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Integrative STEM's Role in the Education of Students with Disabilities

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Abstract

Studies show that integrative STEM education (iSTEM) is useful for all learners as it is hands-on and engaging, utilizes an inquiry approach, fosters essential soft skills - which are defined by the University of Missouri (2023) as "a set of personal attributes, behaviors, and social attitudes that enable individuals to interact effectively with others in a workplace or social environment," and prepares students for the workforce (Roehrig et al., 2021). However, there is a lack of studies that address how iSTEM is used with students with special educational needs. Research suggests that individuals with disabilities are underrepresented in the STEM workforce (Zimmer et al., 2018). Based on the culmination of these findings, there is a gap between integrative STEM education and special education. Using a comprehensive literature review along with qualitative research methodology and my experience as an integrative STEM education methods minor, this study explores why the gap between iSTEM and special education exists and what can be done by schools and educators to decrease this gap.

Keywords: Integrative STEM (iSTEM), inclusive integrative STEM education model, students with special educational needs, engineering design process, twenty-first century skills, authentic, problem-solving, barriers

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Introduction

Since former President Barack Obama's 2009 initiative, Race to The Top, the efforts towards teaching STEM – an acronym for science, technology, engineering, and math – in schools have been rising (Johnson, 2019). Integrative STEM, which will be referred to as iSTEM throughout the paper, has been gaining prominence in schools as a method for integrating STEM concepts across the curriculum. Not only does the teaching of these disciplines lead to economic growth, but it leads to personal growth in the learners that will help equip them for any future career (Zimmer et al., 2018). Integrative STEM goes beyond traditional boundaries and disciplines, instead positioning learning in real-world situations by using an inquiry approach and combining the STEM disciplines with one another as well as other non-STEM content areas such as English Language Arts (ELA) or Social Studies (Ross, 2022). An inclusive STEM model is one that fosters the learning of *all* children, regardless of race, age, gender, or ability (Powell et al., 2018). Combining these two sources, an inclusive STEM integration model would be teaching STEM subjects in conjunction with each other and/or other non-STEM domains in an environment where students of diverse genders, backgrounds, and abilities are learning side-by-side.

The benefits are numerous as both technical skills and soft skills are fostered through iSTEM (Barber, 2022). Recent studies have demonstrated evidence of increased content retention, problem-solving skills, and higher-level thinking skills. More importantly, students are learning to collaborate and work together - capitalizing on each other's strengths -, to think creatively, and to see failure as an opportunity for growth instead of a stopping point (Barber,

2022). Collaboration, creativity, and resilience are three soft kills needed to successfully work in groups in career and social relationships (University of Missouri, 2023).

Parents of students with special educational needs have noted that the U.S. Education System has been failing their children because of the lack of needed supports, low expectations of faculty, alternate diploma options, and the underteaching of soft skills (Butrymowicz, 2018). ISTEM is a great tool for developing soft skills, providing supports, and helping students grasp material (Winnie Wing Mui So, 2022). However, many students with disabilities are often kept out of these engaging types of learning to attend pull-out services or as punishment for behavior (O'Sullivan et al., 2021). Additionally, these opportunities may be treated in a limited manner by their teachers (Ballin, 2022). In order to shift this trend, teachers must be knowledgeable about special education and integrative STEM education, as this will allow them to understand the unique learning needs of their students and address some of those needs using integrative STEM.

As a dual Special Education and Early Childhood major minoring in iSTEM, I sought information to answer three questions: What is integrative STEM and why is it important for learners with special educational needs? What are the barriers to implementing iSTEM, and why is it taught even less with students with special educational needs? What can be done to address these barriers and the gap between iSTEM and special education?

Literature Review

What is Integrative STEM (iSTEM)?

STEM education is instruction focused on science, technology, engineering, and/or mathematics. The focus on these subject areas began in the 1990s, but the subject areas were often taught in isolation with most instruction targeting only math or science (Kelley & Knowles,

2016). The other two disciplines were under-focused on, and all the disciplines were typically taught in isolation (Kelley & Knowles, 2016). This approach can keep students from generalizing these skills and using them in other contexts such as the real world.

Integrative STEM differs from traditional STEM education. It seeks to combine at least two of the STEM content areas with one another or to combine one of the STEM disciplines with content from another subject (Kelley & Knowles, 2016). There are many key characteristics to integrative STEM education. It should be authentic, collaborative, and hands-on – all of which are key features of student-centered learning (Roehrig et al., 2021).

Many times, iSTEM education is carried out through the form of engineering design problems which utilizes the engineering design process. This walks students through the steps of thoroughly thinking through and constructing a solution to a problem (Roehrig et al., 2021). The steps of this cycle are to ask what the needs and constraints are, research the issue, imagine some solutions to the identified problem, plan how to carry out the decided solution, create a prototype, test and evaluate the prototype, and then improve and redefine the design (CU Engineering, n.d.). The sequence of this process is shown in Figure 1. A goal of this process is for students to view failure as an essential part of growth. Furthermore, engineering design problems embody the key characteristics of iSTEM: integrated content domains, an authentic context, an engaging, student-driven nature, and utilization of the soft skills (Roehrig et al., 2021). The engineering design process is often used at the elementary level to engage students in iSTEM experiences.

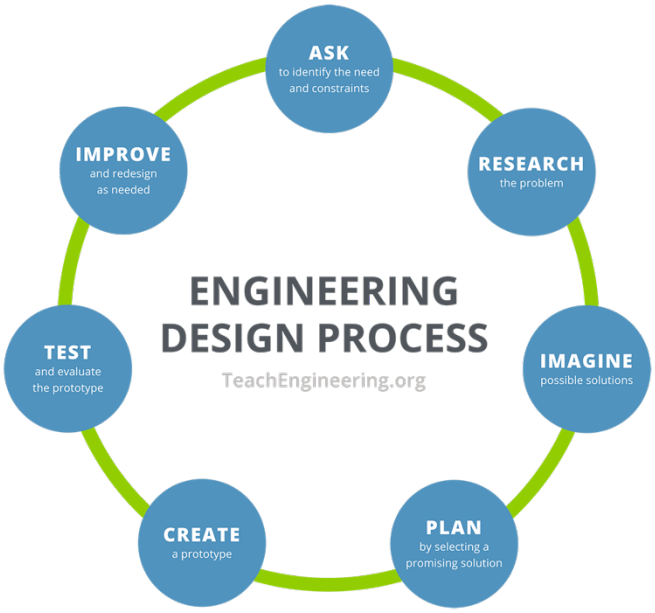

Figure 1: The Engineering Design process as outlined by CU Engineering (CU Engineering, n.d.).

One of the most important features of integrative STEM is for problems to have an authentic context (Roehrig et al., 2021). In order for learning to be authentic, it should clearly show students how what is learned *inside* the classroom applies to life *outside* of the classroom as well. When learning is more relatable and relevant to students' lives, they are more likely to be passionate and motivated (Finch, 2023). An authentic context could look like addressing or coming up with a solution to a real problem in the community or one that the students notice in their environment. Students locate real problems in their settings, and then carry out the engineering design process to address these problems. Doing this allows students to generalize the skills and knowledge they learn, have some agency in their learning, see the importance and applicability of STEM, and increase motivation.

Integrative STEM education is hands-on. Through the engineering design process, students are actively involved in every step (Sabarre et al., 2023). They complete the research, sketch solutions, build the prototypes, perform the tests and evaluations, and build the final product. Sabarre and his colleagues (2023) provide a detailed overview of what this could look like in a fourth-grade classroom. In the beginning stages, students are reframing the prompt into their own words, investigating and collecting data as they do so, brainstorming solutions with others, and comparing their ideas to create the best possible solution. They then design a prototype which they test and collect data on to inform their final solution. They reevaluate and redesign as needed, and then share their findings and final products with an audience (Sabarre et al., 2023). At no point are students passively learning. This creates an engaging, motivating learning environment where the student is at the center.

