pattern of support, develop relationships with students, express expectation 9.1.2 "Second chance learning", mastery of content 9.1.3 Design based learning, Problem based learning, Inquiry-based learning. 9.1.4 Better resources encourage students
9.2 Facilitate personal coping skills and strategies	Educators should provide methods for continual development of necessary skills involved with self-regulation	9.2.1 Direct monitoring of progress 9.2.2 Develop supportive relationship 9.2.3 Develop group work skills 9.2.4 Behavior management strategies	9.2.1 Daily monitoring of progress (spreadsheet in excel) 9.2.2 Direct praise, supporting students without prompting 9.2.3 Social skills, communications of wants and needs 9.2.4 Use of calming toy or environment, take a deep breath, go for a walk, behavior charts

9.3 Develop self-assessment and reflection	Educators need to instill multiple methods for self-assessment skills in students in order for self-regulation skill development	9.3.1 Critical thinking questions 9.3.2 Mastery of content 9.3.3 Group discussions lead to reflection of understanding	9.3.1 Reflexive questioning, predictive questions, self and prompted, rubrics, content related, self-reflection on what they don't know, group discussions 9.3.2 Student derived rubrics

4.3 RESULTS: EXPRESSED PROBLEMS WITH UDL CHECKPOINTS

Table 2 describes problems that our participants had with reaching specific UDL checkpoints. These problems are categorized examples expressed by our participants when using the innovation. Due to our small sample size of participants, examples were only cataloged and not developed into themes within each checkpoint.

Table 4: *Expressed Problems Associated with UDL Checkpoints*

Provide Multiple Means of Representation: [e]	Definition and examples of implementation: [f]	Problems with Implementation [g]
1. Provide options for perception	To reduce barriers to learning, it is important to ensure that key information is equally perceptible to all learners by: 1) providing the same information through different modalities (e.g., through vision, hearing, or touch); 2) providing information in a format that will allow for adjustability by the user (e.g., text that can be enlarged, sounds that can be amplified)	
1.1 Offer ways of customizing the display of information	Display each source of information in a flexible format so that the following perceptual features can be varied-Pg. 14	Complexity - Customizable material is not always readily available.
1.2 Offer alternatives for auditory information	"To ensure that all learners have access to learning, auditory options should be available for any learning material, including emphasis, presented aurally."-Pg. 15	Complexity - Customizable material is not always readily available.
1.3 Offer alternatives for visual information	"To ensure that all learners have equal access to visual information, it is essential to provide non-visual alternatives."-Pg. 15	Complexity - Customizable material is not always readily available.
2. Provide options for language, mathematical expressions, and symbols	"Learners vary in their facility with different forms of representation – both linguistic and non-linguistic. Vocabulary that may sharpen and clarify concepts for one learner may be opaque and foreign to another… inequalities arise when information is presented to all learners through a single form of representation. An important instructional strategy is to ensure that alternative representations are provided not only for accessibility, but for clarity and comprehensibility across all learners."	

[e] The official title of the UDL checkpoint according to the CAST 2011 guidelines
[f] Either an explicit definition of the UDL checkpoint from the CAST (2011) guidelines or a summarizing definition
[g] Problems expressed by our participants corresponding to specific UDL checkpoints

2.1 Clarify vocabulary and symbols	"To ensure accessibility for all, key vocabulary, labels, icons, and symbols should be linked to, or associated with, alternate representations of their meaning"- Pg. 16	Complexity – Teacher has to decide if they want students to learn vocab before or during lesson based on importance to topic Complexity- Giving student vocab sheets can conflict with discovery nature of integrated STEM lesson
2.2 Clarify syntax and structure	"To ensure that all learners have equal access to information, provide alternative representations that clarify, or make more explicit, the syntactic or structural relationships between elements of meaning"-Pg. 17	
2.3 Support decoding of text, and mathematical notation, and symbols	"To ensure that all learners have equal access to knowledge, at least when the ability to decode is not the focus of instruction, it is important to provide options that reduce the barriers that decoding raises for learners who are unfamiliar or dysfluent with the symbols."- Pg. 17	
2.4 Promote understanding across language	For ESOL students providing linguistically options for students to learn in their primary language greatly increases understanding.	Complexity- Explaining to children the need for learning in their non-dominate language Compatibility- Student express frustration at not being able to communicate and share ideas, often hits cogitative overload
2.5 Illustrate through multiple media	"Providing alternatives, especially for key information or vocabulary is an important aspect of accessibility"- Pg.18	
	"Constructing useable knowledge, knowledge that is accessible for future decision-making, depends not upon merely perceiving information, but upon active "information processing skills" like selective attending, integrating new information with prior knowledge, strategic categorization, and active	

3. Provide options for comprehension	memorization. Individuals differ greatly in their skills in information processing and in their access to prior knowledge through which they can assimilate new information. Proper design and presentation of information – the responsibility of any curriculum or instructional methodology - can provide the scaffolds necessary to ensure that all learners have access to knowledge."-pg 18-19
3.1 Activate or supply background knowledge	"barriers can be reduced when options are available that supply or activate relevant prior knowledge, or link to the pre-requisite information elsewhere"-Pg. 19
3.2 Highlight patterns, critical features, big ideas, and relationships	"one of the most effective ways to make information more accessible is to provide explicit cues or prompts that assist individuals in attending to those features that matter most while avoiding those that matter least."- Pg. 19
3.3 Guide information processing, visualization, and manipulation	"Well-designed materials can provide customized and embedded models, scaffolds, and feedback to assist learners who have very diverse abilities in using those strategies effectively".-Pg. 20
3.4 Maximize transfer and generalization	"Supports for memory, generalization, and transfer include techniques that are designed to heighten the memorability of the information, as well as those that prompt and guide learners to employ explicit strategies."- Pg. 20
II. Provide Multiple Means for Action and Expression:	
4. Provide options for physical action	"It is important to provide materials with which all learners can interact. Properly designed curricular materials provide a seamless interface with common assistive technologies through which individuals with movement impairments can navigate and express what they know – to allow navigation or

	interaction with a single switch, through voice activated switches, expanded keyboards and others"- Pg. 22	
4.1 Vary the methods for response and navigation	"To provide equal opportunity for interaction with learning experiences, an instructor must ensure that there are multiple means for navigation and control is accessible."- Pg. 22	
4.2 Optimize access to tools and assistive technologies	"It is critical that instructional technologies and curricula do not impose inadvertent barriers to the use of these assistive technologies."- Pg. 23	Complexity- insufficient assistive technology for building challenges, physical limitation of design challenge. Complexity- students need training in their assistive tech
5. Provide options for expression and communication	"There is no medium of expression that is equally suited for all learners or for all kinds of communication. On the contrary, there are media, which seem poorly suited for some kinds of expression, and for some kinds of learning. It is important to provide alternative modalities for expression, both to the level the playing field among learners and to allow the learner to appropriately (or easily) express knowledge, ideas and concepts in the learning environment." – Pg. 23	
5.1 Use multiple media for communication	"Unless specific media and materials are critical to the goal (e.g., learning to paint specifically with oils, learning to handwrite with calligraphy) it is important to provide alternative media for expression" – Pg. 23	
5.2 Use multiple tools for construction and composition	"Unless a lesson is focused on learning to use a specific tool (e.g., learning to draw with a compass), curricula should allow many alternatives" -Pg. 24	Complexity- Dangerous use of materials Complexity - Students physical limitation pose problems with design challenges. Compatibility- Another concern for students with behavior issues is using potently dangerous objects Compatibility- Limited availability of computer resources

5.3 Build fluencies with graduated levels of support for practice and performance	"Learners must develop a variety of fluencies (e.g., visual, audio, mathematical, reading, etc.). This means that they often need multiple scaffolds to assist them as they practice and develop independence."- Pg. 24	
6. Provide options for executive functions	"Of critical importance to educators is the fact that executive functions have very limited capacity due to working memory. This is true because executive capacity is sharply reduced when: 1) executive functioning capacity must be devoted to managing "lower level" skills and responses which are not automatic or fluent thus the capacity for "higher level" functions is taken; and 2) executive capacity itself is reduced due to some sort of higher level disability or to lack of fluency with executive strategies. The UDL framework typically involves efforts to expand executive capacity in two ways: 1) by scaffolding lower level skills so that they require less executive processing; and 2) by scaffolding higher level executive skills and strategies so that they are more effective and developed." Pg. 25	
6.1 Guide appropriate goal setting	"The UDL framework embeds graduated scaffolds for learning to set personal goals that are both challenging and realistic." – Pg. 25	Complexity- students often have difficulty in understanding good goals with meaning Compatibility- STEM goals are not priority with lack of time, Goals often focus on math, reading or writing
6.2 Support planning and strategy development	"To help learners become more plan-full and strategic a variety of options are needed, such as cognitive "speed bumps" that prompt them to "stop and think;" graduated scaffolds that help them actually implement strategies; or engagement in decision-making with competent mentors."- Pg. 26	
	"Wherever working memory capacity is not construct-relevant in a lesson, it is important to provide a variety of internal	Complexity- the amount of materials in a design challenge can pose an organizational problem.

6.3 Facilitate managing information and resources	scaffolds and external organizational aids – exactly those kinds that executives use - to keep information organized and "in mind.""'-Pg. 26	
6.4 Enhance capacity for monitoring progress	Educators need to provide timely formative feedback that allows learners to monitor and evaluate their progress and use the report to inform their practices moving forward.	Complexity- Lack of time to revisit reflections
III. Provide Multiple Means for Engagement:	Definition and examples:	
7. Provide options for recruiting interest	"Even the same learner will differ over time and circumstance; their "interests" change as they develop and gain new knowledge and skills, as their biological environments change, and as they develop into self-determined adolescents and adults. It is, therefore, important to have alternative ways to recruit learner interest, ways that reflect the important inter- and intra-individual differences amongst learners"- Pg. 28	
7.1 Optimize individual choice and autonomy	Educators should provide choices that are designed to optimize student's engagement.	
7.2 Optimize relevance, value, and authenticity	"To recruit all learners equally, it is critical to provide options that optimize what is relevant, valuable, and meaningful to the learner."- Pg. 29	
7.3 Minimize threats and distractions	"One of the most important things a teacher can do is to create a safe space for learners. To do this, teachers need to reduce potential threats and distractions in the learning environment"- Pg. 29	Complexity- Materials need to be all out at start of class to allow for minimal unmonitored time Complexity- Social nature can lead to distraction, spreading of bad behavior
8. Provide options for sustaining effort and persistence	"However, learners differ considerably in their ability to self-regulate in this way. Their differences reflect disparities in their initial motivation, their capacity and skills for self-regulation, their susceptibility to contextual interference, and so forth. A key instructional goal is to build the	

	individual skills in self-regulation and self-determination that will equalize such learning opportunities" – Pg. 30	
8.1 Heighten salience of goals and objectives	To maintain interest and engagement, educators need to provide periodic or constant reminders of goals and the value of their goals	Complexity- Difficulty in understanding good goals with meaning
8.2 Vary demands and resources to optimize challenge	"Providing a range of demands, and a range of possible resources, allows all learners to find challenges that are optimally motivating. Balancing the resources available to meet the challenge is vital." – Pg. 31	Compatibility- Modification of material for ability level having to modifying for every reading writing, spelling math can be difficult Compatibility- They may have to differentiate the instruction so that they won't have dangerous objects
8.3 Foster collaboration and community	"Flexible rather than fixed grouping allows better differentiation and multiple roles, as well as providing opportunities to learn how to work most effectively with others. Options should be provided in how learners build and utilize these important skills."- Pg. 31	Complexity problem – providing flexibility in lesson requires additional effort, Trial and error with group work- sometime heterogeneous groups don't work, students defer to other students. Smaller groups for non-communicative students, slowly introduce students to group work Complexity- Difficulty developing group personal skills Complexity- Removing students because of unsafe behavior Complexity- Social nature can lead to distraction, spreading of bad behavior Complexity- Assessing mastery in group work

		Compatibility- Group work has the potential to get off task. Ex. group work is one student's bad behavior spreading to the other students in the group. Compatibility- Students with severe behavior issues often have strong opinions and don't work well in teams
8.4 Increase mastery-oriented feedback	Increases the focus of feedback towards mastery of content and skills	
9. Provide options for self-regulation	"While it is important to design the extrinsic environment so that it can support motivation and engagement (see guidelines 7 and 8), it is also important to develop learners' intrinsic abilities to regulate their own emotions and motivations… Unfortunately, some classrooms do not address these skills explicitly, leaving them as part of the "implicit" curriculum that is often inaccessible or invisible to many."- Pg. 32	
9.1 Promote expectations and beliefs that optimize motivation	Educators need to provided multiple options to promote and encourage self-regulation strategies for learners.	
9.2 Facilitate personal coping skills and strategies	Educators should provide methods for continual development of necessary skills involved with self-regulation	
9.3 Develop self-assessment and reflection	Educators need to instill multiple methods for self-assessment skills in students in order for self-regulation skill development	Complexity- Lack of time to revisit reflections

4.4 RESULTS: TOTAL NUMBER OF UDL EXAMPLES FOUND PER CHECKPOINT

The number of examples coded for each CAST UDL checkpoint within the entirety of the project's data is presented in Figure 2. The checkpoints are listed on the vertical axis while the horizontal axis displays the total number of examples.