STEM integration models are cross-domain, meaning that content from at least two of the STEM domains and/or non-STEM concepts are being utilized within the same activity. This often looks like using engineering and technology to engage with science and math content. Going even further, iSTEM can be used in conjunction with other non-STEM content areas, such as social studies, music, or English Language Arts (Sanders & Wells, 2010). One resource,: Approaches to Integrating STEM Learning" (Ross, 2022) details how science, technology, and mathematics were all utilized in a sustainability activity. The students conducted research about renewable energy, which is a scientific concept, investigated an industry that uses renewable energy to carry out their production, which ties in technology, and used mathematics to calculate the volume their design needs to be able to hold (Ross, 2022). An elementary school librarian has also explained how she combines iSTEM with literacy (Barber, 2022). After completing a read-aloud with the class, there is a hands-on STEM activity that is connected to the book. For

example, students were challenged to create a raft for a character in a book used in the read-aloud (Barber, 2022). Integrative STEM has often been used to build upon already existing content and activities.

Another key feature of integrative STEM is its collaborative nature. The fostering of 21st century skills, such as creativity, problem-solving, communication, critical thinking, and collaboration is a prominent goal of iSTEM (Roehrig et al., 2021). Often, in iSTEM activities, students are working in teams or small groups to solve a problem just as many careers would require. Students are each contributing what they know to create what they think would be an ideal solution to an authentic problem (Roehrig et al., 2021).

There have been clear benefits for students with special educational needs from iSTEM's collaborative nature. One study noted that students with disabilities who were typically reserved and unconfident stepped up to lead groups and became much more social with their typically developing peers (O'Sullivan et al., 2021). Another educator noted that her students are often reluctant to work in certain groups, but they quickly come together and capitalize on each other's strengths once in a STEM activity (Barber, 2022). Through engineering design challenges and iSTEM, students are learning to become more effective and confident communicators and collaborators.

Integrative STEM's Effects on Students and Their Learning

The positive effects of integrative STEM education are numerous. Through iSTEM, students experience both social-emotional and educational benefits. An inclusive STEM integration model is when students with special educational needs were working alongside students without special educational needs. In "The DreamSpace STEM-21CLD Model as an

Aid to Inclusion of Pupils with Special Education Needs" (O'Sullivan et al., 2021), students worked in inclusive groups to find a solution to a problem from an imaginary country. One teacher who used this approach noted that students who were typically unconfident and reserved became "socially alive", leading the group and showing eagerness to learn. Another important aspect she noticed with this model was that students did not have to heavily depend on literacy and numeracy skills, something many students with special educational needs struggle with. They were able to complete the same tasks as their peers and could do so confidently (O'Sullivan et al., 2021).

Integrative STEM education also prepares students for their futures through developing job skills such as critical thinking and problem solving (Zimmer et al, 2018). Due to the collaborative nature of iSTEM, students are also learning to work with others by sharing ideas, building on each other's strengths, and giving and taking feedback, all of which are important for life and the workforce. Another important benefit is the exposure to STEM. Through iSTEM, students can gain more interest in and understanding of STEM, increasing the potential of this population taking more advanced STEM classes and even entering a STEM career (Balakrishnan, 2021). This is important as STEM is a key part of our economy, but without educating all students about STEM, the number of potential STEM workers dwindles (Zimmer et al., 2018).

The Gap Between iSTEM and Special Education

The existing literature suggests that students with special educational needs would greatly benefit from integrative STEM education (O'Sullivan et al., 2021). However, this is the population that often receives the least amount of education in the STEM fields. As of 2021,

almost a quarter of the United States' workforce was STEM-related careers, however individuals with disabilities account for only 3% of STEM careers (NSF, 2023). About 25% of the adult population in the U.S. has a disability (CDC, 2023). This data suggests there is an incredibly large gap between those with disabilities and the STEM disciplines. A reason for this could be the unequal opportunities some populations, such as students with disabilities, have had in STEM education (Powell et al., 2018). This could happen due to teachers' attitudes or expectations, or intervention in other areas.

Students with special educational needs often miss out on true integrative STEM education despite its clear benefits. One of the main purposes of iSTEM is to foster critical thinking skills and higher order thinking skills. However, students with disabilities are often taught STEM disciplines in ways that do not foster these skills. In one study that examined how math was taught to both students with disabilities and students without disabilities, there were key discrepancies in instruction and targeted skills. In the general education classroom, students were taught about the reasoning behind fractions, allowing them to use critical thinking and problem-solving skills. However, in the special education classroom that students were pulled out to, the teacher taught them the steps and used non-mathematical vocabulary. With this method, students are only developing rote memorization skills (Ballin et al., 2022). This is problematic as students are not gaining a true or deep understanding of math. They are simply being told how to do it instead of actually coming to understand the concepts.

Not receiving quality iSTEM instruction in a motivating manner could lead to students never continuing in STEM courses or entering the STEM field as they may believe they cannot succeed as they may lack in self-efficacy, desire to continue, or positive attitudes toward STEM

(De Loof et al., 2022). According to one study, students with special educational needs stop taking STEM courses by the time they reach middle school, which would hinder them from learning about STEM in secondary and post-secondary education or entering a STEM career (Basham & Marino, 2013). In addition to receiving lower-quality STEM instruction, students with special educational needs sometimes miss out on STEM instruction entirely. STEM's importance is often overlooked or seen as a fun extra – especially when it comes to technology and engineering, so when students go to another classroom to receive additional support, it could be during this time (O'Sullivan et al., 2021).

The Reason for this Gap

Teachers play a very large role in their students' education. They help determine what material is taught, how it is taught, and even what career paths students will eventually take (Balakrishnan et al., 2021). In addition to the attitudes and preparedness of the educator, resources and services can also impact the iSTEM education that students with disabilities are receiving.

One factor to consider is the expectations that the educator has for students with special educational needs. Low expectations are listed as one of the seven barriers to inclusive STEM education (Klimaitis & Mullen, 2021). Low expectations could be one of the reasons teachers use ineffective methods, like rote memorization. Teachers could expect that students with disabilities would not be able to comprehend the problem or use higher-order thinking skills like their general education peers could, leading the educator to require students to simply practice problems repeatedly until students have them memorized.

Teacher preparation is another factor impacting teachers that could hinder their students from a high-quality STEM education. This could come in the form of not feeling prepared to teach STEM or to not meet the learning needs of students with special educational needs, or a combination of the two. If teachers believe they can teach students with special educational needs and that they are prepared to do so, they are more likely to educate inclusively and effectively address the diverse needs of their students (Zimmer et al., 2018) Teachers must have both the content knowledge and the pedagogical skills to effectively meet the learning needs of students with special educational needs. A 2018 study looked at the effects of having special education (SPED) professionals involved in methods courses, which teach special education students the content of subject areas and how to teach the subject. The participants whose course involved the SPED faculty member had an increase in their positive attitudes about inclusion and in their ability to meet diverse learning needs. On the other hand, participants who did not have instruction from the SPED faculty member felt less positive about inclusion and their ability to meet diverse learning needs. They were less knowledgeable about response to intervention (RTI), which is used in general education to address diverse needs of students (Zimmer et al., 2018). Acquiring knowledge about content, inclusion, and meeting diverse needs is essential for teachers to effectively teach STEM to students of varying learning needs as it increases their attitudes about inclusion and their abilities to teach students of special educational needs.

Another reason for this gap could be that most instructional efforts are focused on other domains instead of on the STEM fields. Interestingly, high school students with disabilities graduate with the same number of English credits as their typically developing peers, however, they have far fewer math and science credits at the time of graduation (Schneiderwind & Johnson, 2020). This could be due to pull-out services - where students get more focused,

individualized instruction on a specific subject that they need more support in - taking the place of STEM instruction. Most supplemental support targets English Language Arts, reading, and math, while science is seen as an area that can be replaced with intervention in those other domains (Smithsonian Science Education Center, 2020, p. 11).

Statement of Problem

To summarize the key findings from the literature review, there is a distinct gap between integrative STEM education and special education. Students with special educational needs may not receive a quality iSTEM education because of low expectations from educators, under-preparedness of educators, pull-out services replacing iSTEM instructional times, or lack of resources. This is problematic as all students, especially those with special educational needs, would benefit from integrative STEM education as it is student-centered and fosters many skills needed later in life.

Methods

Qualitative data was collected in the form of semi-structured interviews. For this study, five Millersville University graduates with educational and employment backgrounds in integrative STEM education were contacted by Dr. Charlton Wolfgang to see if they would be willing to be interviewed for an undergraduate research project pertaining to iSTEM. All five responded to Dr. Wolfgang's message saying that they would participate. From there, an email request was sent to them using the contact information they provided Dr. Wolfgang. Four of these individuals responded to this email request, and once consent was received, semi-structured interviews were conducted via Zoom or in-person. These interviews were audio recorded with the participants' consent and analyzed for common themes.

Limitations

The nature of this study was limiting as it was qualitative data. With a semi-structured interview, there is room for interpretation by both the interviewee and the interviewer. For example, "effective" and "ineffective" is up to the interviewee's interpretation. This was not defined by quantifiable data, but by what the participant has observed and what they count as worthy of being deemed "effective" or "ineffective." Another limit of this study is the number of and characteristics of the participants. Only four individuals were interviewed due to the time constraints and lack of responses from the initial recruitment email sent by the alumni office. All the participants were Millersville graduates who have received a degree in education and undergone integrative STEM education methods courses. To strengthen this study, the sample could be broadened to include educators who received education at other post-secondary institutions, teachers outside of Pennsylvania, and middle-level and secondary education teachers (grades 6-12). Another way to strengthen this study would be to have a larger sample size.

Participants

There were four participants involved in this study. All the participants were Millersville University graduates who received a Bachelor of Science in Education. Three of the participants had majored in both early childhood and special education, and one majored in early childhood education. Each of the interviewees had either completed or taken courses in the Integrative STEM Education Methods minor offered at Millersville University.

Interview Questions

1. Please tell me about your educational background, classroom setting (Gen. Ed, Special Ed., separate STEM room), and classroom population.

2. What are some of the most prominent learning needs and strengths in your students?
3. What are some of the skills you are most focused on fostering in your students?
4. What are the teaching methods you have found to be effective and ineffective in your classroom? What activities are your students most engaged in?
5. Rank the subjects in the order of how much instructional time is spent on each. If this differs for your students with special educational needs, please clarify how instructional time differs for them. Are there areas you wish were more focused on?
6. How would you describe integrative STEM, and what is its role in your classroom?
7. If you use integrative STEM, what effects have you seen on your students' learning and soft skills development? If you have any students with special educational needs, please describe the effects you've specifically seen iSTEM have on them.
8. While integrative STEM's presence in elementary schools has been growing, there is still room for growth. What are some barriers you have encountered or noticed to implementing integrative STEM?
9. If you were to give suggestions to first-year teachers who are trying to implement iSTEM into an inclusive classroom (both general education and special education students), what would you share with them? What advice do you have for teaching integrative STEM?
10. Is there anything you'd like to share that we did not discuss?

Discussion

After completing the interviews, the answers were analyzed for common themes. The notes taken during the interviews were examined for recurring answers, and the interviews were listened through again to verify these themes. Many themes have emerged that help provide a

definition for what integrative STEM is, what effects teachers have seen iSTEM have on their students, and barriers to implementation. Due to the large number of smaller themes, they were categorized into three larger themes: characteristics, effects on students, and barriers to implementation. After analyzing the data and discussing the common themes, suggestions for how educators can begin to implement an inclusive integrative STEM education model into a classroom are provided.

Theme I

Integration

Each interviewee was asked to provide a definition of integrative STEM that has been shaped by their educational and professional experiences. All mentioned that there must be a bridge between two or more content areas. A common theme was using more than one STEM discipline within activities, such as using math concepts in computer science or in engineering a technology, which the educator described as a tool or device that addresses a problem. Bridging with non-STEM disciplines was another similarity in their responses. These educators have used STEM in combination with writing, music, and reading. For them, this has looked like creating an engineering design challenge that addresses a problem raised in a children's book, coding a robot to play a musical melody that was created in students' music class, or coding their writing into a story.

Use of Hands-On, Student-Directed Learning

Another common theme that emerged from the interviews was the use of student-directed learning in integrative STEM. Each educator discussed the importance of letting students explore and actively engage with the materials. They noted that students are most engaged when figuring

out why things occur, exploring, and doing hands-on activities. This often looks like giving guidelines but not exact instructions or utilizing Gradual Release of Responsibility (GRRM) where the teacher models how to do something, does it with the students, and then the students do it on their own (Interview #1). One teacher even noted that the classroom activities are least effective when students are given directions on exactly how to carry out the challenge (Interview #2).

Student-centered or student-directed learning is when "the learning environment has learner responsibility and activity at its heart" (TEAL Center Staff, 2010, p. 1). In this type of learning, students get to have a say in what is being taught and how it is being taught. They are actively constructing knowledge, monitoring their learning, producing something, and collaborating with their peers. Learning should move past rote memorization and toward higher order thinking skills, and students should be responsible for their learning. The benefits are numerous: motivation, self-confidence, and achievement are common effects of student-directed learning (TEAL Center Staff, 2010).

Focus on Twenty-First Century Skills

Another common theme emerged when the participants were asked to share the skills they were most focused on fostering in their students. All four educators mentioned collaboration or teamwork. Critical thinking and problem-solving were also skills the STEM teachers were hoping to instill through their classes. One educator stated, "Ultimately, I try to make sure they have cleaner and more concise life skills that are going to be able to help them," and that content mastery is not the main goal (Interview #2). This participant was aiming to help students learn to be global citizens, critical thinkers, continuous learners, communicators, and collaborators. In

planning lessons, this educator keeps these goals and characteristics at the forefront of lessons as these are skills the educator feels are most important for life (Interview #2). Another participant talked about using the engineering design process to solve real-life problems and learning how to communicate well by doing this in teams (Interview #3). The fourth participant also mentioned collaboration and utilization of the engineering design process, while also wanting to target creativity (Interview #4).

Many of the skills the participants are trying to foster through iSTEM are the twenty-first century skills which are the "knowledge, life skills, career skills, habits, and traits that are critically important to student success in today's world" (Buckle, n.d.). These skills prepare students for a postsecondary education, a career, and adaptation in a world that is always changing (Roehrig et al., 2021). Twenty-first century skills also include but are not limited to critical thinking, communication, creativity, innovation, problem solving, perseverance, and collaboration (Buckle, n.d.). Integrative STEM is a great way to foster these essential skills. Through the engineering design process, which is commonly used in iSTEM, students think critically as they solve problems, think creatively as they think about how to improve their designs, collaborate as they work in teams, communicate as they share their ideas and give feedback to others, and persevere as they encounter designs that do not work as planned and think of more effective solutions (Roehrig et al., 2021).

Theme II

The educators interviewed also detailed the effects they have witnessed in their students. Common themes emerged when asked about this. The participants have noticed a change in students' confidence, communication and collaboration skills, perseverance in challenges, and

problem-solving skills from before starting their class to the present. These skills that the educators have seen improvements in are some of the 21st century skills, which are the skills necessary for success in life after K-12 schooling (Roehrig et al., 2021). One educator said, "The soft skills have impacted their learning in other areas," such as relationships and other courses (Interview #2).

Increased Confidence

Another effect of integrative STEM education that was noted across multiple interviews was increased self-confidence and seeing their value. It was noted that the students who go to intensive learning support have begun to feel valued by their peers as they have worked in teams and toward a common goal with them. This particular educator pushed for special education students to be included in the STEM class, so this is one of the only times their typically developing peers are with them in the school day. Through interactions in this class, the general education students have actually interacted with students with special educational needs, showing them that students with disabilities are capable of the learning the same material as them and that they are worth interacting with. In turn, the students with special educational needs have felt more confident to talk to their peers and that what they have to say matters (Interview #2). Another educator said that his students who have Autism Spectrum Disorder have become more confident in advocating for themselves to their educators. These students have shared their frustration when pulled out of STEM class and have asked to be able to stay during that class (Interview #4). Another participant noted the students with special education needs have begun to "use their voice." Over the course of the year, they have found activities they prefer to engage in during choice time, and they have begun to use their augmentative and alternative

communication (AAC) device to ask for those activities. AAC is an assistive technology that allows people who struggle with speech and communication skills to communicate without talking (ASHA, n.d.). At the beginning of the year, the students just used whatever was given to them by the teacher, but they have grown in confidence and have started to make their preferences known.