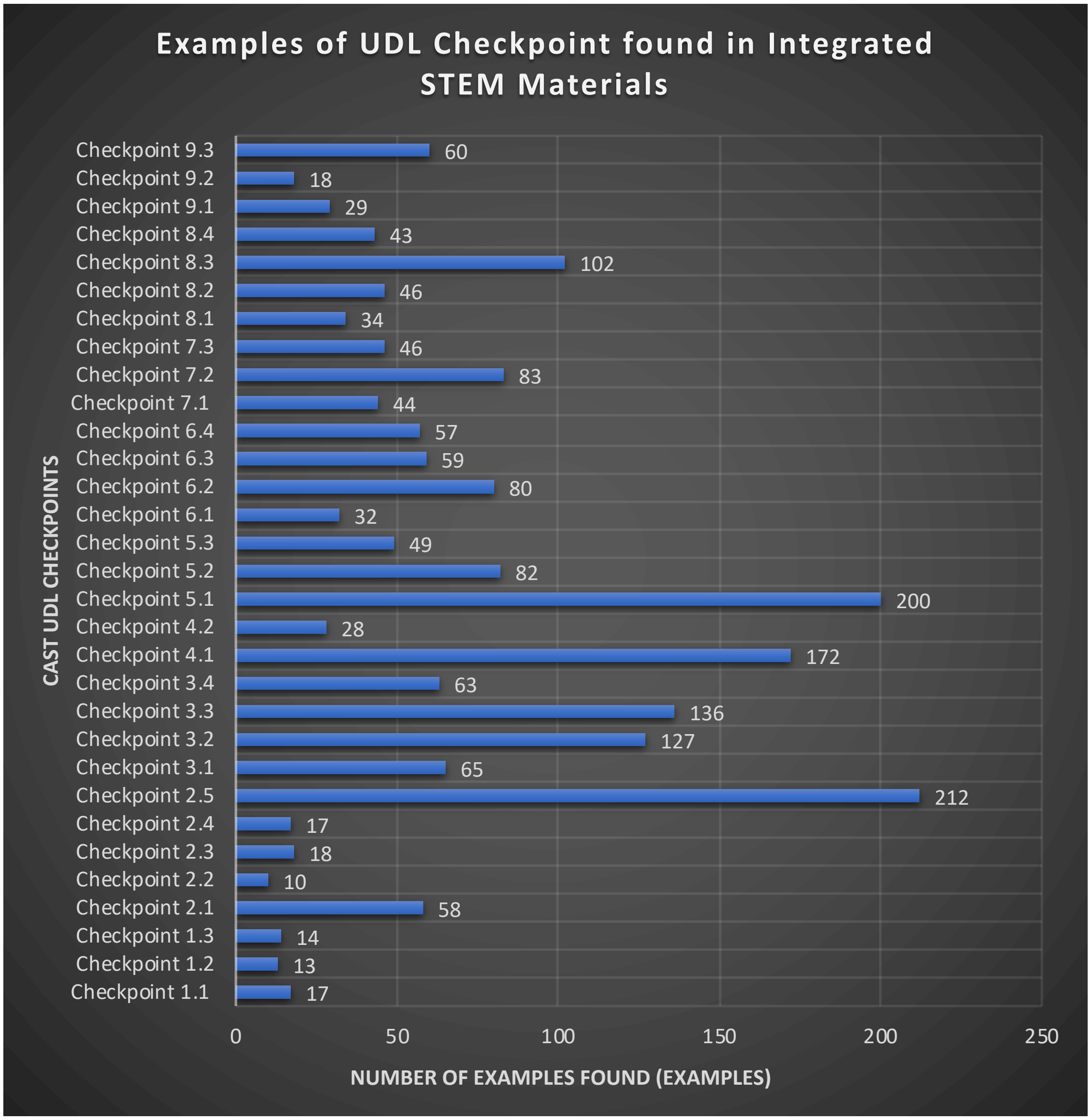


Figure 2: *Examples of UDL Checkpoints Found in Integrated STEM Materials*

To further evaluate the data from Figure 2, we separated UDL checkpoints into categories (tiers) based on High, Medium and Low frequency. These are presented in Figures 3, Figure 4, and Figure 5, respectively. The checkpoints are listed on the vertical axis while the horizontal axis displays the total number of examples.

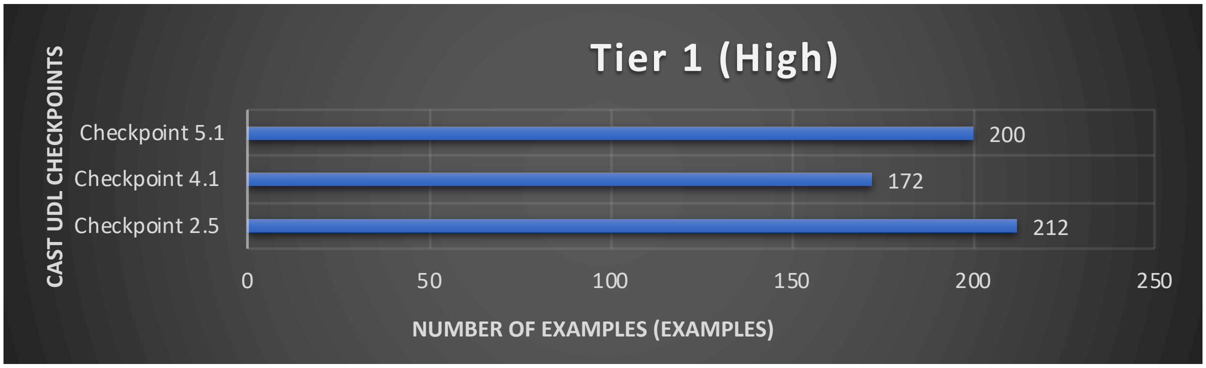


Figure 3: *Tier 1 Examples of UDL Checkpoints Found in Integrated STEM Materials*

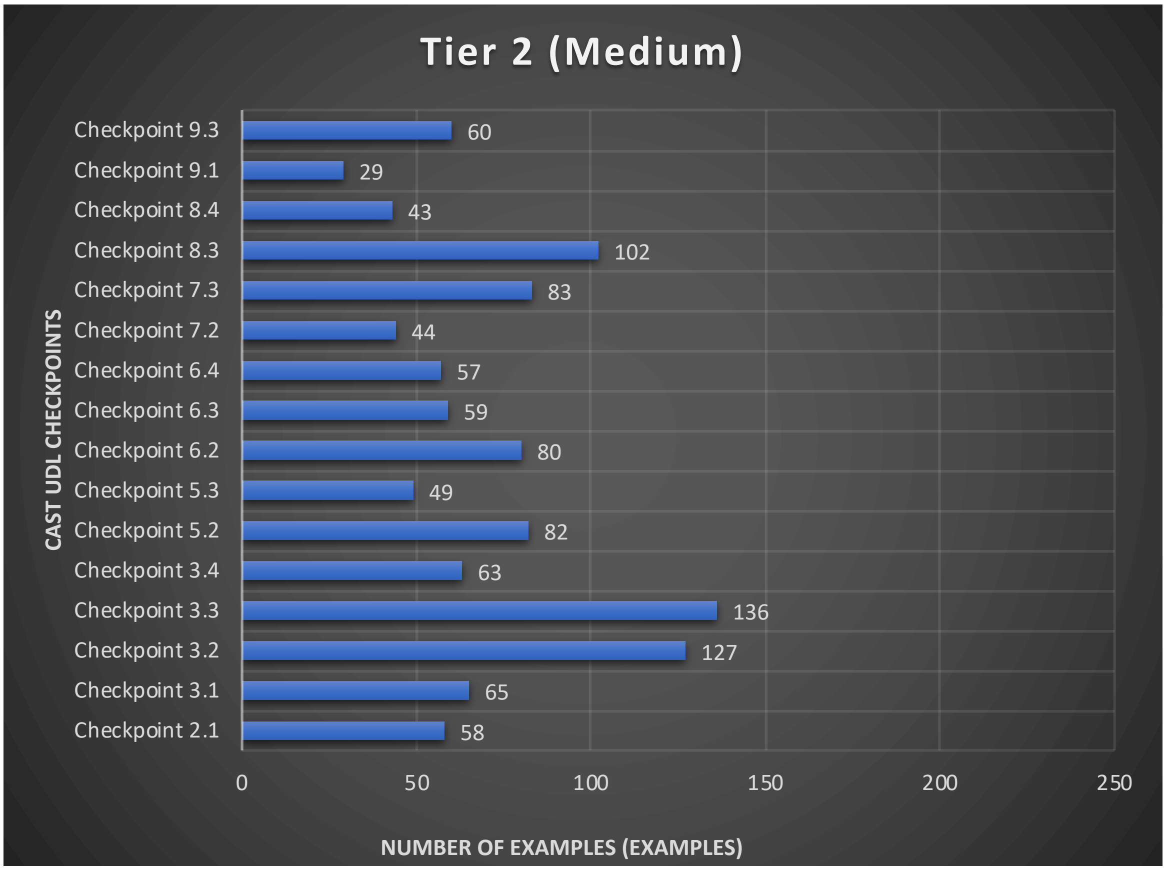


Figure 4: *Tier 3 Examples of UDL Checkpoints Found in Integrated STEM Materials*

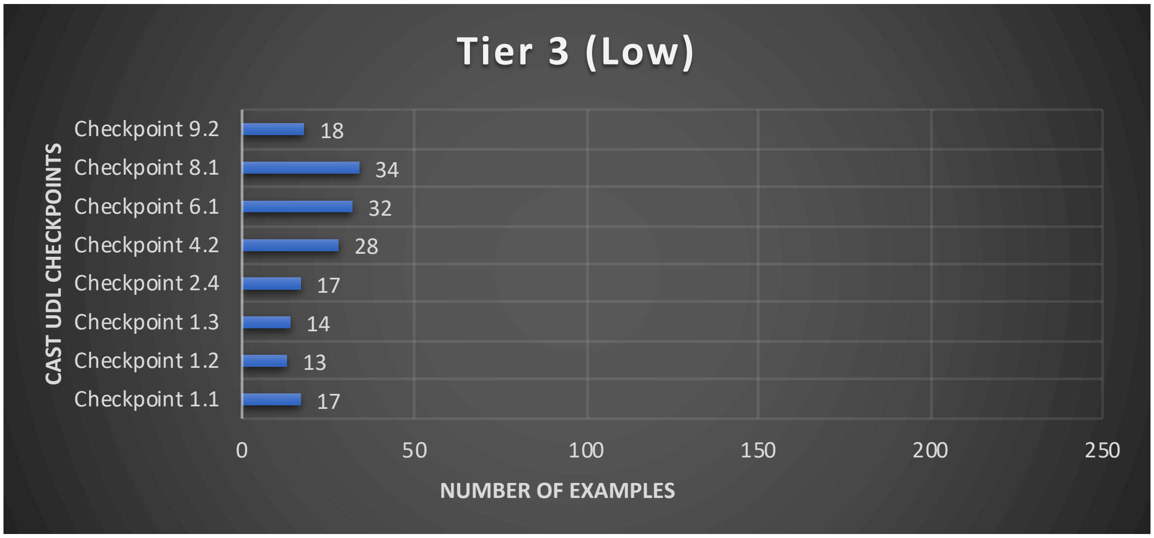


Figure 5: *Tier 3 Examples of UDL Checkpoints Found in Integrated STEM Materials*

4.5. RESULTS: DIFFUSION OF INNOVATION

As to frame our document analysis of lessons and the interviews, the study was based around understanding Rogers 5 attributes of the innovation. Through our coding we discovered themes about the use of the innovation through the perspective of our participants.

Something that should be noted about this theme is that some of these themes only occurred in Part II of our interview protocol. Part II of the interviews were where participants were discussing the general use of UDL in integrated STEM classrooms. The questions in part II focused on investigating the 5 attributes of an innovation, but the participants were not asked specific in-depth questions about the use of UDL checkpoints until Part III. Throughout the course of the interview, however, while answering questions aimed at specific UDL checkpoints or other factors of an innovation's diffusion, themes about the difficulties combining the two teaching methods surfaced.

4.5.1. *Theme: At a broad level, if a teacher is using Integrated STEM teaching methodology, they are already naturally using Universal Design for Learning*

The participant below was asked about how complex Universal Design for Learning is to use in an integrated STEM classroom. Instead, their response foreshadowed a theme that translated across all 5 participants.

> the two are married. I mean if you are really thinking about a stem challenge or a STEM lesson, you are focusing in on hands-on learning, and really the exploration of a problem of kids solving through and working through that issue. That's all UDL, it's taking everything that you know, and taking all of those pieces, and it's totally married. so to me its integrated its one, it's the same, there are no issues. (9.9)

This quote occurred three minutes into the study's first interview and says a great deal about the perspective of Integrated STEM educators use of UDL. "to me it's integrated, it's one, it's the same, there are no issues". The researcher continued on with the line of questioning described in the methods section for all 5 participants, but the perspective of complete embedded nature of Integrated STEM and Universal Design for Learning continued. This pattern also continued across the study's questions aimed at understanding the innovation through Rogers 5 attributes that influence the rate of the adoption of an innovation.

In responses to questions aimed to see if elements of UDL would be observable in a classroom using both UDL and Integrated STEM to someone who only trained in integrated STEM education, the participants believed the differences are not observable: “So could a teacher who just teaches STEM outside [without using UDL] and who has not been trained in UDL, see the difference, probably not” (9:26). The majority of the participants naturally pointed out that there are drastic differences between Integrated STEM and a traditional classroom. For example, our participant above continued on to say: "However if they are just stuck in the ‘science is one thing math is another' then yeah they are going to see that there is a huge difference." (9.27). From the participants perspective if the innovation is already adopted, then

UDL would already be a part of their current methodology and therefore there would be no differences to observe.

The interview questions on trialability aimed at understanding how easy it would be to try UDL in an Integrated STEM classroom on a short-term basis. The participants came to a similar conclusion as our overarching theme: “if you are honestly teaching STEM, then that's a way of teaching, which goes with UDL in my mind. So you're already kind of doing it” (76.16). The participant continued on to say “so if you get that, that [Integrated STEM is] a way of teaching then UDL shouldn't be an issue because like I said, I feel like they're completely intertwined naturally” (76.17). From the participants’ perspective, there is nothing preventing someone in an integrated STEM classroom from trying UDL because they are already using UDL.

The participants believed the teaching methodology of UDL is completely compatible with that of integrated STEM education. Through their training, our participants evaluated how they would use UDL in their integrated STEM classrooms. When we directly asked "What may hinder the compatibility of these two teaching methodologies?" a question aimed at understanding what could get in the way of combining these methods, the response was often something like this.

> I don't really see that they do per se. Maybe I have a different, uh, like through my lens so that I don't see that they do that. The learning that I did in the STEM program fits very well with UDL, like for example, the lesson that you were referring to, the force and motion lesson. I mean it's, it's UDL is embedded within it. They kind of go together. (76:3)

Because there is a natural similarity between these teaching methods, the participant's perspectives were that the two teaching methodologies fit together with no hindrance in their compatibility.

The perspective of participants about the compatibility of using the innovation is mirrored in their perspective on how complex it is to combine the two teaching methodologies. If you are using Integrated STEM, you are using Universal Design for Learning; therefore, if UDL is already being used, it's not complex.