Not only has students' confidence in interacting with peers and adults increased, but their confidence in their work and abilities has also increased. One educator noted, "The students are flourishing!" (Interview #4). They have begun to be proud of and take ownership of their work. Students in another inclusive integrative STEM environment have become more confident in trying new things as they've experienced working through challenging tasks before, showing them that they are capable of engaging in difficult activities and that mistakes are not detrimental but a way to grow (Interview #3).

Fostering a child's self-confidence is important for educators to do as there are correlations between higher confidence and resilience, willingness to learn, and academic achievement (Gill, n.d.). Confidence is a trait that is important to develop in students, and as seen through these interviews, an inclusive integrative STEM education model is an effective way to do this.

Improved Communication and Collaboration

All four of the educators noted that through the use of an inclusive integrative STEM education model, their students have grown in their communication and collaboration skills. In the third interview, the educator said students who use an AAC device have begun to use their device more to request certain activities. As discussed earlier, this shows an increase in

confidence in making their desires known. This also suggests that the students have had more opportunities to practice communicating and making requests through iSTEM and that they are more competent in using their communication devices. A similar pattern was seen in the fourth interview as this educator's students have also begun expressing their wants and needs more.

In addition to the increase in students communicating their desires, they have learned how to work in teams. In these classes, students often work in teams to solve an engineering design challenge. They have learned to compromise, which is a critical component of relationships and working with others. Students have learned to share their ideas with others, build on each other's strengths, and share responsibilities amongst each other. Teamwork is something essential for life as most careers require collaboration (O'Sullivan et al., 2021). A study that utilized an inclusive integrative STEM integration model found that teachers' perceptions of the abilities of students with special educational needs increased when they saw these students working with their peers (O'Sullivan et al., 2021). As demonstrated in the interview data, integrative STEM is a powerful tool for increasing perceptions of and confidence in students with disabilities.

Increased Embracing of Challenges

A third common effect seen by the interviewees was that students have become more willing to engage and persist in challenging activities. Not only have students grown in their comfortability in doing new and unknown things within their STEM courses, but this has translated to their other classes as well. One educator stated, "Because in my class I foster a lot of problem-solving, growth mindset… when they try other things in their classroom, they're more willing to not give up and push through" (Interview #1).

Students' problem-solving skills have increased because of their integrative STEM instruction which could be a reason for them being more persistent in other challenging situations (Interview #2 & Interview #3). In integrative STEM, the students are often tasked with solving a real-life problem or trying a task, such as coding, for the first time. In doing this, they have learned to think creatively and outside-of-the-box as they come up with solutions to authentic challenges. One of the participants explained that the students have translated their problem-solving skills to other classes (Interview #2). As a result of doing investigative research as a first step in engineering design challenges, they have learned to not give up when doing research in other content areas, such as writing or social studies. The educator explained that the students have progressed from doing a simple, surface-level Google search and have begun doing more in-depth, scholarly searches. Previously, the students had become frustrated and quick to give up when they did not find helpful information in their initial search, but they have learned how to solve this problem and go more deeply into an investigation through integrative STEM (Interview #2).

Another reason could be because through integrative STEM, students are learning to see failure as an opportunity for growth. In the engineering design process, failure is expected and even encouraged as it shows students areas that could be improved in their design and create a more effective and innovative product (Roehrig et al., 2021). A school librarian noted that through integrating STEM into her classroom, the students have stopped fearing failure and instead want to take another attempt at the activities they are challenged in (Barber, 2022). As demonstrated in the literature and the experiences of practicing STEM teachers, iSTEM is helpful in fostering perseverance and willingness to try new, challenging things.

Theme III

Each participant was asked to share what they think barriers are to non-STEM teachers utilizing iSTEM in the classroom. Two common themes emerged: emphasis on other content areas and hesitation to try it based on lack of knowledge on what integrative STEM is, how to implement it, and where to find resources for it.

School-Wide Emphasis on Math and English Language Arts (ELA) Instruction and Lack of Set Curriculum

Each participant was asked to rank the content areas by how much instructional time is spent on them in their respective schools. All four interviewees explained that most instructional time is devoted to English Language Arts and mathematics. While the answers differed on exactly how much time is spent on ELA and math compared to iSTEM and the other content areas, all reported a significant difference. In one school, about an hour and a half is spent on both math and ELA. This year, that school has begun to implement 30 minutes of science each school day. Very little time is allotted for social studies, and students go to STEM class for about 80 minutes in a six-day cycle, receiving two 40-minute instructional periods in that cycle. The interviewee from this particular school also noted that almost every day, at least one student with special educational needs gets pulled from their STEM class in order to receive intervention in another subject area, usually being math or ELA (Interview #4).

An interviewee from another school shared a very similar experience. In this participant's school, most instruction is devoted to ELA and math, while only 30 minutes at the end of the school day is allotted for science and social studies to be taught. While this time is supposed to be for science or social studies, this teacher has noticed it usually ends up being time for students

to catch up on the work they are behind on. Science instruction does not become a priority until fourth grade, and in fifth grade, students get 80 minutes of science instruction twice a week and 80 minutes of STEM instruction once a week. This educator had to advocate for students with special learning needs to stay in the STEM class. The district wanted to pull out the students who receive intensive learning support from STEM to receive other services. This educator pushed for those students to stay. This is the first time they have had integrative STEM instruction, and they and their parents have been pleased with the growth and engagement they've seen through this class. With the exception of this educator's class, there have not been any more special education students pushed into other inclusive integrative STEM environments despite receiving this feedback from parents and the educator (Interview #2).

Interviewees noted some potential reasons for this could be lack of curriculum and lack of accountability for STEM instruction. There is a set curriculum for ELA and math, but there is not one for science. While there are science standards, there is not much guidance on how to actually implement these into the classroom. "There are standards, but you can take those in so many different directions" (Interview #3). This interviewee went on to explain they are hopeful for the new PA Science, Technology & Engineering, Environmental Literacy & Sustainability (STEELS) standards as they provide more ideas and resources on how educators can practically teach STEM and integrate it into their classrooms. In Pennsylvania, science is not formally assessed on statewide assessments until fourth grade, so often, schools don't start focus on science instruction until students are in fourth grade. This participant went on to explain that Pennsylvanian school districts are required to submit their instruction schedules to the state. She explained that a district is required to have a certain number of math and reading minutes,

however, there is currently not a certain number of required science or social studies minutes (Interview #2).

Educators' Hesitation

The participants noted that other educators hesitate to implement integrative STEM because they do not even know where to start. They may not know what integrative STEM is or know what materials are needed. When one participant was asked to define what integrative STEM is, they noted that teachers would be very confused and likely would not know what that term means. Two participants noted that the other educators in the school do not feel confident to teach it because they have not had much experience in iSTEM or don't know where to find the resources to teach it. All four interviewees were asked if professional development on the topic of iSTEM, or even STEM education in general, has been given in their schools since it may be a relatively new concept for teachers, especially those who have been teaching before STEM education efforts have taken off. Each one said there has not been any professional development devoted to this topic.

This theme correlates with the existing literature. One study found that, as of 2013, only four percent of elementary school teachers felt prepared to teach engineering, but that STEM is important to teach for numerous reasons (Madden et al., 2016). Another study found that when special education faculty were put into a STEM-based elementary methods course, their self-efficacy, or belief that they would be able to, for teaching STEM and implementing it increased (Zimmer et al., 2018). The interviews and existing literature suggest that teachers would benefit from being taught how to integrate STEM into their classroom as many recognize its importance but are unsure of how to do it themselves.