> like how complex? I mean, I think if you're doing integrated STEM that I think you're naturally doing the UDL, at least my understanding of UDL. So, I don't think it was involved any more complex than doing integrated STEM. I mean I think they kind of go hand in hand. (94.10)

From an integrated STEM educator's perspective, the addition of using Universal Design for Learning in the classroom is already occurring and therefore adds no complexity.

4.5.2 Theme: UDL is just good teaching practice

From the perspective of our participants, the main theme for the relative advantage of using Universal Design for Learning in an integrated STEM classroom is that UDL is viewed as a good teaching practice or best practice for teachers.

> I find [UDL] to be a natural, um, strategy of teaching. It's just best practice I think to represent things in multiple ways to reach as many learners. And then they're not one size fits all learners, so how they showed you their learning, it cannot be just one way. So, I mean, it has the fancy name of UDL and the different principles underneath it, but so to me, it's just good teaching of show it in different ways, have them represented in different ways and how they show you they've mastered a skill is up to them as a learner. So to me as a teacher that was just common sense to me. (76.1)

The participants believe UDL provides the flexibility to adjust classroom executions to learners' strengths, interest, and needs.

> It just lets us meet the needs of our learners and it taps into the different parts of the learner, whether a student is kinesthetic, auditory, visual it doesn't matter when you are doing UDL, or when you are using UDL in your classroom, you are tapping into all of those components different types of learner. (9.1)

In this quote, the participant describes the relative advantages of the teacher's ability to focus in on the forms of representation and expression that best fit the student's needs. This intentional decision to adjust to students needs is considered to be best practices for all teachers and not just integrated STEM teachers. With the best practice of using UDL, teachers can create an environment for all learners even those who struggle in school.

> And with UDL, I have a place for everybody in the classroom, especially in STEM. Um, and really sometimes there are kids who struggle in the subjects, like the math and the reading. They shine in STEM because you have another way that you're getting at their intelligence (44.4)

UDL includes the flexibility to create an environment for all students to express and understand material through media that fits their individual needs. This inclusive practice from the perspective of the participants is considered a good teaching practice. "I don't think it's particularly hard. I think when we look at good teaching, all good teaching practices keep going back to UDL." (44.16)

4.5.3. *Theme: Students with needs are in or could be included in integrated STEM classrooms*

The data analysis revealed a theme in understanding the needs of the potential adopting population of integrated STEM educators, which informs the attribute of compatibility. In an assignment reflecting on an integrated STEM lesson, one of our participants described a situation exemplifying the need for UDL in STEM instruction.

> I think that what I am doing is innovative in regards to trying this type of instruction out for students with mental health issues. Rarely are these students allowed to participate in good STEM instruction because they struggle to work cooperatively, analyze and use all the technology safely. What I am trying to show is that if students are exposed to this type of instruction on a daily basis they no longer struggle! (85.11)

This statement has a few key meanings. First, the perception that some teachers with students who have mental health issues might not being comfortable letting them participate in Integrated STEM lessons heightens the need for the use of an inclusive teaching methodology like Universal Design for Learning. The other key meaning is that there is an influx of students in integrated STEM classrooms who would thrive using Universal Design for Learning.

> it's very different. I'm trying to put it in context, because of over the past several years in (our school district) we have had an influx of kids from ESOL Students, I have always worked with special Ed kids. (9.10)

Teachers who have adopted integrated STEM teaching methodology are now having to adjust their teaching methods based on incoming students need. Every participant in the study, when asked if they have had to adjust their teaching materials and instructions for a student's need's indicated that it occurs at least on a yearly basis. Throughout the data collection, our participants described teaching an assortment of student needs in their integrated STEM classrooms. This wide range of students that came into these 5 participants classrooms indicates there is a present need for these teaching methodologies.

4.5.4. Theme: Adopters need to be able to adjust to student's needs.

> You know maybe starting out like what I did at STEM camp this summer, I had a group of kids who didn't know each other and they were all behavior, all had behavior concerns, which is why they were at this camp this summer and I found from day one when I tried to have them working in groups to do something and I was like, well this is just not working. We had explosions, we had kids attacking another, we had a kid fight another kid because they didn't like their idea that they presented in their group. So the next day I was like, okay, we got to stop what we're doing and change it up. What we did the next day is that every kid got to do their own design and then the following day for that they got to share, their design with one person and look at each other and take one idea from the other person's design. So, like slowly we figured out how to work by group by taking little baby steps. Finally, in the last week, everybody was in groups. Everybody got along for the most part and they all came up with really cool and like the arcade design thing. (42:52)

Using Universal Design for Learning in an Integrated STEM classroom requires flexibility. In the passage above the participant talks about a failed attempt at grouping students during an integrate STEM lesson. In this case, the teacher needed to identify the problem, what was causing the problem, adjust accordingly and finally work their way back to the main goal of working together. Adjustments happen on a daily basis. Often the teachers discussed having to rapidly change plans and that is not always easy to accomplish. In the passage below a different teacher again described modifications she had to make for students and classroom adjustments that were made ‘on a dime'

> My readers were nonreaders, they came into me on a kindergarten reading level, I teach 4th. So really, I had to modify every piece of reading, writing, spelling math, STEM challenge, so that it can meet their needs. I tried several different ways to do that, so if we had a STEM design challenge, first I tried doing a heterogeneous, group where I had some of my better readers, some middle and low readers, it didn't work. Because they allowed the other kids to sort of taking over." So, I think that you have to be flexible in your grouping, you have to be flexible in your planning, you have to be willing to make changes on the dime, and I think that that happens no matter what you are looking at so eventually I actually grouped them together, when we went to peer coach, and it worked beautifully. So you know that flexibility in teaching, and especially if its STEM UDL or whatever, I just think that it's a challenge. (9.17)

4.5.5. Theme: Using UDL in integrated STEM classrooms is difficult to use solo and often demands the adopters to acquire additional assistance

Integrated STEM teachers, especially those with more than one student with needs in their classroom, require direct support in order to execute UDL methods in an integrated STEM classroom.

> This year, in particular, I had seven special ed education students in my classroom, greatest number I've had in a long time and each one of them had a modification for a reader and a writer. And it was me. How in the world do you go and read material and writing materials for seven children in a stem lab? (9.38)

This passage stresses the need for assistance within an integrated STEM classroom, to help provide students with classroom accommodations and differentiated instruction. Direct support is also provided through guidance counselors. Especially for students with behavioral difficulties, having the assistance of a guidance counselor allows for the incorporation of these students into integrated STEM classrooms. This assistance can come in the form of teachers aids like in the passage found above or support from guidance counselors found in the passage below.

> for my real behavioral kids. um, one of the things that I do is I work a lot with the guidance counselor and um, to be honest, I'm not afraid to ask for help um because I don't always know why they're picking up things and throwing them across the room. (44.75)

Especially for students who have emotional difficulties guidance counselors are considered necessary in order to help student face their problems in the classroom. While some support is offered by the schools, often our adopters have expressed having to go to administration and advocate to have aides brought in for their classrooms.

> I eventually argued and got myself an assistant who helps me in the afternoon time. So by going out and saying this is what I need for these children, that was extremely helpful and that one on one assistant or when I'm seven assistant was huge for me to be able to help, but it still took the two of us plus a special ed assistant I had three days a week in order to write for each of the kids. (9.43)

In order to get the support needed to reach these UDL checkpoints, teachers need to advocate to their administrators their need for supplementary assistance. This can often be a complex issue outside of the factors of the innovation but does require effort on the part of the adopter. Once the participants have the support they need, often they still need to work with the support staff on a constant basis.

> we have some great ESOL teachers in the county. So one of the things that I do is each week, um, and I do this for everybody that's a resource teacher in my classroom. So whether they're special ed, gifted and talented or ESOL. Um, I go ahead each Sunday and I sit down and I send everybody my plans for the week. I do it in a quick format and then we decide over email what kinds of resources I'm going to need in order to meet the needs of kids that are ESOL (9.85)

This teacher hosts weekly planning meetings, on the weekend, to address her student's needs. This also requires developing positive working relationships with support teachers. Weekly meeting requires consistent effort throughout the school year and adds to the complexity of using Universal Design for Learning in an integrated STEM classroom.

4.5.6. Theme: Lack of time

> Time- time is always my greatest factor in anything that I am doing. UDL is wonderful, it has a great way to think about each child but what puts the greatest disadvantage, is my lack of time. whether it's the hours of the day, the minutes of the lesson or the time that I need and the components from the county and their expectations on me, that flexibility is not necessarily there (9.6)

Time is not in infinite abundance for teachers, it rather is a finite amount. Therefore, the major complexity about using UDL in an integrated STEM classroom is the amount of time that it takes. Providing adjustments to students takes time. As described in the passage below if an assistive technology takes too much time, a teacher has to be creative with the class schedule to find more.

> It killed some kids with spellchecks and it takes them a little bit longer because they use their spellchecker and their word production software. So you just give them more time. They just, you know, if they need a little bit of time the next morning to finish something that they have at dismissal time to finish something they have it. So, I mean sometimes you have to give them a little bit of extra time (76.67)

Providing accommodations to students, especially multiple students takes time. This is often time a teacher doesn't have. In the passage below a participant describes the difficulties with providing accommodations to non-communicative students.

> They're also noncommunicative. So speaking with them was very difficult. So the processing as a difficulty for them. So if I'm asking you a question and we're having a conversation, it might take them five minutes to respond to you. *I don't have five minutes, you know?* I mean with 25 kids and the kids are integrated, it makes it really challenging (9.41)

Specific UDL checkpoints, even if it would help students, if not absolutely necessary are often difficult to accomplish with the limited availability of time. Below a participant describes the effort it took for the teacher to customize videos in other languages, without immediately available resources in their curriculum.

> I think it's just time I look at like everything that I have to do and you get five hours of planning a week to cover everything with none of us can do it all in five hours, so it takes more than that and I think, I think I just run out of time. So I'm like, okay, I've got a video and it's closed caption and yes we're going to go with that. Like I didn't make it the hands-on experience for them or I didn't, you know, I didn't give them a text version of it. I think it's just time, like finding those resources (94.31)

4.5.7 *Theme: Difficulty in Assessment*

A theme for complexity of the innovation was the difficulty of evaluating students. By allowing students multiple means of expressing their understanding, teachers have to develop ways of comparing different projects evenly and with fairness. The participant below describes the difficulty associated with developing different but fair criteria in real-world integrated STEM classrooms.

> I think that that menu is one of the things from UDL that has been fabulous. I mean because it just allows kids to tap into whatever their strength is. So if they hate drawing, they're not going to pick a poster, but they probably love acting it out and showing me. So I think there's the hard part about that is how the criteria and making the criteria so that it's about equal number and because ultimately on a report card to put a grade and not 100 percent into it, but ultimately so it has to be the same number of value a point so that sometimes the challenge when you're doing a UDL menu of items (9.65)

Teachers, regardless of what is graded, often have to give a grade. In that similar thinking, there are limitations in having to give benchmark tests that are not UDL accessible. While Integrated STEM itself do not have standardized testing, teachers who use integrated STEM to teach Science and Mathematics have to face standardized benchmark testing. Our participant below describes a problem teachers who uses integrated STEM as a method to teach Math curriculum face when using UDL.

> if it's other content areas like math, we are held by certain curriculum standards so we have to give a unit tests, we have to give benchmark and there's really no room to alter those assessments for students who have those struggles. (61.39)

Even within the choice of how the teacher wants to evaluate students in integrated STEM education, there can be problems. Both Universal Design for learning and Integrated STEM education stress the importance for community and group work, however assessing mastery of content in group work has difficulties as well.

> I have a hard time knowing whether they really got it. Especially because a lot of our work is done in groups so like if they are working in a group where they writing- Like sometimes I feel like they're just writing down what their buddy told them to write down in their notebook which isn't really their learning. So if I asked them two weeks later, you

> know, what do you remember about buoyancy? I feel like they're not going to remember anything. they're just going to remember what their buddy told them to wrote down with their buddy for them to write down. So I feel like that's the part I struggled to know, even what they know, because of the team work together, um, you know, I think sometimes they kind of paste their partner's ideas and write those down. (94.55)

Integrated STEM education often focused on the physical expression of understanding. If that is through design-based learning methodology, which is common in integrated STEM, this often limits in the output of Design challenges. The participant below discusses the challenges faced by her student who has Cerebral Palsy and was participating in a design-based project where the students were required to build a physical model of a beach.

> when a kid has a physical limitation, particularly with hands-on exploration, assistive tech isn't going to necessarily help them. Do you know? the exploration. If we're building a beach, she can't use her iPad to build a beach. She could use it to help draw her thinking, but she's going to have to or he's going to have to be able to physically be able to do that. So, you know, with that hands-on exploration piece that, that STEM educators are really looking for that authentic problem-solving hands on that can be difficult, um, to provide to students who have disabilities. (61.44)

The participant above explains that students who have physical limitations may not be able to participate in physical expression in the same way that other students can. Because authentic hands-on problem solving often requires physical expression of understanding, if a student's barriers conflict with physical expression, that student misses out on that opportunity. If the assistive technology cannot help this student express their understanding in a physical manner then they must rely on other methods of expression.

4.5.8. Theme: Identification, Evaluation of Student's Limitations, and Adaptations

Perhaps the most difficult part of using Universal Design for Learning in an integrated STEM classroom is the identification, evaluation, and adaptation to student's limitations. Teachers have to identify what a student's needs are in order to meet said needs. The participant below analyses the habits of her student in order to identify his attention difficulties in her case study.

> John struggles to sustain attention when reading and writing. When being taught during a 15-minute guided reading lesson, he will need to redirect roughly 2-3 times a minute. Once he has started a task the redirection usually only needs to occur about once a minute. He often will stare into space, start randomly talking or making noises or just get up and walk away from the task because something else catches his interest (84.4)

These limitations are not always flagged to create a student's IEP at younger ages. If a student meets the technical requirement for being proficient, they can slide under the radar until they are truly behind. The participant describes this situation and the problems associated with diagnosing a student's need in 2nd grade and below.

> Second grades are really tough year because we're trying to figure out what they know and I don't know what you know about the special education testing, but it's very different between k one and two and three, four and five. If they can rate a five-word sentence in second grade, they're considered proficient. However, the expectation our county has is that they can write a full paragraph. So, um, that's where we get into a lot of difficulties with, with kids in special needs, if that makes any sense because that's like a huge (44.62)

If a student has multiple disabilities this can also pose a problem for teachers to identify the best ways to both represent material and allow for expression in multiple ways. The following participant describes the challenges that she faced while trying to meet the need of her students with dysgraphia and verbal commination difficulties.

> So your kids who are struggling with writing and processing the Dysgraphia, Sometimes that they can't get it down on paper so you can get it verbal. These children didn't have the verbal and they didn't have to write. So we would use tape recorders. Um, sometimes we pulled two kids each and try to write. For them it was, it was a challenge. It was a huge challenge (9.44)

The teacher needs to then evaluate whether the student needs to practice facing the barrier or would it be better to avoid it all together. The passage below describes a teacher working through this problem focusing on the student's overall educational experience moving forward.

> what exactly is the barrier that the student needs to get over? Is this a barrier that they are always going to have and I'm going to teach them some strategies so that they can never have a barrier anymore, or is this something that they need to learn? , either it's always going to be a barrier and then they're going to learn ways around it and it won't be a barrier anymore. In that sense, it's a barrier that you shouldn't have and we need to attack it and get rid of it and that you no longer have it in that way (76:57)

The decision to address or avoid a need especially at a younger age is critical to a student’s development. If the problem can be addressed and is avoided, it would be harder to overcome later in life when learning habits are solidified. This is a complex problem and tremendous responsibility.

5. CHAPTER FIVE: DISCUSSION & CONCLUSIONS

5.1 DISCUSSION OF RESEARCH QUESTIONS

Our research questions aimed to evaluate the following information about the innovation of using Universal Design for Learning in an integrated STEM classroom. In order to further understand our findings, we have to discuss our results through the study's research questions to draw meaningful conclusion

5.1.1 Research Question 1: How is the innovation of utilizing Universal Design for Learning in Integrated STEM education classrooms being implemented in real-world classrooms?

We aimed to understand how the innovation of using Universal Design for Learning in an integrated STEM classroom was used in real-world classrooms. We were able to gather the direct utilization of the innovation by practicing integrated STEM educators from document analysis of the provided materials and the stated actions of teachers from their interviews. In our data analysis, we were able to find categories representing overall trends of how integrated STEM educators achieved UDL checkpoints (Table 1). We were also able to give explicit examples of how the teachers executed some of these categories for the UDL checkpoint effectively answering research question 1A.

Table 1 has bridged a significant gap between educational research and the practical application of these two teaching methodologies. To date, there has been significant research into how these two teaching methodologies are theoretically compatible (Access, 2007; Basham & Marino, 2013; Goeke & Ciotoli, 2014; Hwang & Taylor, 2016; Israel et al., 2015; Marino et al., 2010; Moon et al., 2012). However, our study provides explicit description of how practicing Integrated STEM educators are utilizing Universal Design for Learning in their classroom.

5.1.2. What challenges do adopters encounter when implementing Universal Design for Learning?

Along with understanding how the adopters used UDL in an integrated STEM classroom, we also wanted to catalog the problems that the teachers faced when using specific UDL checkpoints. Table 2 describes the problems expressed by the participants when discussing UDL checkpoints. This table provides real-world context to the use of these UDL checkpoints. Teachers were able to express the problems that they face when using these teaching methods outside of the theoretical application of the use of UDL in an integrated STEM classroom. Trends among these challenges were used to formulate themes through Rogers 5 attributes of an innovation.

5.1.3 At what frequency does Universal Design for Learning checkpoints occur in the data?

To answer this question, we evaluated all of the data collected from both the document analysis and the interviews to better understand the patterns of what checkpoints of UDL are used in greater or less frequency. Identifying patterns in what checkpoints are used in higher or lower frequency, allows us to draw conclusions about specific UDL checkpoints. These patterns were found in Figure 2

A limitation of Figure 2 is that if a UDL checkpoint would not be typically something that is documented in a lesson plan or would only come up in an interview (standard questions) then their numbers would be significantly lower. Additionally, the project's data analysis was subject to qualitative interpretation by the researcher, to identify an example of the 31 UDL checkpoints available in the data. Therefore, this data should not be interpreted as concrete data for a quantitative analysis but rather supporting evidence of observations and general trends. Looking at the data in Figure 2, we conclude that different checkpoints are used in different frequencies. We can also conclude that each of the 31 checkpoints has an example, and therefore if there is a need for a UDL checkpoint, it can be implemented.

5.1.4. Research Question 2: What do patterns of the adopter's implementation say about the adoption of the innovation?

In figure 2, we can conclude that teachers have the potential to use any of the UDL checkpoints in their classroom, however they occur in different frequencies. To further evaluate the data, we separated each UDL checkpoint into one of three tiers. Tier 1, consists of UDL checkpoints that required minimal additional effort for our participants and occur on a high enough frequency that it can be concluded they occurred naturally. Tier 2 consists of UDL checkpoints that vary in the amount of additional effort needed to utilize them in an integrated STEM classroom. Tier 3 consist of UDL checkpoints that do not occur naturally within an integrated STEM classroom. These checkpoints occurred because of a specific student needs and consequently occurred at the lowest frequency.

From figure 3, we can see clear trends in the UDL checkpoints that are easily implemented. UDL's core principles are providing students with multiple forms of representation, multiple forms of engaging the student and multiple methods for students to express understanding (CAST, 2011, pg. 5) These definitions arguably closely correspond with checkpoints 2.5 "Illustrate through multiple media", 4.1 "vary the methods for response and navigation", and 5.1 "use multiple media for communication". As our graph demonstrates these checkpoints have a significantly higher number of examples found in the data with 212, 172, and 200 examples respectively. This evidence supports literature citing the similarities between the teaching methodologies of integrated STEM and Universal Design for Learning ("Access STEM Building capacity to include students with disabilities in science, technology, engineering, and mathematics fields. Seattle," 2007; Basham & Marino, 2013; Goeke & Ciotoli, 2014; Hwang & Taylor, 2016; Israel et al., 2015; Marino et al., 2010; Moon et al., 2012). This finding also seems to support the perspective of the participants in our study believing that using integrated STEM naturally uses Universal Design for Learning. By painting the three core principles of Universal Design for Learning in broad stokes, teachers are in fact using Universal Design for Learning with minimal to no additional effort. It should be noted that other checkpoints could fall into Tier 1 based on teachers' individual execution of integrated STEM classrooms. From our graphic representation, Checkpoints exceeding roughly 80 examples have a distinct possibility of being in Tier 1.

Moving beyond the clear examples of natural similarity, looking at Figure 4 we see Tier 2 begins to develop a spectrum. While all checkpoints in Tier 2 are easily compatible in integrated STEM teaching methodology, they require varying degrees of effort. We can also provide further understanding through the prevalence of the categories within each checkpoint. Some of the UDL checkpoints had categories that occurred in greater frequency than others. This leads us to believe that these categories may be easier ways to implement this checkpoint then other categories for that checkpoint. For example, checkpoint 3.1 "Activate or supply background knowledge" out of 64 total examples found, 34 of them were for categories 3.1.2 "Using critical thinking questions about the background." Critical thinking skills are part of developing students with strengths in higher order thinking along with problem-solving and reasoning (Bybee 2013). Another example of minimal additional effort on the part of the adopter is checkpoint 8.3 "Fostering Collaboration and Community". Our analysis revealed 102 examples of this UDL checkpoint, 67 of those were some variation of utilizing students working in groups (categories 8.3.1). However, categories 8.3.2 "Include parental assistance in the community" only had 4 examples found. This leads us to believe 8.3.1 requires less additional effort to implement than checkpoint 8.3.2.

Figure 5 shows us Tier 3 UDL checkpoints occurred in the lowest frequency in our data analysis. These UDL checkpoints, while still compatible with Integrated STEM methodology, require intentional implementation outside the scope of the lesson. For example, Checkpoint 6.1 and 8.1 are based around goal setting for students personal and academic goals. This, while included in each of the participant's classrooms, likely occurred at a lower frequency because of the additional effort required to set and follow up on goals. Some of these checkpoints only appear to be used when addressing a specific student need. For example, Checkpoint 2.4 is specifically strategies to help students with a language barrier. Without a student with a language barrier, this checkpoint would be used. These elements did not appear naturally within integrated STEM lessons and required direct questioning which could also affect the frequency of occurrence in the data. This was a similar pattern for Checkpoint 4.2, where this checkpoint was only used if a student needed an assistive technology. The participants were able to describe what they would do for students in these situations, however, the categories that correspond to these checkpoints are either testing modifications, classroom accommodations, or require a large amount of additional effort to address a student's needs. We also understand from our themes in complexity that teachers may not have enough time to meet these checkpoints with every student.

Evaluating how the participants use UDL can alternatively be thought about through affordance theory. Affordance theory is based on the idea that a tool's usefulness is based around the users need for that tool (Gibson, 1966). Therefore, because each participant has different needs in their classroom, they would use the tool, in this case, UDL, differently. UDL's CAST Guidelines were intentionally designed for this purpose. Hall, Meyer, and Rose (2012), the founders of the UDL CAST guidelines discussed how the UDL principles could be "Mixed and matched" in order to meet the teacher's specific goals. This is supported by our findings in Tier 2 and 3. Teachers used these checkpoints in varying frequencies based on their perceived usefulness in their classroom.

5.1.5 Research Question 3: What do the actions and perspective of the adopters say about the innovation through Rogers (1995) five attributes of innovations?

From a Diffusion of Innovation theory standpoint, our study helps us to understand the innovation. Understanding that our participants believe the practices of UDL occur naturally within integrated STEM, we can look at the Diffusion of Innovation theory's factors of an innovation's observability and trialability and can rationalize the lack of data. If the participants believe integrated STEM teachers are already using UDL, adopters would not have to try UDL, they would already be using the innovation. This would also mean that there would be no observable differences between the practices of adopters and potential adopters; UDL would already be embedded in the potential adopters teaching practices. Our participants have also expressed a clear need for Universal Design for Learning in their integrated STEM Classrooms which supports the idea of a flawless adoption by this group of integrated STEM educators.

The participants expressed consistently throughout all questions focused on understanding the innovation of combining UDL and Integrated STEM through Diffusion of Innovation theory, that they were already doing these things naturally within the classroom. In other words, if a teacher was using their definition of Integrated STEM education, they were naturally using UDL. This discovery through the lens of Diffusion of Innovation theory could be interpreted as similar to the findings of Hahn (1974) who determined that an educational innovation needs to be compatible with the teachers previous teaching methodologies, but not so similar that it is not considered an innovation. An innovation that is too similar, can appear to offer no advantages over to its predecessor and won't be adopted. However, our study is slightly different. The teachers did not reject the innovation because it was too similar to what they were already doing, rather they determined that they were already using the innovation. They also believe that anyone who teaches using integrated STEM teaching methods also has already adopted Universal Design for Learning. This means that our early adoptive portion of the population believe the population we have investigated have already adopted the innovation.

Therefore, our results show that from the perspective of the adopters, the innovation is already adopted by integrated STEM educators, but using that innovation takes additional effort. If statements are taken at face value, that yes, the innovation automatically occurs, but it also takes effort, from Diffusion of Innovation theory these statements conflict. If the innovation is atomically adopted, then there is theoretically nothing that prevents its adoption except adopting a name change from "Integrate STEM" to "Integrate STEM and Universal Design for Learning". If we take a step back and look at the whole picture, these statements fit with what we are seeing with our data.

There may be a difference between our adopters speaking about the innovation as a general overview compared to discussing the use of specific UDL checkpoints in an integrated STEM classroom. As mentioned in the results section there was an interesting difference in responses between Part 2 and Parts 3 and 4 of the interviews when adopters were discussing the use of the innovation. When our participants were discussing the use of UDL in an integrated STEM classroom as a broad overarching concept, they described very little difficulties while combining the two teaching methodologies. However, when the participants discussed the use of specific UDL checkpoints in an integrated STEM classroom they remembered problems that they had faced. There could potentially be a reason for this discrepancy between the quick snapshots and the in-depth analysis of UDL in Integrated STEM classrooms. Understanding this discrepancy could provide insight into how to frame interviews regarding these two teaching methodologies moving forward.

we develop a future research question that is partly answered by our findings. Taking a step back and looking at the actions and perspective of our participants, a question arises:

When teachers discuss the use of UDL in integrated STEM classroom they believe there is automatic adoption but, when discussing specific UDL checkpoints problems arise. In that situation, what UDL checkpoints are considered fundamental by adopters?

Although our preliminary research study was not framed around answering this new research question, our results provide insight into a working hypothesis for future research.

UDL is considered automatically adopted by Integrated STEM educators because the core principles of UDL are naturally achieved in these classrooms.

There appears to be a lack of research for what checkpoints are required in order for this innovation to be considered adopted from the perspective of integrated STEM educators. CAST UDL guidelines (2011) consider the three principles of UDL, multiple means of representation, action and expression, and engagement as "essential". This is evidenced on page five of the UDL CAST Guidebook, where the three principles of UDL are discussed. The guidelines end each section of the core principles by saying "*providing options for representation is essential,"* "*providing multiple options for engagement is essential"* and "*providing options for representation is essential*" in italic lettering.

These three core principles of UDL are also a consistent theme throughout research developing models for UDL implementation into classrooms (Basham, Meyer, et al., 2010; Browder et al., 2008; Coyne et al., 2012; Dalton et al., 2011; Kennedy et al., 2014; King-Sears et al., 2015; Lieber et al., 2008; Marino et al., 2014). If we look again at our participants Tier 1 checkpoints result in Figure 3, we see checkpoints (2.5, 4.1, 5.1) are used in the highest frequency. The UDL core principles of multiple means of representation and action and expression in their general definition correspond well with these checkpoints. Therefore, according to our participant's actions, the core principle of UDL are naturally embedded in integrated STEM classrooms.

If the core principles of UDL are considered the minimum threshold for adoption, other UDL checkpoints could be evaluated through an Affordance theory standpoint (Gibson, 1966). Adoption of Tier 2 and 3 checkpoints would not be required but instead, adopters would use these checkpoints as a way to adapt their current teaching methods in order to address specific students' needs. As demonstrated in our data, not every checkpoint is utilized in every classroom every time and some checkpoints appear to require additional effort in order to be implemented. Hall, Meyer, and Rose (2012) also make the point that not all checkpoints are necessary in UDL and can be “Mixed and matched” in order to fit the teacher’s needs. This from a Diffusion of Innovation theory standpoint means that not all UDL checkpoints are needed in order to consider the innovation adopted.