Applying the Data

Based on the findings from the existing literature and the semi-structured interviews, all students would benefit from more integration of inclusive iSTEM lessons. Educators trying to implement integrative STEM should place students at the center of their lessons. As they are planning, teachers can develop a planning checklist and think through: would my students care about this topic outside of this classroom; are they actively demonstrating and constructing knowledge; does it go beyond rote memorization; and am I giving them step-by-step directions or giving them the open-endedness to figure out their own, unique solution?

Teachers can begin implementing iSTEM into their classrooms by building off activities they are already doing. When doing a read aloud, teachers could develop a design challenge where students can design a solution to a problem in the book. When engineering a solution to this challenge, ask students to think about the mathematical and scientific concepts involved in the design such as angles, velocity, or gravity.

In math, use the concepts being taught to create an engineering design challenge where students utilize these concepts. For example, if students are learning about right triangles, place two locations on perpendicular sides of a lake and ask students to design a prototype for a bridge that would diagonally connect the two locations. In this challenge, students would work in teams and would have to consider what length the bridge would need to be, consider ratios as they construct a smaller-scale bridge, decide what materials would be strong enough to hold cars and withstand severe weather, and engineer a prototype. Students could even practice pitching an idea to the class as a construction company may have to do a local governing board. Within this one activity that started from a math lesson on triangles, students are practicing multiple

mathematical and scientific concepts, social sciences as they consider local laws and boards, and social skills such as pitching an idea and collaborating with a team.

Using Universal Design for Learning (UDL), a framework to optimize learning for all students, will help to meet the unique needs of each student. The main idea of UDL is for there to be multiple means of engagement, representation, and expression (Durhman College, n.d.). In an integrative STEM activity, this could look like guided notes sheets for students with special educational needs to use as they research, plan, and evaluate their solutions. A task analysis which breaks an activity down into each of its individual tasks or a visual checklist could be provided to students who need some support staying on task and anticipating what comes next. Students who have fine motor impairments can sketch and create their design digitally. Through UDL, teachers can adapt an activity to meet each student's unique strengths and needs.

Another suggestion for teachers trying to implement inclusive integrative STEM into their classrooms is to seek professional development and resources. Each of the interviewees noted that the other teachers in their district do not feel confident in integrating STEM into their classroom, however, their districts have not provided professional development on the topic of integrative STEM despite seeing its success in the participants' classrooms. Madden et al. (2016) reported that a very small population of elementary teachers feel prepared to teach engineering, but that attitudes about content areas and confidence in their ability to teach a content area affect the amount and quality of instruction given in that area. Therefore, action should be taken to inform and engage practicing educators about what integrative STEM is and how to practically implement it into the classroom.

Educators can choose to gain knowledge and confidence in integrative STEM via colleges and universities that offer a minor or graduate degree in Integrative STEM Education Methods. Another great resource for growing in knowledge and skills in teaching STEM is local educational organizations. For example, the IU13, which is an education service agency that serves the public and non-public schools in Lancaster and Lebanon Counties, provides workshops, coaching, and professional development opportunities (IU13, 2023).

Another suggestion is for districts to implement professional development days that target this topic. Inviting a practicing iSTEM educator or professional to provide information to all teachers within a district may, at the least, help elementary educators understand what integrative STEM is and why it could benefit each of their unique learners. Districts should also ensure general education teachers are aware of how to best support their students with disabilities. Professional development on UDL, having high expectations for these learners, and ways to scaffold are a way to ensure teachers feel equipped to meet the needs of *all* learners.

In addition to continuing education and district-implemented professional development, resources have been created to help educators learn how to implement integrative STEM into an inclusive classroom. One of these resources is the *Zero Barriers in STEM Education Accessibility and Inclusion Workbook.* This workbook provides suggestions, such as station-based learning and collaborative groups, for teachers who are trying to implement STEM into a classroom with students with special educational needs (Smithsonian Science Education Center, 2020). A quick Google search will reveal numerous other resources for teachers. Current practicing iSTEM teachers are another option for teachers to grow in their knowledge about what integrative STEM is and how to implement it. In the semi-structured interviews, the participants

noted collaborating with other teachers and creating newsletters for the school to inform them of resources and activities that are available. Because of recognizing the positive effects they have seen iSTEM have on their students, they are willing to help other teachers do the same!

Conclusion

The goal of this thesis was to explore what integrative STEM is, how it can impact the knowledge and soft skills of all unique children, what its current role in elementary schools is, what barriers to its implementation exist, and how all elementary school teachers can implement it in their diverse classrooms. Through the literature review and semi-structured interviews, the answers to these questions are more thoroughly understood. Integrative STEM is a way to foster the knowledge and soft skills in students by integrating science, technology, engineering, and math with one another and other subject areas in order to solve a problem with an authentic context. The benefits for students are numerous. Students, both in the literature and in the classrooms of the participants, showed an increase in confidence, collaboration, communication, creativity, persistence, and problem-solving skills. The interviewees saw their students with special educational needs flourishing as they became more confident in their ability to advocate for themselves and talk with their peers.

An inclusive integrative STEM education model is a great way to build up and equip each unique learner for their future, but barriers still exist to true implementation. Teachers are unsure of what iSTEM is and doubt their abilities to teach it. They may not know where to find materials or where to learn about it. Students with special educational needs may get pulled out of iSTEM to receive other services despite the positive effects seen on the students who have used iSTEM. Educators looking to implement iSTEM must advocate for their students and seek

information on integrative STEM and its resources. Plans for accommodating and meeting each student where they are should be made, and a great place to begin integrating STEM is by examining where it can be built into existing lessons Place students in the center of learning and watch them flourish! Educators who have been implementing iSTEM should serve as a resource to those who do not know as much about integrative STEM. They can share what has and has not worked, the resources that have been helpful, and the gains seen in the students. Integrative STEM has shown to be a positive tool for all students of all abilities, and efforts should be made to overcome all the potential barriers.

Suggestions for future research would be to increase the sample size of the participants. Also, the population of the participants could be broadened to include non-Millersville graduates who have become knowledgeable about integrative STEM through ways other than the courses offered at Millersville University. Educators that are not knowledgeable about integrative STEM could be interviewed to learn more about what has kept them from implementing iSTEM and what their current understandings of it are. Despite these limitations, the positive effects of integrative STEM and common themes have been seen across the literature and four different elementary schools.

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Appendix A- Interview Questions

1. Please tell me about your educational background, classroom setting (Gen. Ed, Special Ed., separate STEM room), and classroom population.
2. What are some of the most prominent learning needs and strengths in your students?
3. What are some of the skills you are most focused on fostering in your students?
4. What are the teaching methods you have found to be effective and ineffective in your classroom? What activities are your students most engaged in?
5. Rank the subjects in the order of how much instructional time is spent on each. If this differs for your students with special educational needs, please clarify how instructional time differs for them. Are there areas you wish were more focused on?
6. How would you describe integrative STEM, and what is its role in your classroom?
7. If you use integrative STEM, what effects have you seen on your students' learning and soft skills development? If you have any students with special educational needs, please describe the effects you've specifically seen iSTEM have on them.
8. While integrative STEM's presence in elementary schools has been growing, there is still room for growth. What are some barriers you have encountered or noticed to implementing integrative STEM?
9. If you were to give suggestions to first-year teachers who are trying to implement iSTEM into an inclusive classroom (both general education and special education students), what would you share with them? What advice do you have for teaching integrative STEM?
10. Is there anything you'd like to share that we did not discuss?

Appendix B- Interview #1

Interviewer: I was wondering if you could share about your educational background, your classroom setting, and your classroom population.

#1: So, I actually also went to Millersville. I was a dual Early Childhood and Special Education major with the iSTEM minor. I am currently an elementary teacher. I am grades one through four computer science teacher. I teach thirty classes in two buildings in my school, so when I counted at the beginning of the year, I had 652 students.