This hypothesis would also explain the reason why complexity themes emerged when participants talked about checkpoints that were not evident in their document analysis, in contrast to perceiving the innovation as automatically adopted. In theory, if there was a minimum threshold for a potential adopter to perceive the innovation as adopted, and those requirements are already met naturally in the lesson, the problems and complexities that the adopter faces outside of those minimal requirements wouldn't affect their perception of the automatic adoption the innovation. Because this study did not target a minimal requirement for adoption, we are unable to draw any definitive conclusion.

5.2 FUTURE RESEARCH

5.2.1. Research Question: Is UDL is considered automatically adopted by Integrated STEM educators because the core principles of UDL are naturally achieved in these classrooms?

In order to test the working hypothesis above, researchers could frame a future study similar to our study. Future research, in general terms, would need to follow a similar format to our study. First, the researcher would need to confirm that the teachers natural teaching methodology is integrated STEM education. Second, they would need to interview the participants to gain their perspective on the methodology. Third, they would need to evaluate the actions of these practicing educators in regards to Universal Design for Learning. Confirming and refining our study's results can develop an understanding of this new research question.

In order to more clearly answer the new research question, researchers should change the interview questions to focus on the participant's opinions about the different UDL checkpoints and how they relate to their understanding of UDL, by asking them directly which UDL checkpoints are needed to consider the innovation adopted. Researchers should also consider giving participants a copy of the CAST UDL guidebook prior to the interview to familiarize or re-familiarize themselves with the checkpoints. This will allow participants to refine and develop opinions prior to the interview about the CAST UDL checkpoints, and allow for theoretically richer results.

5.2.2 Research Question: Where is the idea of automatic adoption coming from? How have participants been taught through professional development programs?

There could potentially be other solutions to why adopters spoke of automatic adoption when discussing the innovation in general concepts vs problems when discussing specific UDL checkpoints. There could be difficulty expressing the use of all of UDL by adopters. UDL has a relatively simple definition with the three core principles. However, expressing an understanding of the intricacy of all 31 UDL Cast Guideline checkpoints is much more difficult explain succinctly. Further research needs to understand more about where this idea of automatic adoption is coming from. What are potential adopters' reactions to the innovation of UDL in integrated STEM classrooms through professional development programs? If the professional development program is discussing the use of UDL using it's general definition, according to our participants it is likely potential adopters would already consider themselves adopters. A study focusing on potential adopters in a real-world UDL professional development program could help provide insight into initial reactions to the innovation. This is different than our participants who are current adopters, speculating what the reactions may be like for potential adopters.

5.2.3. Research Question: Knowing that teachers cannot plan for every problem that a teacher will encounter in a classroom, what are characteristics about the Early Adoptive portion of the population that make them better equipped to face these problems?

Through our research, we have a great understanding of how the innovation is used by the early adoptive portion of the population, both through their perception and their actions. However, understanding characteristics about the early adopter portion of the population can provide insight into who could become or what train is needed to become an adopter of both Universal Design for Learning and Integrated STEM education. Research can seek to understand the required knowledge, training, and dispositions to help prepare potential adopters.

Further research could also seek to develop a method of introducing UDL as a method to adopt Integrated STEM teaching methodology. If teachers using traditional teaching methods need to adjust to an incoming student with needs and plan to use Universal Design for Learning, Integrated STEM methodology could provide a potential avenue for adoption. The findings in this study have demonstrated that there are clear similarities in how these teaching methodologies can be executed and therefore pose the potential for the adoption of both teaching methodologies instead of only the adoption of one.

5.3 LIMITATIONS OF THE STUDY

Some limitations of this study consists of the inexact nature of documenting every UDL checkpoint possible within each document. When conducting our document analysis, researchers needed to be able to identify examples of UDL checkpoints within each document. This required a complete understanding of all 31 UDL checkpoints and the mental flexibility to interpret document passages from multiple standpoints. A text excerpt often qualified for more than one UDL checkpoint due to the interconnected nature of UDL and being able to identify all potential UDL checkpoints for each excerpt was a challenge. UDL CAST guidelines are focused from a teacher's perspective i.e. how the teacher represents material, allows the student to express understanding, and strategically engages students. However, because integrated STEM is focused on a student-centered model, identifying UDL checkpoints often required an overlap between UDL categories of multiple means of representation, engagement, and expression. Each UDL checkpoint had to be interpreted from both the perspectives of both the teacher and the student. Some of the questions our researcher had to ask themselves when evaluating a passage are:

> Are the teacher or student representing material to themselves or their classmates?
> Are the students expressing an understanding of the material to themselves or their classmates?
> How is the student engaged with the class materials or with their classmates?
> How is the teacher aiding the engagement of students with the material and with their classmates?

This level of qualitative analysis would prove difficult to apply to a large enough sample size for a fully robust quantitative analysis of the findings.

Another limitation of the study's framework is evaluating UDL checkpoints 2.2 "Clarifying Syntax and Structure" and 2.3 "Support Decoding of text, mathematical notation, and symbols". These two UDL checkpoints were difficult to evaluate using our methods specifically because of their role in Integrated STEM classrooms. Because of the clear English and Math focus of these UDL checkpoints respectively, purposefully documentation in integrated STEM lesson plans often isn't a priority. These checkpoints were additionally difficult to ask about through the interview, because of the interconnected nature of integrated STEM. The questions about sentence structure and math formulas were often misunderstood and described as teaching vocabulary, which is a priority in integrated STEM classrooms. Because these checkpoints often occur when a teacher teaches math or English, it was difficult taking the participants out of the headspace of integrated STEM and into an isolated subject. Some of these teachers taught only integrated STEM and their students would encounter these checkpoints in a different classroom. We could mitigate the subjective nature of document analysis further through classroom observations or video documentation of the lessons execution.

There are also limitation that arise from our study of participants. There is a potential of an unintentional selection bias of our participants. There were 24 potential participants in the alumni database, this study ended with 5 participants. We had 2 rounds of recruitment but only 5 participants joined the study. Likely the participants who joined the study are the most excited about using UDL in an integrated STEM classroom, or are most passionate about creating an inclusive classroom environment. This should be considered when interpreting themes especially those describing the needs of the adopter population. If these teachers are more likely to have students with disabilities in their classrooms their needs are less representative of the early adopter population as a whole. Because our sample size is only 5 participants, to draw more concrete findings this study will need to be repeated and scaled up to a larger sample size. This small sample size is a limitation especially when discussing the generalization of our findings. Providing an incentive to join the study could persuade other less enthusiastic participants to gain a better perspective of the early adopter of the population.

5.4 UTILITY OF FINDINGS

This study's epistemology and ontology were based around pragmatism and therefore, stressed the usefulness of the findings to both practicing educators and educational researchers. Practicing teachers, especially those in integrated STEM, could find our research findings especially useful. Table 1 provides current and future educators explicit examples and categories of how practicing educators are utilizing these UDL checkpoints in integrated STEM classrooms. UDL and Integrated STEM could be considered complex so providing explicit examples of how practicing educators are interpreting the innovation of UDL provides practicing educators the opportunities to evaluate what they already do or what they could easily implement. Our findings, particularly Tables 1 and 2, could be useful for special education teachers or teacher's aids. The data suggest that adopters do not use every UDL checkpoint on an equal basis. This means that it is not the goal of an educator to use every UDL checkpoint in every lesson, it is the responsibility of the teacher to use what checkpoints are best suited for the needs of their participants. There are complexities associated with the use of this innovation and by understanding these problems, special educators can seek to be proactive moving forward. From an educational researcher's perspective understanding the real-world application of combining these two teaching methodologies helps bridge the divide between theoretical framing and applied application. Our results provide insight into how these teaching methods are actually being used in real world classrooms. This information is critical to help ground future theoretical research with evidence of applied practice.

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Appendix A. Adapted Integrated STEM Screening Rubric

The criteria below are elements that are expected to be present in an integrative agricultural education program. Determine how well each criterion is met using the following scale:

0 - not applicable/inadequate 1 - developing 2 – proficient 3 - advanced

Integration

Is the lesson problem or project based?	0 1 2 3
Were connections between lesson subject and STEM content obvious?	0 1 2 3
Were authentic resources used?	0 1 2 3
Were students encouraged to ask critical questions about the topic or other STEM Subjects?	0 1 2 3
Was scaffolding support provided for STEM concepts?	0 1 2 3
Were at least two subject areas covered in the lesson (Lesson subject + *n*)?	0 1 2 3
Were students sharing ideas in groups?	0 1 2 3
Were students asked to reflect on their learning either in writing or orally?	0 1 2 3
Were activities offered with multiple methods or variations for ability levels?	0 1 2 3
Were students asked to relate the learning to their own experiences?	0 1 2 3
Were students asked to seek out more information that related to the topic?	0 1 2 3
Were students encouraged to consider alternative processes/solutions/consequences related to the topic?	0 1 2 3

Integration-
Is the lesson problem or project based?
Problem or project based learning has students working toward a big idea. The goal is finding a solution to the problem or completing a project. A problem would be a well-organized challenge that provides the big picture details but leaves students to work on discovering other needed information or skills as they work toward a solution. Likewise, a project would include clear directions on beginning the project, provide constraints on materials or resources, and communicate to students the criteria needed

for completing the project. In the process of reaching the goal, students are engaged in the learning process through hands-on activities and cognitively active learning activities that are relevant to the purpose of the problem or project.			
0	1	2	3
Lesson is dependent on lecture, worksheets, brief hands-on activities, etc.	There is a problem or project but the <u>*big idea is not clear.*</u>	Lesson provides <u>*opportunity*</u> for students to engage with big idea of project.	Lesson describes how students will be engaged in the learning process through activities that have them involved, taking ownership of their learning. Lesson plan <u>*clearly explains how students will think about the big idea*</u> as they learn about details that support the idea.

Integration			
Were connections between STEM subjects and the lesson topics obvious?			
Learning objectives explicitly include connections between STEM subjects and the lesson topic. Students will find opportunities when a STEM subject is required during work related to learning about the lesson content. A STEM subject's background is clearly needed in order to better understand the lesson topic.			
0	1	2	3
<u>*No STEM subject is used during the lesson.*</u> <u>OR</u> STEM content or processes are performed but the need for information is not clear or not required to move the activity along. It seems to be added on or unrelated.	There is STEM topics/concepts are referred to during an activity that supported the lesson topic in <u>*order to provide context to the new material*</u> (e.g.: "To make sure the frame is square we measure the diagonals. This is like doing	The reason for using STEM information was clearly stated or highlighted by the lesson activity. <u>*Students draw from STEM background to solve a few parts of the overall challenge*</u>	The reason for using the STEM content is clearly stated or highlighted by the activity. <u>*Students would likely not be able to complete the activity without using STEM background to solve all problems associated with the challenge.*</u>

	the Pythagorean Theorem in math class.")		

Integration			
Were authentic resources used?			
Authentic resources are information sources that can be found in everyday life and come from legitimate, real-life sources. Examples of authentic resources include but are not limited to newspapers, reputable internet sites, drug labels, peer reviewed research articles, and technical manuals.			
0	1	2	3
Resources are fictitious, provide *unrealistic information*, or cannot be traced back to a real source. OR No resources are used.	Resources provide realistic information and appear to be from a real source. *All resources have been edited to streamline the information being provided.*	Resources provide realistic information and appear to contain all information needed to complete the *activity but some modifications have been made when compared to original sources.* (e.g.: instead of using an original food label, a computer generated, slightly simplified label is provided to students)	Resource is provided to students with *no modifications and all intact information is as provided by the source.*

Integration-			
Were students encouraged to ask critical questions about the topic or other STEM Subjects?			
Critical questions guide students to a more thorough understanding of the topic. Students should have opportunities to ask their own questions that look at alternative points of view, future predictions, or relate one topic to another. Opportunities may also be scaffolded with guiding questions that focus students thinking in a similar fashion.			
0	1	2	3

Lesson plan does not give students an opportunity to ask questions. Students may be given questions to answer *but do not prompt critical thinking.* For example, the questions are superficial, solutions or answers are found verbatim in resources provided, or do not require some speculation.	Lesson plan gives students limited opportunities or limited time to ask questions. Guiding questions are provided, but the activity *does not require* students to thoroughly explain "why" or "how" when addressing the questions. (e.g. What type of triangle would help represent a squared-up terraced bed?)	Lesson plan gives students the opportunities to ask questions with ample time for follow up questions to be posed and considered. *Students are given opportunities to explain "why" or "how" type questions but there lacks a focus on details*. (e.g. Explain, in one sentence only, how you used right triangles in designing your terraced garden bed and how triangles were helpful.)	Lesson plan designates several opportunities for students to ask questions either in class discussions, in groups, or in written assignments. Lesson explains how teacher will encourage students to *ask about background information, seek new connections, engage with prior experience/knowledge (apply intuition), consider future use or implications of the topic*.

Integration-			
Was scaffolding support provided for STEM concepts?			
Scaffolding is a technique that provides students with support through challenging material. Of particular interest is support for STEM concepts that are used in the lesson or activities. For example, scaffolding can be provided through guided questions that initially help students think through the process to be used, verbal cues to trigger appropriate techniques or similar examples that students can reference as needed when working with challenging concepts. These are only a few examples of scaffolding.			
0	1	2	3
There is no evidence of scaffolding in the planning. STEM related activities stand alone in the lesson with the expectation that students should already be proficient in the STEM concepts and definitions being used.	Scaffolding is somewhat evident in the planning of STEM related activities. *Scaffolding may be weak or unclear in some cases*.	Scaffolding is included in the planning of the STEM related activities showing clear connections between challenge and STEM materials. *But teachers scaffolding questions are direct, allowing for little student discovery.* Ex. How can you use the equation for	Scaffolding is evident in the planning of STEM related activities. Scaffolding is appropriate and provides clear direction toward achieving the STEM content related goals of the lesson. *Scaffolding is derived from student made connections to background*

		surface area to solve the challenge?	*with open ended direction by teacher.*

Integration			
Were at least two subject areas covered in the lesson (Lesson subject + *n*)?			
The lesson subject should be at the forefront of the lessons however to be integrative, there should be an embedded subject area apparent.			
0	1	2	3
Only the original lesson topics are included in the lesson.	Other subjects are in included in the lesson. *The connection between the lesson topic and the additional subject are trivial.* STEM subjects are added in as "fun facts" and do not add to the lesson subject	Other subjects are included in the lesson. The connection between the original topic and the additional subject is minimal; *students would have likely been able to learn about the original topic without STEM content areas*	Other subject areas were included in the lesson that was embedded in the original topic. *Without including the learning activities associated with the other subjects, the original topic would have been more challenging to understand*.