Interviewer: Are those mainly students from general education classrooms or do you have a good mix?

#1: I have a pretty good mix. So, the way that my district does it is they kind of split up the special education students that are more severe; so, like one school has all the life skills, one school has all the autistic support, one school has all the emotional support. I'm at the two buildings that have emotional support and autism support.

Interviewer: Usually, would they come to your class with a general education classroom, or would they come separate?

#1: All of the emotional support come with their generally education peers. Autistic support I don't see except for the rare occasion that maybe one might come with a gen ed. class, but it's very rare.

Interviewer: Then what are some of your students most prominent learning needs and then also their most prominent strengths?

#1: A lot of their needs are mostly in reading, so they need a lot of support with like comprehension and just reading in general. They struggle a lot with like reading instructions or understanding like what they should be doing. Their strengths, they are very good at problem solving and communicating

Interviewer: Have you felt like those things have like grown from like starting the computer science class to now?

#1: Probably.

Interviewer: What are some of the skills that you are most focused on fostering in your classroom?

#1: I am most focused on critical thinking and computational thinking. That's part of like my curriculum. Also, like, growth mindset and communication and collaboration.

Interviewer: Are they usually working in teams within your classroom?

#1: Yeah, almost always.

Interviewer: How often do they see you?

#1: They see me once every six days, so throughout the school year, I see them 28 times.

Interviewer: What are the teaching methods that you found to be most effective and ineffective in your classroom?

#1: Most effective, it depends on the activity that we're doing. So, if we're doing, for example we do a lot of like puzzles and *code.org* to learn about coding and all that, for that my main strategy is like an I do, we do, you do. So, I will show them how the lesson works, we will do a few

puzzles together, and then they have time to work independently or amongst each other on a few puzzles. Another aspect is I do a lot of like hands-on STEM activities, and for that one I basically just give instructions and then like have them go at it. I really try to stay out of it. For those, I am just there to facilitate, like they are learning, they are doing their thing, and I am there in case anything goes wrong.

Interviewer: Do you feel like they usually like are able to kind of figure it out on their own then once you step back?

#1: Yeah.

Interviewer: What activities are they most engaged in?

#1: They are most engaged in those hands-on group projects, for sure.

Interviewer: Could you rank the subjects in the order of how much like instructional time is spent on them, and then, if you do notice a difference for students with special educational needs, how does that differ?

#1: Because my class is mostly just Computer Science, that is our main focus. I'd say a good 85% is on coding computational thinking and then like the 15% is within like the STEAM subjects. So, all of our projects that we do are heavily Computer Science based and then some of them will have like STEAM components to it.

Interviewer: And do you know at all, within the school, if there's like certain areas, like reading or like how that would compare to history or science or anything like that?

#1: I'm not sure. I know that we have spent most time in ELA and math.

Interviewer: Are there any areas that you wish were a little bit more focused on, either within your class that you had more room to do or within the school as a whole?

#1: I would say I wish for myself that I could focus more on STEAM than computer science, but that's just the curriculum that I'm given. I would also say within this school I wish that there were more science-based activities.

Interviewer: How would you describe integrative STEM and its role in your classroom?

#1: Because I don't really integrate STEM, my class is stem, I would say that I try my best within the Computer Science focus to really pull aspects of STEM in there. A lot of my computer science challenges will either focus on math, of like angles or measurement or I have them do like a basketball robot thing, or we focus on science and trajectory and all of that kind of stuff, so I really try to pull in the STEAM within the Computer Science. I also try to, because they like come to me, to integrate my projects with other things that they're doing in their classrooms. For example, we do a project with me and the music teacher. They do a project in music class and then they come to me, and we code the robot to play the xylophone. We do interdisciplinary connections. I pair with third grade and first grade as like an extension of their writing. They take their writing, and they code it in *Scratch Junior* for storytelling. Then in 3rd grade they do a project on habitats, and then we'll do it in *Scratch*. They have to code their habitat and like click on things for facts about their habitat.

Interviewer: What effects have you seen this class have on your students' learning and the development of like their soft skills?

#1: I would say I see them, because in my class I foster a lot of problem-solving, growth-mindset, they try other things in their classroom. They're more willing to not give up and push

through and all that. I think that that kind of helps with like the school culture. Then with them working collaboratively on almost all the projects, it really helps them with their communication and working together, teamwork, like all of that kind of stuff. That was really hard to relearn post pandemic, like we were so used to doing everything by themselves for a year or two that when we started doing those group projects again, I had to teach them how to communicate with each other again and like how to take turn.

Interviewer: With the students who come to you that are in emotional support, have you noticed any specific impacts or growth in them?

#1: I would say it depends on how they're feeling that day, yeah, usually if they make it to my room. For a lot of them, my space is like an escape so to speak. So, when they're in my room, I honestly rarely have behavior issues because they're just so focused on the activity and we're working with other people. It's like I rarely have problems because they're just so engaged in what we're doing. I'm assuming that you know this, but I also have, within the general kids that come, kids that receive learning support services.

Interviewer: Because I do have some focus on the special ed. piece within my thesis, would you say there's any specific impacts for them, like have you seen them picking up more skills or even just understanding of the content then within that room. Do you think it's any different than within a regular classroom?

#1: Yeah, so like I even see it within the two different realms, so like if they do receive learning support services and we are working on like puzzles and *code.org* where they need to read instructions and create algorithms and it's independent, they really struggle. They get very far behind because it's, again that reading piece, you need to comprehend what the instructions are

asking you to do before you can do it; whereas when we do the hands-on where I'm like, "Figure it out, you're on your own," they thrive.

Interviewer: You mentioned that sometimes the students are in emotional support don't get to your room some days. Is there a particular reason for that? Is it that it goes somewhere else?

#1: Yeah, so, if they are in the emotional support room and they are losing it, they won't come because they're still escalated. They'll come to me if they're like deescalated and ready to learn.

Interviewer: And are there any students who would be in the class that's coming but don't come because they go to like any other services or anything?

#1: They will always come to specials.

Interviewer: Awesome, that's great! So, there's definitely been a growth in integrative STEM's presence, but have you noticed any barriers with implementing it, even if you notice any teachers who aren't specifically Computer Science, if you've noticed them having any barriers or any questions that they come to you with?

#1: Yeah, I think there's just a hesitation, especially with more veteran teachers because it is such a new thing. Unless they are taking graduate classes on it or they took professional development training on it, they're just like scared to try it just because it is something new. Even just like for us, what would probably be like simple technology, for them it's like a whole new world. So, I think it's more of like the teachers' hesitation than it is the students.

Interviewer: And is there any like professional development or anything that happens within the school district to help them with implementing that?

#1: (shook head, signifying "no")

Interviewer: If you were to give suggestions to first year teachers who were trying to implement integrative STEM into an inclusive classroom, like with both general education and special education students, what would you share with them? What advice would you have for them?

#1: My advice would be to just try it. Even if it tanks, at least you tried it. For me personally, because I teach the same lesson six days in a row, my lesson on day one looks totally different than my lesson on day six because I've already worked through the kinks, and I figured it out. I am one where I will just try it. I get these crazy ideas in my head and I'm like, "I need to try it!" Half of them are awful, but I'm like at least I try.

Interviewer: Good advice! Then is there any anything else that you would like to share that we hadn't discussed?

#1: I don't think so.

Appendix C- Interview #2

Interviewer: Would you be able to tell me about your educational background, your classroom setting, and your classroom population?

#2: My bachelor's degree is in Early Childhood and Special Education with a minor in Integrative STEM Education, and I have a master's in teaching with a concentration in STEM Education. I have been teaching 5th grade classroom in a low-income, rural setting, and I primarily teach science, writing, and STEM to the fifth graders. They have other teachers for reading and math. Within my science classroom, I also have the luxury of having some of our learning support or intensive learning support students. For our intensive learning support students, they are only pushed out into my classroom. They are not pushed out for reading or math, so it is the main time with their peers.

Interviewer: You mentioned that you teach writing, science, and stem. Is that all within one period, or is it separate periods throughout the day?