Integration-			
Were students sharing ideas in groups?			
Students are asked to hold relevant conversations in small or whole group settings. Students will be given guidance to ensure they are talking about details of the activity, asking each other questions, providing explanations of their own thinking, or constructively working toward completing the activity at hand as a group.			
0	1	2	3
Working in groups or having whole group discussions are not part of the lesson. If whole group discussions are included but focus on students answering direct questions	Working in groups is plausible with the lesson methodology but is *not explicitly described*	Some intent to structure group discussion is in the lesson plan *but doesn't meet all criteria for 3 rating.*	*The structure of the discussion promotes in-depth conversations, elaboration, and constructive critiques of other's ideas.* The structure of the activity may provide

without explanation or elaboration this would not be considered sharing ideas.			*guiding questions*, a *focused* and *complex associated problem*, the expectation of a *well-developed group presentation*, etc.

Integration			
Were students asked to reflect on their learning either in writing or orally?			
Students may be asked to reflect on their learning by responding to well-developed writing prompts that pose complex or in-depth questions related to the content. In a less formal method, students may also be asked to share their experience and explain how they will be able to use their new knowledge or skill now or in the future, especially focusing on unique or different situations. Students may also be asked to consider how they best learned or how they may be able to improve their learning process in the future. (metacognition)			
0	1	2	3
No opportunities for reflection are provided. OR Prompts or questions may attempt to relate newly learned information to future situations however, if students are not asked to explain how, why, or when the new knowledge will be used they are not being reflective.	Students are asked to consider how they may use new information in new situations. *Elaboration is minimal and focus is on when to use the new information.*	Students are asked to think about what was learned, only relating the information to *other situations or prior experiences*. Explanations are focused on how and when to use the information, *without greater transfer of knowledge*	Students are *asked several times during the lesson* or when appropriate *following a significant learning activity to consider what they have learned* and how it relates to prior experiences, anticipated new experiences, or upcoming activity work. Students may also be asked to consider how to improve on their learning experience or habits.

Integration

Were activities offered with multiple methods or variations for ability levels?

Accommodations or variations should be made so each student can participate in all aspects of the learning activity. This may come in many forms from role assignments during group work to variations in project specifications to meet special needs.

0	1	2	3
No variations are apparent but do seem to be needed depending on the activity. OR No variations are needed to support students during the activity.	Methods or variations are apparent but *are minimal*. There are many other suggestions that could be made.	Methods or variations are apparent however there are *others that would likely help students*. OR Methods or variations are *inappropriate* for the activity or activities included in the lesson.	*Methods or variations are apparent and appropriate given the activity or activities included in the lesson.*

Integration

Were students asked to relate the learning to their own experiences?

Students use prior experience to make meaning of learning and generate connections between new and old information. Students should have opportunities to relate new information to their prior knowledge. For example, students may be asked to apply intuitive guesses at the onset of an activity, think about their own experiences, or by having students share a relevant story. Activities that allow students to be engaged on a very personal level (e.g. achieve a personal benefit, meet a personal goal outside of school, etc.) highly relate to students' own experiences.

0	1	2	3
Students are not asked to relate the learning to their own experiences. Including the student in a problem story is	*Prior knowledge contributes to the introduction or a small part of the lesson.* Students provide input of a personal	Prior knowledge provides a *personal connection to the activity* and *provides some use of the prior knowledge to work*	*Prior knowledge provides a guide to the work for the activity.* Students may use their experiences as an

superficial (e.g. You have three lambs that have developed a cough…)	nature that requires storytelling to relate to the activity but does not require reflection on the connections to the new situation. (e.g. Think about a bad customer service experience you've had in the past, or you've witnessed with your parents, etc. What could have been done differently to make the situation better?)	*through the activity.* (e.g. Heavy rains have caused serious flooding in our area. What are some of your personal concerns about the flooding? Could some of those concerns be related to the topography of the land around your home? Could there be a connection between the flooding concerns and the use of the land near your home?)	example, a non-example, or a starting point to try new methods. Questions about the situation may be generated as a result of the previous experience. (e.g. recording water use at home for a project, talking with a school board member about the agricultural education program budget, sharing local news articles that focus on the current in-class topic followed by discussion and analysis of the facts/situation.)

Integration			
Were students asked to seek out more information that related to the topic?			
Students should be given problems or projects that may not provide all needed information explicitly. Instead, some information is left for the student to seek out to better understand the context or complete the needed procedure. As an alternative, students may also be given opportunities to research topics, numerical information or representations that relate to the activity.			
0	1	2	3
When students are given a problem or project, *all information, processes, procedures, materials, etc. are explicitly included.*	Some information has been left out of the problem, *however, it is trivial information* or only a small amount of important information has been left for students to interpret or find on their own.	More information is implied. *The balance between trivial and important information has shifted to more important information* being left for student interpretation or research.	*Problems or projects are posed with valuable information left to be interpreted or researched by the student.* Students are asked to research a topic, values, or representations to complete an activity or project.

Integration			
Were students encouraged to consider alternative processes/solutions/consequences related to the topic?			
When students are given authentic, complex activities often there are multiple ways to arrive at an appropriate outcome. Students should have opportunities to discuss, view, or experience these alternatives. This may be done with class discussion, peer evaluation, tool design, guided group discussion, or experimentation/trial and error to name a few examples.			
0	1	2	3
Problems or projects are very directive and seek a final, correct solution with no variation in the method, approach, or process used to arrive at the final outcome.	Students are asked to consider alternatives *but opportunities remain superficial.* (e.g.: Can you think of other ways to solve this problem?)	*Students have several opportunities to discuss, explore, or experience alternatives related to the topic or activity*. (e.g.: Can you think of other ways to solve the problem? How would an alternative method change the long term outcomes?)	Students have several opportunities to discuss, explore, or experience alternatives related to the topic or activity. *Students are asked to reflect on these alternatives or consider them in comparison in the light of different situations*. (e.g.: Are there alternative methods? How would alternative approaches improve on your method? In what other situations would the same method be useful?)

Appendix B. Adapted Universal Design for Learning Codebook

Provide Multiple Means of Representation:	Definition and examples:	Examples found in teaching practices:
1. Provide options for perception	To reduce barriers to learning, it is important to ensure that key information is equally perceptible to all learners by: 1) providing the same information through different modalities (e.g., through vision, hearing, or touch); 2) providing information in a format that will allow for adjustability by the user (e.g., text that can be enlarged, sounds that can be amplified)	
1.1 Offer ways of customizing the display of information	Display each source of information in a flexible format so that the following perceptual features can be varied Pg.14: ○ The size of text, images, graphs, tables, or other visual content ○ The contrast between background and text or image ○ The color used for information or emphasis ○ The volume or rate of speech or sound ○ The speed or timing of video, animation, sound, simulations, etc. ○ The layout of visual or other elements ○ The font used for print materials	
1.2 Offer alternatives for auditory information	"To ensure that all learners have access to learning, auditory options should be available for any learning material, including emphasis, presented aurally." Pg. 15 *Implementation Examples:*	

	○ Use text equivalents in the form of captions or automated speech-to-text (voice recognition) for spoken language ○ Provide visual diagrams, charts, notations of music or sound ○ Provide written transcripts for videos or auditory clips ○ Provide American Sign Language (ASL) for spoken English ○ Use visual analogues to represent emphasis and prosody (e.g., emoticons, symbols, or images) ○ Provide visual or tactile (e.g., vibrations) equivalents for sound effects or alerts ○ Provide visual and/or emotional description for musical interpretation	
1.3 Offer alternatives for visual information	"To ensure that all learners have equal access to visual information, it is essential to provide non-visual alternatives." Pg. 15 *Implementation Examples:* ○ Provide descriptions (text or spoken) for all images, graphics, video, or animations ○ Use touch equivalents (tactile graphics or objects of reference) for key visuals that represent concepts ○ Provide physical objects and spatial models to convey perspective or interaction ○ Provide auditory cues for key concepts and transitions in visual information	

	Text – providing a method for audio representation of text-based material allows more options to students for access to the content *Implementation Examples:* o Follow accessibility standards (NIMAS, DAISY, etc.) when creating digital text o Allow for a competent aide, partner, or "intervener" to read text aloud o Provide access to text-to-Speech software	
2. Provide options for language, mathematical expressions, and symbols	"Learners vary in their facility with different forms of representation – both linguistic and non-linguistic. Vocabulary that may sharpen and clarify concepts for one learner may be opaque and foreign to another… inequalities arise when information is presented to all learners through a single form of representation. An important instructional strategy is to ensure that alternative representations are provided not only for accessibility, but for clarity and comprehensibility across all learners."	
2.1 Clarify vocabulary and symbols	"To ensure accessibility for all, key vocabulary, labels, icons, and symbols should be linked to, or associated with, alternate representations of their meaning" Pg. 16 *Implementation Examples:* o Pre-teach vocabulary and symbols, especially in ways that promote	

	connection to the learners' experience and prior knowledge o Provide graphic symbols with alternative text descriptions o Highlight how complex terms, expressions, or equations are composed of simpler words or symbols o Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) o Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)	
2.2 Clarify syntax and structure	"To ensure that all learners have equal access to information, provide alternative representations that clarify, or make more explicit, the syntactic or structural relationships between elements of meaning" Pg. 17 *Implementation Examples:* o Clarify unfamiliar syntax (in language or in math formulas) or underlying structure (in diagrams, graphs, illustrations, extended expositions or narratives) through alternatives that: o Highlight structural relations or make them more explicit	

	○ Make connections to previously learned structures ○ Make relationships between elements explicit (e.g., highlighting the transition words in an essay, links between ideas in a concept map, etc.)	
2.3 Support decoding of text, and mathematical notation, and symbols	"To ensure that all learners have equal access to knowledge, at least when the ability to decode is not the focus of instruction, it is important to provide options that reduce the barriers that decoding raises for learners who are unfamiliar or dysfluent with the symbols."- Pg.17 *Implementation Examples:* ○ Allow the use of Text-to-Speech ○ Use automatic voicing with digital mathematical notation (Math ML) ○ Use digital text with an accompanying human voice recording (e.g., Daisy Talking Books) ○ Allow for flexibility and easy access to multiple representations of notation where appropriate (e.g., formulas, word problems, graphs) ○ Offer clarification of notation through lists of key terms	
2.4 Promote understanding across language	For ESL students providing linguistically options for students to learn in their primary language greatly increases understanding. *Implementation Examples:* ○ Make all key information in the dominant language (e.g., English) also available in first languages (e.g.,	

	Spanish) for learners with limited-English proficiency and in ASL for learners who are deaf o Link key vocabulary words to definitions and pronunciations in both dominant and heritage languages o Define domain-specific vocabulary (e.g., “map key” in social studies) using both domain-specific and common terms o Provide electronic translation tools or links to multilingual glossaries on the web o Embed visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc)	
2.5 Illustrate through multiple media	“Providing alternatives, especially for key information or vocabulary is an important aspect of accessibility” Pg. -18 *Implementation Examples:* o Present key concepts in one form of symbolic representation (e.g., an expository text or a math equation) with an alternative form (e.g., an illustration, dance/movement, diagram, table, model, video, comic strip, storyboard, photograph, animation, physical or virtual manipulative) o Make explicit links between information provided in texts and any accompanying representation of that information in	

	illustrations, equations, charts, or diagrams	
3. Provide options for comprehension	Constructing useable knowledge, knowledge that is accessible for future decision-making, depends not upon merely perceiving information, but upon active "information processing skills" like selective attending, integrating new information with prior knowledge, strategic categorization, and active memorization. Individuals differ greatly in their skills in information processing and in their access to prior knowledge through which they can assimilate new information. Proper design and presentation of information – the responsibility of any curriculum or instructional methodology - can provide the scaffolds necessary to ensure that all learners have access to knowledge.	
3.1 Activate or supply background knowledge	"barriers can be reduced when options are available that supply or activate relevant prior knowledge, or link to the pre-requisite information elsewhere" *Pg.* 19 *<u>Implementation Examples:</u>* o Anchor instruction by linking to and activating relevant prior knowledge (e.g., using visual imagery, concept anchoring, or concept mastery routines) o Use advanced organizers (e.g., KWL methods, concept maps) o Pre-teach critical prerequisite concepts through demonstration or models	

	- Bridge concepts with relevant analogies and metaphors - Make explicit cross-curricular connections (e.g., teaching literacy strategies in the social studies classroom)	
3.2 Highlight patterns, critical features, big ideas, and relationships	"one of the most effective ways to make information more accessible is to provide explicit cues or prompts that assist individuals in attending to those features that matter most while avoiding those that matter least." Pg. 19 *Implementation Examples:* - Highlight or emphasize key elements in text, graphics, diagrams, formulas - Use outlines, graphic organizers, unit organizer routines, concept organizer routines, and concept mastery routines to emphasize key ideas and relationships - Use multiple examples and non-examples to emphasize critical features - Use cues and prompts to draw attention to critical features - Highlight previously learned skills that can be used to solve unfamiliar problems	
3.3 Guide information processing, visualization, and manipulation	"Well-designed materials can provide customized and embedded models, scaffolds, and feedback to assist learners who have very diverse abilities in using those strategies effectively" *Pg.* 20 *Implementation Examples:*	

	○ Give explicit prompts for each step in a sequential process ○ Provide options for organizational methods and approaches (tables and algorithms for processing mathematical operations) ○ Provide interactive models that guide exploration and new understandings ○ Introduce graduated scaffolds that support information processing strategies ○ Provide multiple entry points to a lesson and optional pathways through content (e.g., exploring big ideas through dramatic works, arts and literature, film and media) ○ "Chunk" information into smaller elements ○ Progressively release information (e.g., sequential highlighting) ○ Remove unnecessary distractions unless they are essential to the instructional goal	
3.4 Maximize transfer and generalization	"Supports for memory, generalization, and transfer include techniques that are designed to heighten the memorability of the information, as well as those that prompt and guide learners to employ explicit strategies." Pg. 20 *Implementation Examples:* ○ Provide checklists, organizers, sticky notes, electronic reminders	