#2: I have them in a five-day cycle, so I teach two days of writing, two days of science, and one day of STEM.

Interviewer: What are some of the most prominent learning needs and prominent learning strengths in your students?

#2: Some of the prominent learning needs for all of the students are collaboration, critical thinking, problem solving, and perseverance. They do really well with step-by-step, being told what to do. They like to please; they want to do well. With the challenges, that doesn't always translate with them. They are creative, but some of my special ed. Students, they also have some

like behavioral needs. With those needs comes the stronger support for when they are in collaborative groups and being able to compromise here or even communicate their own thoughts and needs, like feeling comfortable enough to communicate their own thoughts

Interviewer: As an educator, what are some of the skills that you're most focused on fostering in your classroom?

#2: So, within my classroom, ultimately fostering content mastery is not the number one piece. The number one thing, especially because I do get intensive learning support, behavioral friends in with my general students, ultimately, I try to make sure that they have clear and concise life skills that'll be able to help. Within my district, we have decided that there are skills that students need to be prepared for the world and that was discerned by talking to families and businesses within the community. Those things are being communicators, collaborators, global citizens, critical thinkers, continuous learners, and communicators. Ultimately, those are the things that I try to really focus on. I might not always be like, "Friends, today we're working on collaboration," but I try to be really cognizant of keeping those in the forefront because no matter where my students choose to go in their lives from my classroom, those pillars are real and will help set them up as a result.

Interviewer: What are the teaching methods that you found to be most effective and ineffective within your classroom?

#2: So, in ineffective, always telling them exactly what to do, when to do it, how to do it because, one, it doesn't always happen, but two, that's what they've done for four years before they come to us. So, what I find being more effective is I give them like parameters or guidelines and then let them try to start figuring out some of the parts for themselves. Sometimes it's

uncomfortable for them and sometimes it's even uncomfortable for me because sometimes they're working on something, whether it's been a group work or they're working on an assignment, and like you're at the tipping point of, "OK, is this going to get it they're going to have that light bulb moment or is this all going to come crashing down, and then we have to rebuild." So, it's definitely a little daunting. They want structure but not every second of their day planned and decided for them.

Interviewer: Was that something that they like initially seemed really uncomfortable with, and then have they adjusted and become more comfortable with it?

#2: Yes, after a month or so. They're just now finally starting to not question every single thing and not like be opposed to every single thing, like they were astounded. They were never allowed to even pick partners because they've always had done for them, so, you know, the beginning, there were some arguments because there always be like a few students that wouldn't get picked or people would always pick their best friends, but then they want to get their stuff done. It's been a learning curve for them to be able to have that freedom and learn from it. I say typically the first like six to eight weeks of school is more difficult for them, and then once they realize that I'm not going to tell them everything, but it's going to be okay, and they're going to be fine, and they understand that I've got them I'm going to keep them safe, like things might get uncomfortable sometimes, but it's not going to go to a point that too much. The Zone of Proximal Development, like that zone of what is going to push them to grow but not be detrimental in either direction.

Interviewer: What activities are they most engaged in?

#2: They love science and STEM, and they don't consistently get science until fourth grade unfortunately. They are obsessed, but even when they came at beginning of the year and I said, "Yep, every day two and three we will do science and every day one we will do STEM," and they thought I was joking, like they thought other schedule things would come up and I would change it. They love being able to explore the STEM areas and learn about the world around them and create things.

Interviewer: Do you know why they don't really get it consistently until 4th grade?

#2: Yeah, in college, you know, they teach you, when you're creating lesson plans and stuff, oh you have the standards, but realistically when you go to work for a school district, that isn't always the priority. So, we have science kits and teachers are encouraged to use them, but the school district doesn't structure teachers time in a way that encourages science. So, there are building schedules, you know, they have huge chunks for math, a huge chunk for reading, and then the last 30 minutes of the day for the K-3 schedule is it's 30 minutes that says "writing, social studies, science." And when you talk to teachers and when you look at teachers' lesson plans, those 30 minutes is almost always catch-up, like they didn't finish something else earlier today, for whatever reason, and then they make it up then. But then even you know you can't even blame it 100% on the teachers because there's not accountability from administration. Now, I will say l with the positions that I am lucky enough to hold within our district, in addition to a classroom teacher, I know that that's going to change because Pennsylvania did adopt the science standards, and I know that our upper administration is very aware now, they were not, but now they are about K-3 for science. So, I know that that's going to shift, but again, that's very

uncomfortable for people because we have some teachers that their extent of teaching science is like watching a *Magic School Bus* video or growing plants for Mother's Day.

Interviewer: Does science start being assessed on the PSSAs in 4th grade?

#2: It is. So, the way our school district works is fourth and fifth grade are departmentalized, so we're still in elementary school, but students switch between teachers throughout the day and part of that was because the PSSA's do start in fourth grade. They will not be staying in fourth grade though; they are going to be moving to fifth grade.

Interviewer: Have they been doing alright on the science PSSA's without receiving the K-3 instruction?

#2: Yeah. So, they do better on the science than they do on all of the other math or reading PSSA. On average, their scores for the buildings are like in the mid to high seventies and in the last year now, their average was a 78 on the science, which is which is pretty good. When you look at the example questions from the current PSSA the science part of it of is currently very much a reading assessment. It's very much like when you read the questions, if you have a logical thought process, it is very simple, without ever learning content to figure out, using process of elimination which answer it's not. So, with them, like they score well, but they don't really know the material. Whenever a fourth-grade science teacher in the Spring, she really digs in and tries to review stuff with the kids she's like, "Yeah, they don't know it and they don't retain it very well after I teach it and then they score well interesting." The one thing that they've been saying is like with the new state standards, you're no longer going to be able to teach science through reading. What people have been doing is like, "Oh, in reading class today we're going to focus on main ideas details but we're going to read about this desert or we're going to

read about the water cycle." But even still, like that's like logical process stuff. I remember looking at the fourth-grade sample questions, and I'm like, "Yeah, clearly the picture depicts a water word and out of four of the options only one of them include the water, like clearly it's that one." From the conversations I've had with people in PDE, the test is going to change dramatically, and it's going to be much more content based than really just a reading test.

Interviewer: And they are shifting from 4th to 5th grade for that, right?

#2: Yes.

Interviewer: So, you said that they spend most of their day on reading and math?

#2: Yeah, in K-3 classrooms, I think it's like an 80-minute reading block and a 75-minute math block, and the rest is very small. So, one thing I didn't know about that, because I brought that up as a question, the state of Pennsylvania requires school districts to submit schedules to the state. When they submit those schedules, they have to have a certain amount of math and reading minutes on them but not science or social studies minutes which is interesting to me because you also have a science PSSA, but you're not requiring that. I'm curious if that would shift as well when these standards drop, and schools are actually responsible for them in the next two or three years.

Interviewer: How would you describe integrative stem, and what is its role in your classroom?

#2: So, STEM means a lot of different things to a lot of different people, and to me, the definition of STEM that I've built over the years is ultimately, when I'm teaching it with fifth graders, we're using science and math concepts to engineer a technology that's going to solve a problem. So, we're actually able science and math standard, per say, to create and build

something that is a technology that's going to solve the problem because technology does not have to be an electrical item or coded item; it can be something else. So, integrative STEM to me is when I'm teaching science or writing, I try to include and like kind of frame things through a STEM light, per say. I teach the engineering design process, like within other areas of my classroom while we're working through stuff, and I compare it to that. Even when we're doing writing assignments, I like to compare it to that iterative framework and trying to encourage them within my own classroom and within my coworkers in school as well to make it so it's not like, "Oh STEM can only be when we do a 30-minute activity on a Fun Friday."

Interviewer: What effects have you seen on your students learning and their soft skill development?