	- Prompt the use of mnemonic strategies and devices (e.g., visual imagery, paraphrasing strategies, method of loci, etc.) - Incorporate explicit opportunities for review and practice - Provide templates, graphic organizers, concept maps to support note-taking - Provide scaffolds that connect new information to prior knowledge (e.g., word webs, half-full concept maps) - Embed new ideas in familiar ideas and contexts (e.g., use of analogy, metaphor, drama, music, film, etc.) - Provide explicit, supported opportunities to generalize learning to new situations (e.g., different types of problems that can be solved with linear equations, using physics principles to build a playground) - Offer opportunities over time to revisit key ideas and linkages between ideas	
II. Provide Multiple Means for Action and Expression:	Definition and examples:	
4. Provide options for physical action	It is important to provide materials with which all learners can interact. Properly designed curricular materials provide a seamless interface with common assistive technologies through which individuals with movement	

	impairments can navigate and express what they know – to allow navigation or interaction with a single switch, through voice activated switches, expanded keyboards and others. (Ex. e.g., turning pages, handwriting in spaces provided, e.g., using a joystick or keyboard)	
4.1 Vary the methods for response and navigation	"To provide equal opportunity for interaction with learning experiences, an instructor must ensure that there are multiple means for navigation and control is accessible." Pg. 22 *Implementation Examples:* o Provide alternatives in the requirements for rate, timing, speed, and range of motor action required to interact with instructional materials, physical manipulatives, and technologies o Provide alternatives for physically responding or indicating selections (e.g., alternatives to marking with pen and pencil, alternatives to mouse control) o Provide alternatives for physically interacting with materials by hand, voice, single switch, joystick, keyboard, or adapted keyboard	
4.2 Optimize access to tools and assistive technologies	"It is critical that instructional technologies and curricula do not impose inadvertent barriers to the use of these assistive technologies." Pg. 23 *Implementation Examples:* o Provide alternate keyboard commands for mouse action	

	○ Build switch and scanning options for increased independent access and keyboard alternatives ○ Provide access to alternative keyboards ○ Customize overlays for touch screens and keyboards ○ Select software that works seamlessly with keyboard alternatives and alt keys	
5. Provide options for expression and communication	There is no medium of expression that is equally suited for all learners or for all kinds of communication. On the contrary, there are media, which seem poorly suited for some kinds of expression, and for some kinds of learning. It is important to provide alternative modalities for expression, both to the level the playing field among learners and to allow the learner to appropriately (or easily) express knowledge, ideas and concepts in the learning environment.	
5.1 Use multiple media for communication	"Unless specific media and materials are critical to the goal (e.g., learning to paint specifically with oils, learning to handwrite with calligraphy) it is important to provide alternative media for expression" Pg. 23 *Implementation Examples:* ○ Compose in multiple media such as text, speech, drawing, illustration, design, film, music, dance/movement, visual art, sculpture or video	

	- Use physical manipulatives (e.g., blocks, 3D models, base-ten blocks) - Use social media and interactive web tools (e.g., discussion forums, chats, web design, annotation tools, storyboards, comic strips, animation presentations) - Compose in multiple media such as text, speech, drawing, illustration, comics, storyboards, design, film, music, visual art, sculpture, or video - Solve problems using a variety of strategies	
5.2 Use multiple tools for construction and composition	The use of multiple tools in order to customize a match between ability's and the lesson task. *Implementation Examples:* - Provide spellcheckers, grammar checkers, word prediction software - Provide Text-To-Speech software (voice recognition), human dictation, recording - Provide calculators, graphing calculators, geometric sketchpads, or pre-formatted graph paper - Provide sentence starters or sentence strips - Use story webs, outlining tools, or concept mapping tools - Provide Computer-Aided-Design (CAD), music notation (writing) software, or mathematical notation software	

	○ Provide virtual or concrete mathematics manipulatives (e.g., base-10 blocks, algebra blocks) ○ Use web applications (e.g., wikis, animation, presentation)	
5.3 Build fluencies with graduated levels of support for practice and performance	"Learners must develop a variety of fluencies (e.g., visual, audio, mathematical, reading, etc.). This means that they often need multiple scaffolds to assist them as they practice and develop independence."- Pg. 24 *Implementation Examples:* ○ Provide differentiated models to emulate (i.e. models that demonstrate the same outcomes but use differing approaches, strategies, skills, etc.) ○ Provide differentiated mentors (i.e., teachers/tutors who use different approaches to motivate, guide, feedback or inform) ○ Provide scaffolds that can be gradually released with increasing independence and skills (e.g., embedded into digital reading and writing software) ○ Provide differentiated feedback (e.g., feedback that is accessible because it can be customized to individual learners) ○ Provide multiple examples of novel solutions to authentic problems	
	Of critical importance to educators is the fact that executive functions have very limited	

6. Provide options for executive functions	capacity due to working memory. This is true because executive capacity is sharply reduced when: 1) executive functioning capacity must be devoted to managing “lower level” skills and responses which are not automatic or fluent thus the capacity for “higher level” functions is taken; and 2) executive capacity itself is reduced due to some sort of higher level disability or to lack of fluency with executive strategies. The UDL framework typically involves efforts to expand executive capacity in two ways: 1) by scaffolding lower level skills so that they require less executive processing; and 2) by scaffolding higher level executive skills and strategies so that they are more effective and developed.	
6.1 Guide appropriate goal setting	“The UDL framework embeds graduated scaffolds for learning to set personal goals that are both challenging and realistic.” – Pg. 25 *Implementation Examples:* o Provide prompts and scaffolds to estimate effort, resources, and difficulty o Provide models or examples of the process and product of goal-setting o Provide guides and checklists for scaffolding goal-setting o Post goals, objectives, and schedules in an obvious place	
6.2 Support planning and	“To help learners become more plan-full and strategic a variety of options are needed, such as cognitive “speed bumps” that prompt them to “stop and think;” graduated scaffolds that help	

strategy development	them actually implement strategies; or engagement in decision-making with competent mentors."- *Pg.* 26 <u>*Implementation Examples:*</u> o Embed prompts to "stop and think" before acting as well as adequate space o Embed prompts to "show and explain your work" (e.g., portfolio review, art critiques) o Provide checklists and project planning templates for understanding the problem, setting up prioritization, sequences, and schedules of steps o Embed coaches or mentors that model think-aloud of the process o Provide guides for breaking long-term goals into reachable short-term objectives	
6.3 Facilitate managing information and resources	"Wherever working memory capacity is not construct-relevant in a lesson, it is important to provide a variety of internal scaffolds and external organizational aids – exactly those kinds that executives use - to keep information organized and "in mind.""-Pg. 26 <u>*Implementation Examples:*</u> o Provide graphic organizers and templates for data collection and organizing information o Embed prompts for categorizing and systematizing o Provide checklists and guides for note-taking	

6.4 Enhance capacity for monitoring progress	Educators need to provide timely formative feedback that allows learners to monitor and evaluate their progress and use the report to inform their practices moving forward. *Implementation Examples:* o Ask questions to guide self-monitoring and reflection o Show representations of progress (e.g., before and after photos, graphs and charts showing progress over time, process portfolios) o Prompt learners to identify the type of feedback or advice that they are seeking o Use templates that guide self-reflection on quality and completeness o Provide differentiated models of self-assessment strategies (e.g., role-playing, video reviews, peer feedback) o Use of assessment checklists, scoring rubrics, and multiple examples of annotated student work/performance examples	
III. Provide Multiple Means for Engagement:	Definition and examples:	
7. Provide options for recruiting interest	"Even the same learner will differ over time and circumstance; their "interests" change as they develop and gain new knowledge and skills, as their biological environments change, and as they develop into self-determined adolescents	

	and adults. It is, therefore, important to have alternative ways to recruit learner interest, ways that reflect the important inter- and intra-individual differences amongst learners”	
7.1 Optimize individual choice and autonomy	Educators should provide choices that are designed to optimize student’s engagement. *<u>Implementation Examples:</u>* ○ Provide learners with as much discretion and autonomy as possible by providing choices in such things as: ○ The level of perceived challenge ○ The type of rewards or recognition available ○ The context or content used for practicing and assessing skills ○ The tools used for information gathering or production ○ The color, design, or graphics of layouts, etc. ○ The sequence or timing for completion of subcomponents of tasks ○ Allow learners to participate in the design of classroom activities and academic tasks ○ Involve learners, where and whenever possible, in setting their own personal academic and behavioral goals	
7.2 Optimize relevance, value, and authenticity	“To recruit all learners equally, it is critical to provide options that optimize what is relevant, valuable, and meaningful to the learner.”- Pg. 29 *<u>Implementation Examples:</u>*	

	○ Vary activities and sources of information so that they can be:
	    ○ Personalized and contextualized to learners' lives
	    ○ Culturally relevant and responsive
	    ○ Socially relevant
	    ○ Age and ability appropriate
	    ○ Appropriate for different racial, cultural, ethnic, and gender groups
	○ Design activities so that learning outcomes are authentic, communicate to real audiences, and reflect a purpose that is clear to the participants
	○ Provide tasks that allow for active participation, exploration and experimentation
	○ Invite personal response, evaluation and self-reflection to content and activities
	○ Include activities that foster the use of imagination to solve novel and relevant problems, or make sense of complex ideas in creative ways	

7.3 Minimize threats and distractions	"One of the most important things a teacher can do is to create a safe space for learners. To do this, teachers need to reduce potential threats and distractions in the learning environment"- Pg. 29 *Implementation Examples:* ○ Create an accepting and supportive classroom climate	

	- Vary the level of novelty or risk - Charts, calendars, schedules, visible timers, cues, etc. that can increase the predictability of daily activities and transitions - Creation of class routines - Alerts and previews that can help learners anticipate and prepare for changes in activities, schedules, and novel events - Options that can, in contrast to the above, maximize the unexpected, surprising, or novel in highly routinized activities - Vary the level of sensory stimulation - Variation in the presence of background noise or visual stimulation, noise buffers, number of features or items presented at a time - Variation in pace of work, length of work sessions, availability of breaks or time-outs, or timing or sequence of activities - Vary the social demands required for learning or performance, the perceived level of support and protection and the requirements for public display and evaluation - Involve all participants in whole class discussions	
	However, learners differ considerably in their ability to self-regulate in this way. Their	

8. Provide options for sustaining effort and persistence	differences reflect disparities in their initial motivation, their capacity and skills for self-regulation, their susceptibility to contextual interference, and so forth. A key instructional goal is to build the individual skills in self-regulation and self-determination that will equalize such learning opportunities (see Guideline 9). In the meantime, the external environment must provide options that can equalize accessibility by supporting learners who differ in initial motivation, self-regulation skills, etc.	
8.1 Heighten salience of goals and objectives	To maintain interest and engagement, educators need to provide periodic or constant reminders of goals and the value of their goals *Implementation Examples:* ○ Prompt or require learners to explicitly formulate or restate goal ○ Display the goal in multiple ways ○ Encourage division of long-term goals into short-term objectives ○ Demonstrate the use of hand-held or computer-based scheduling tools ○ Use prompts or scaffolds for visualizing desired outcome ○ Engage learners in assessment discussions of what constitutes excellence and generate relevant examples that connect to their cultural background and interests	

8.2 Vary demands and resources to optimize challenge	"Providing a range of demands, and a range of possible resources, allows all learners to find challenges that are optimally motivating. Balancing the resources available to meet the challenge is vital." – Pg. 31 *Implementation Examples:* o Differentiate the degree of difficulty or complexity within which core activities can be completed o Provide alternatives in the permissible tools and scaffolds o Vary the degrees of freedom for acceptable performance o Emphasize process, effort, improvement in meeting standards as alternatives to external evaluation and competition	
8.3 Foster collaboration and community	"Flexible rather than fixed grouping allows better differentiation and multiple roles, as well as providing opportunities to learn how to work most effectively with others. Options should be provided in how learners build and utilize these important skills."- Pg. 31 *Implementation Examples:* o Create cooperative learning groups with clear goals, roles, and responsibilities o Create school-wide programs of positive behavior support with differentiated objectives and supports o Provide prompts that guide learners in when and how to ask peers and/or teachers for help	

	○ Encourage and support opportunities for peer interactions and supports (e.g., peer-tutors) ○ Construct communities of learners engaged in common interests or activities ○ Create expectations for group work (e.g., rubrics, norms, etc.)	
8.4 Increase mastery-oriented feedback	Increases the focus of feedback towards mastery of content and skills *Implementation Examples:* ○ Provide feedback that encourages perseverance, focuses on development of efficacy and self-awareness, and encourages the use of specific supports and strategies in the face of challenge ○ Provide feedback that emphasizes effort, improvement, and achieving a standard rather than on relative performance ○ Provide feedback that is frequent, timely, and specific ○ Provide feedback that is substantive and informative rather than comparative or competitive ○ Provide feedback that models how to incorporate evaluation, including identifying patterns of errors and wrong answers, into positive strategies for future success	
	"While it is important to design the *extrinsic environment* so that it can support motivation	

9. Provide options for self-regulation	and engagement (see guidelines 7 and 8), it is also important to develop learners' *intrinsic* abilities to regulate their own emotions and motivations… Unfortunately, some classrooms do not address these skills explicitly, leaving them as part of the "implicit" curriculum that is often inaccessible or invisible to many."	
9.1 Promote expectations and beliefs that optimize motivation	Educators need to provided multiple options to promote and encourage self-regulation strategies for learners. *<u>Implementation Examples:</u>* o Provide prompts, reminders, guides, rubrics, checklists that focus on: o Self-regulatory goals like reducing the frequency of aggressive outbursts in response to frustration o Increasing the length of on-task orientation in the face of distractions o Elevating the frequency of self-reflection and self-reinforcements o Provide coaches, mentors, or agents that model the process of setting personally appropriate goals that take into account both strengths and weaknesses o Support activities that encourage self-reflection and identification of personal goals	
9.2 Facilitate personal coping skills and strategies	Educators should provide methods for continual development of necessary skills involved with self-regulation *<u>Implementation Examples:</u>*	

	○ Provide differentiated models, scaffolds and feedback for: ○ Managing frustration ○ Seeking external emotional support ○ Developing internal controls and coping skills ○ Appropriately handling subject specific phobias and judgments of "natural" aptitude (e.g., "how can I improve on the areas I am struggling in?" rather than "I am not good at math") ○ Use real life situations or simulations to demonstrate coping skills	
9.3 Develop self-assessment and reflection	Educators need to instill multiple methods for self-assessment skills in students in order for self-regulation skill development *Implementation Examples:* ○ Offer devices, aids, or charts to assist individuals in learning to collect, chart and display data from their own behavior for the purpose of monitoring changes in those behaviors ○ Use activities that include a means by which learners get feedback and have access to alternative scaffolds (e.g., charts, templates, feedback displays) that support understanding progress in a manner that is understandable and timely	

Appendix C. Participant Recruitment Email

Hello STEM ESIL graduates,

My name is Daniel Steger and I am a current Masters Student at Virginia Tech, conducting research in the field of STEM education.

The research team and I would like to formally invite you to participate in a research study aiming to better understand trained Integrated STEM educator's perspectives on the use of Universal Design for Learning (UDL). You were selected for participation based on your expertise in Integrated STEM methodology, and your training through the STEM Education Certificate Program. As an educator in the state of Maryland, you are required by law to use UDL guidelines and principles in your curriculum development, instructional materials, instruction, professional development, and student assessment. Our questions target your unique perspective as an Integrated STEM educator teaching in the field on how UDL fits into an Integrated STEM classroom.

We understand that there are a lot of elements of UDL and Integrated STEM education, the purpose of this study is not to evaluate your teaching but to learn from your perspective on how elements of UDL fit into Integrated STEM education classrooms to help future educators.

Participation in this study would require:

- Allowing the research team access to the STEM portfolio you designed for your current classrooms in the course STEM Education Portfolio.
- Participating in a 45- minute audio-recorded interview aimed at gaining information about the classroom implementation of one lesson and your perspective on the use of Universal Design for Learning in an integrated STEM classroom.

Results of this study will be used for academic publications, academic conferences, and presented in my MS thesis. Results will also provide practitioners wisdom to Integrated STEM educators looking to adopt Universal Design for Learning.

If you are interested in participating in this study, please follow the link below to the consent form. Here you will be able to learn more about the study, including its risks and benefits, and indicate whether or not you are willing to participate. A response by May 10th 2018 is requested.

https://virginiatech.qualtrics.com/jfe/form/SV_37X0eJGtmopJ6mh

If you have any questions or concerns please contact me or one of the other members of the research team.
Best,
Daniel Steger
Dr. Hannah Scherer (hscherer@vt.edu, MS committee chair)
Dr. Donna Westfall-Rudd (mooredm@vt.edu, MS committee member)
Dr. Bonnie Billingsly (bbilling@vt.edu, MS committee member)

Appendix D. IRB Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants
in Research Projects Involving Human Subjects

Title of Project: Understanding the Innovation of Utilizing Universal design for Learning in Integrated STEM Classroom in Early Adopters

Investigator(s):
Daniel Steger, sdaniel3@vt.edu , 585-315-4563
Hannah Scherer, hscherer@vt.edu, 540-231-1759
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Donna Westfall-Rudd, mooredm@vt.edu , 540-231-5717

I. Purpose of this Research Project

The purpose of this research study is to understand the potential for widespread adoption of Universal Design for Learning (UDL) by educators using Integrated STEM education methods. We aim to understand this potential through the theoretical framework of Diffusion of Innovation theory. Each presence and absence of UDL elements in real world Integrated STEM classrooms provides understanding into its potential for widespread adoption in all Integrated STEM classrooms. The collected data will be analyzed to view the use of UDL in Integrated STEM classrooms as an "Innovation". The goal is to evaluate the actions and decision-making rationale of the early adoptive portion of the population through Rodgers (1995) 5 attributes of an Innovation that influence the rate of adoption. This evaluation will provide better understanding of the real-world implementation of this innovation and its potential for widespread adoption.

The results of this research study will be used to construct academic conference presentations, academic scholarly articles, and a Master's thesis. The research study is open to all students trained in Integrated STEM from a STEM Education Certificate Program, currently teaching STEM in Maryland Elementary schools.

II. Procedures

Should you agree, participation will involve:

1. If you agree to be a part of this study, you will be asked to be asked to allow the research team access to your integrated STEM lessons designed in your STEM Education Portfolio.
2. If you agree to be a part of this study, you will be asked to participate in an audio-recorded interview of approximately 45-minutes. This interview will involve sharing with the investigator your expertise's using Universal Design for Learning as an Integrated STEM educators. The interview will be scheduled at your convenience via a video chat format (Google Hangout, WebEx, or skype) and only the audio format of the interview will be recorded for data collection.

III. Risks

The risks of involvement in the interview are minimal and involve only the provision of one's experiences related to the use of Universal Design for Learning in integrated STEM classrooms. You may withdraw from the study at any time and the interview questions will not focus on any potentially embarrassing or dignity threatening topics.

IV. Benefits

Participation in this study will benefit future teachers, students, and society by clarifying how Universal Design for Learning is used in the real-world context of Integrated STEM education. This knowledge will allow teachers to construct more effective learning environments to include the needs of all students who enter their classroom. Finally, no promise or guarantee of benefits has been made to encourage you to participate.

V. Extent of Anonymity and Confidentiality

The information that are collected from you during your interview may include information that could potentially identify you, such's your program of study or description of your current teaching environment. Your identity, and that of any person who you mention, and the specific program you are in will be kept confidential, will be kept confidential at all times and will be only known to the research team. At no time will the researchers release identifiable results of the study to anyone other than individuals working on the project without your written consent. The audio recording of the interview will be transcribed by the investigator, and false names will be used for your name and for the names of any other people you mention.

The audio recording of the interview, all paper and electronic copies of the interview transcript, and the demographic data will be stored securely when they are not being used. The signed consent forms that is kept by the researcher, will be stored securely, in a separate location from the above data. Only the investigator will have access to the above data or the signed consent form. The audio recording of the interview, all paper and electronic copies of the interview transcripts, the demographic data, and the signed consent forms will be erased or shredded promptly after the data has been published or 3 years after completion of the study.

The Virginia Tech (VT) Institutional Review Board (IRB) may view the study's data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

VI. Compensation

No compensation for participation will be provided.

VII. Freedom to Withdraw

It is important for you to know that you are free to withdraw from this study at any time without penalty. You are free not to answer any questions that you choose or respond to what is being asked of you without penalty. If you choose to withdraw from the study, any information about you, and any data that you have provided, will be destroyed.

Please note that there may be circumstances under which the investigator may determine that a subject should not continue as a subject.

VIII. Questions or Concerns

Should you have any questions about this study, you may contact one of the research investigators whose contact information is included at the beginning of this document.

Should you have any questions or concerns about the study's conduct or your rights as a research subject or need to report a research-related injury or event, you may contact the Virginia Tech Institutional Review Board at irb@vt.edu or (540) 231-3732.

IX. Subject's Consent

By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.

I have read the Consent Form and conditions of this project. I have had all my questions answered. By clicking the "Provide Consent" button below, I hereby acknowledge the above give my voluntary consent, and accept that my consent will be electronically supplied to the research team to document my participation in this study.

Name:
Date:

[Provide consent button]

(Note: each subject must be provided a copy of this form. In addition, the IRB office may stamp its approval on the consent document(s) you submit and return the stamped version to you for use in consenting subjects; therefore, ensure each consent document you submit is ready to be read and signed by subjects.)

Appendix E. Interview questions

Introduction to the study: *Thank you for your participation in this educational research study. The goal of our research is to better understand trained Integrated STEM educator's perspective on the use of Universal Design for Learning. You were selected for participation based on your expertise in Integrated STEM methodology, and your training through STEM Education Certificate Program. As an educator in the state of Maryland, you are required by law to use UDL guidelines and principles in your curriculum development, instructional materials, instruction, professional development, and student assessment. Our questions target your unique perspective as an Integrated STEM educator teaching in the field on how UDL fits into an Integrated STEM classroom. We have selected one of your lessons from your academic profile that exemplifies Integrated STEM education and would like to know more about the implementation of this lesson into your classroom. We understand that there are a lot of elements of UDL and Integrated STEM education, the purpose of this study is to gain your perspective on elements of UDL fit into Integrated STEM education classrooms to help future educators.*

Part 1

a. Have you consciously put effort into using Universal Design for Learning in your Integrated STEM classroom? (yes or no) (If yes proceed to Question 2.a, If no proceed to Question 2B. a)

Part 2A-Factors of adoption

a. From a pedagogical standpoint, what do you believe are the advantages of using UDL in Integrated STEM classrooms? (Relative Advantage)

b. Students with disabilities or those that face a language barrier often need classroom adjustments in order to succeed. Have you ever had to make classroom adjustments because of a student's needs? Can you tell me a little more about that experience? (Compatibility)

c. From your perspective what hinders the compatibility between these two teaching methodologies? (Compatibility)

d. From the perspective of a teacher using both UDL and integrated STEM methods, how complex is it to used Universal Design for Learning in your Integrated STEM classrooms? (Complexity) What makes it complex or simple?

e. How difficult would it be for educators to try Universal design for learning in Integrated STEM classrooms on a basis? (Trialability)

f. The idea of using UDL in an integrative STEM classroom could be perceived as innovative. How do you believe the use of UDL in these types of classrooms could spread throughout the community of integrated STEM educators? (observability)

a. If another integrated STEM educator without any training in UDL viewed your classroom using both methods, do you believe that they would recognize differences between their classroom using only one and yours using both? (observability)
b. What elements would make it noticeable?

Part 2B- Views on innovation (in substitute of 2A)

a. Can you expand upon your decision making rational for why you do not utilize UDL in your classroom?

b. Have you ever had to make classroom adjustments because of a student's needs? (Compatibility)

c. From a pedagogical standpoint, do you believe that there are the advantages of using UDL in Integrated STEM classrooms? (relative advantage)

d. Is there an added difficulty to using UDL in Integrated STEM classrooms? (complexity)

e. In your opinion, how much effort would it take to use UDL on a trial bases? (trialability)

f. Do you believe that the use of UDL in an integrated STEM classroom would be recognizable to another integrated STEM educator without formal training? (observability)

Part 3- Standard UDL Checkpoints
Introduction: "At this point I would like to talk about some of your general classroom practices that you use throughout a school year."

a. (Doc) or (Interview)- What are some steps you take to promote goal setting of student's personal skills within your classroom? (6.1) or *What is your professional reasoning behind excluding goal setting from your classroom?*

    a. What methods do you use to insure and promote this progress? (6.2, 8.1) or *What is your professional reasoning behind excluding goal setting from your classroom?*
    b. (Doc) with (Interview)- What feedback do you provide to students about their academic goals? (6.4)

b. (Interview)- What methods and strategies are taken to promote self-regulation? (9.1) or *What is your professional reasoning behind excluding self-regulation skills from your classroom?*

a. Over the course of the year what methods are used to provide continual development of Self-regulation skills? (9.2)
b. Over the course of the semester, how do you promote self-assessment skill development? (9.3)

<u>Part 4- Customized lesson-specific UDL questions</u>

<u>Intro</u>*: "I would like now to talk about your well crafted integrated STEM lesson. Again we would like your perspective on what elements of UDL are utilized in Integrated STEM lessons and what are left out. I have reviewed your lesson and wanted to clarify some various elements of UDL that may or may not be present. We are also interested in your perspective on decision making rational for why UDL elements didn't fit into your lesson plan. By understanding your perspective on decision making rational we can further inform educators on the combination of these two educational methodologies."*

Representation

a. (Doc) or (Interview)- How do you clarify terms specific to the content being taught? (2.1, 2.2, 2.3)
    a. *What is the pedagogical reason behind not clarifying terms?*

b. (Doc) or (Interview)- What options do you have available to students whose primary language is not English? (2.4)
    a. *What prevents options becoming available for students?*

c. (Doc) or (Interview)- Please describe to me the types of material you make available for this course? (2.5)
    a. *What limits what materials you make available for students? Or What is the pedagogical reason behind providing only…?*

d. (Doc) or (Interview)- How do you tie information from this lesson to information previously taught in this class? (3.1)
    a. *what is the pedagogical reason behind not utilizing previous lessons?*

e. (Doc) or (Interview)- How you promote methods for student retention and generalization of the content in this lesson to be used in later lessons? (3.4)
    a. *what is the pedagogical reason behind not utilizing previous lessons?*

Action and expression

a. (Doc) or (Interview)-Students could theoretically have physical challenges with… due to …. How do you or theoretically would you reduce physical barriers presented in this lesson? (4.1)
    a. *What prevents your ability to reduce the physical barriers in a classroom?*

b. (Interview)- How do student utilize their accommodations in this lesson? (4.2)
    a. *what academic success tools are made available for this lesson? (5.2)*

c. (Doc) or (Interview)- How do you customize this lesson experience to the student's independency level? (5.3)
    a. *What is your pedagogical rational for not customizing these lessons experience to student's independency levels?*

Multiple means of engagement

a. (Doc) or (Interview)- How do you engage a student's personal relevancy to the content of this lesson? (7.2)
    a. *What is lost from this lesson by not engaging in a student's personal background with the content?*

b. (Interview)- What steps do you take in this lesson to minimize distraction and minimize threats to learning? (7.3)
    a. *What is your pedagogical reason for doing so?*

c. (Doc) or (Interview)- How do you focus your feedback to students in this lesson?
    a. *What prevents focusing feedback on mastery of content and skills*

Appendix F: Integrated STEM Rubric Screening Results

Lesson Title	Score Average
Lesson 1.1.1	2.75
Lesson 2.01	2.416667
Lesson 2.02	2.5
Lesson 2.03	2.08333
Lesson 2.04	2.5
Lesson 2.05	2.5
Lesson 2.06	2.75
Lesson 2.07	2.33333
Lesson 2.08	2.83333
Lesson 2.09	2.08333
Lesson 2.10	2.66666
Lesson 3.1	2.83333
Lesson 3.2	2.66667
Lesson 3.3	2.75
Lesson 3.4	2.833
Lesson 4.1	2.3333
Lesson 4.2	2.6666
Lesson 4.3	2.3333
Lesson 4.4	2.25
Lesson 5.1	2.41666
Lesson 5.2	2.58333
Lesson 5.3	1.75