#2: So, they're learning the soft skills that then impact their learning in other areas. Through integrative STEM, they become stronger problem solvers. So, ultimately yes that helps them in our design challenges, but then when we're doing other stuff, like we're doing writing, they're problem-solving, they're researching for a natural disaster, right. Their problem-solving to find information is so much stronger. They're not like, "Google doesn't just tell me the answer in a little summary box at the top," but they find things better. In the same boat, things like communication, like they learn how to communicate, collaborate, and compromise. Oh yeah, compromise. They did not know how to compromise. We're learning how to compromise in our science or integrative STEM stuff, and then that's transitioning into when they're working in other classes, or when they're having a disagreement with a friend, like being able to use those skills. I would say with the soft skills are impacting their content knowledge and their other interactions as well.

Interviewer: Have there been any things that you've specifically noticed with your students who have some special needs?

#2: Oh yeah, for sure. So, one of the biggest things that has benefited and impacted my kids with special educational needs is like communicating and collaborating with their peers from the sense that they feel confident enough to collaborate and communicate, but also for their neurotypical peers to actually hear them and value what they have to say. My classroom is the only class that they really get a lot of that interaction, especially with those have more than just like a simple learning disability; they get that exposure and that practice within that classroom. I would also say problem-solving skills and confidence. I talk to their special education teachers regularly, and they're like the kiddos' confidence, like in themselves and what they are thinking or doing absolutely can be right and it's valued. Confidence is so incredibly undervalued of a skill and in society itself, let alone with her kiddos that have special education. Not even just kiddos that have special education rules, but when you think about the typical power struggles in society between introverts and extroverts, like we just, as a society, see introverts as less than, and when you think of a lot of our special education kiddos, especially the female special education kiddos, they are almost always introverts. For them, it's not because they're quiet or they don't have any idea; it's because that's just not how they share their thoughts. My favorite is when note booking because they will draw or write whatever in their notebooks, and then when I come around to groups and say, "Wow, Chloe, that's a really great idea. Look at her really great idea here," and like that aspect too just allows for them to share in a way that is meaningful to them but allows like me to kind of use it as a catalyst to get their group kind of going.

Interviewer: While integrated STEM's presence has been growing, there's definitely still room for growth. What are some of the barriers that you've either encountered yourself or noticed in other classrooms in implementing it?

#2: So, last year we did some coding items that were graded level programs for all the grades, and then within that my fifth graders learned all the coding items and then we aligned times to go into these teachers' classrooms with their students and teach them how to code. While we were doing that, the main purpose was, one, teachers don't feel confident in STEM and they don't feel like they have the time for STEM, so that was like the main two for me like going in and helping with this coding because I got to teach the teacher right along with the students how to use this stuff. Then while I was in there, I got to talk to the teachers more because I don't get a lot of opportunity to talk to like the kindergarten and first grade teachers because our schedules don't align that we have the same planning period time. I'm like, "Hey, pre-COVID, you guys used to do stuff on your no special day every week, so like every week they had a 40-minute chunk where the kids didn't have gym or music and they would do STEM. I noticed that it's not happening anymore." And they're like, "We just don't have the materials and we don't know where to get the materials from," because we public education has such a thing about money or lack thereof, and they just don't know where to get items from, or they don't know like reputable things to do. There were multiple teachers I talked to that were like, "Yes, I understand that. I can't just have the kids build a tower every time. That's not STEM every time. But when I go to Pinterest, it all looks pretty, but what is actually beneficial for me?" So, I would say, again, the main things would be time, confidence, knowing where to get items, and knowing where to get activities. So, I've been working with my principal to try to bridge some of those things and fill some of those points for teachers because when I told him about those things like he was like,

"Oh, that's why they're not doing it," and I was like, "Yeah, they want to go back to doing it on their no special day, but they just don't have lessons and they don't have the time to plan more STEM, like they don't know STEM, so planning those lessons feels very cumbersome to them. And then they need materials." So, working on solving that problem, but those have been the main things. I just sent out a monthly STEM newsletter yesterday to teachers to send to families, and it literally has a book connection, a career spotlight, a STEM activity, and then a suggested STEM item that maybe they could buy or borrow from our library for their family. The teachers were like, "Wow, this is so nice. This is so easy for families to do if they want to do them at home," and the teachers are super excited about it. From what I've gathered, it's not that they don't want to do it because they do love it; they just don't know how, and they don't know what the stuff to use is.

Interviewer: Have the principal and district, since becoming aware of the lack of materials and stuff, have they helped provide some of that?

#2: Yeah, so it was funny. I told him this, and he goes, "Oh, well our PTO has a part of their budget set aside to buy STEM materials for teachers." I was like, "That's news to all of them, like none of them know about that money. How do they go about requesting items?" So, I was like, "We need to tell teachers that, like we need to tell them how much it is and how they go about getting those items." The same with like I didn't realize that like my principal has a budget that he's supposed to spend, like he gets a budget from school district and a certain percentage of that you know it's supposed to be spent on staff stuff it's supposed to be sent on spent on like other stuff. We didn't realize that we had this money, so November 8th is National STEM Day. I went to him and I was like, "I want to do a National STEM Day K-5. We're all doing STEM. I

want to do a book debrief, I want to do a building challenge, I'll do coding. I can write up my request for money from PTO, and I show them the breakdown." He goes, "No we got it. We'll just buy all the stuff and use PTO as manpower to l help distribute items, but we got it." And it's like multiple thousands. But that's just it, like we as teachers are out that information and it's uncomfortable to ask for money because in public education, you think we have none, but that's not always the case. I've also been encouraging teachers to use things like Donors Choose where they can go on, and they can request items from big-name companies like Kleenex and the Bill Gates Foundation and Dick's Sporting Goods that donate to teachers' stuff specifically. I've been trying to encourage them to be more comfortable with seeking out their own sources of funding as well too, you know, they don't have to always rely on the district.

Interviewer: If you were to give suggestions to first year teachers who are trying to implement integrative stem into an inclusive classroom, what would you share with them, like what advice would you have?

#2: It depends on the type of teacher, so I'm going to say this with two prongs. The overall thing is you just need to do it, regardless of where you are, what kids you work with, what your situation is; you just need to do it. The two prongs of that being if you feel confident enough in your STEM knowledge and in yourself to be able to request from your administration that you have dedicated time to do that because I can almost guarantee it's not being scheduled and it's not going to be on your scope and sequence of what you're supposed to teach. Ask, even if it's like, "Oh, can I have every Friday or every first Friday of the month to do integrative STEM?" Ask for it. If you're too afraid to ask for it, just do it in the age-old adage of "ask for forgiveness" because when they see it or if they know about it, and they come in and see how engaged your

kids are, and they see regular ed. and special ed. together, and they see how excited they are, and they see that they're not just building the tallest tower out index cards, like they're doing stuff that integrates their science and math and technology, which is also huge part of the new state standards for science, they'll find a way to make that work. So, I just kind of started doing it, and then I kind of just like wrote a grant. I was like, "Hey, I got all these materials. I want to do this every day one." And he goes, "Sounds good," and he just came in, he saw it, and he trusted me. Especially if you are going to have that iSTEM endorsement, you are the expert, like you really are the expert, and that was one of the biggest things I had to accept when I was in college and when I was a brand-new teacher, like I am the expert. I have degrees that have STEM stuff, and other people that I work with, nobody else does, so I have to be confident enough to comfortable enough to try it and work through this.

Interviewer: Is there anything else you'd like to share that we haven't talked about already?

#2: The one thing I would like to share is that I had to advocate to keep my intensive learning support kids when I was doing science and STEM.

Interviewer: Where did they want them to go?

#2: They wanted them to go to their pull-out special education classroom. They did not want them to push in with general education, and not the teacher. Their teacher wanted them to push in. Their teacher believed that it was beneficial, but luckily, I advocated for them, so I have them. I know, even when science does happen in the younger grades, a lot of times, learning support, behavior, and intensive learning support kids are not getting that science or STEM instruction and exposure. Most of it is because the teachers don't feel confident, but that would just be my

one thing I'd like to add is that I had to advocate for these kids, and it's not always easy, like it is hard and it can make it more challenging, but the benefit that those kids get is well worth it.

Interviewer: Did it take a lot of advocating, or were they pretty receptive to it pretty quickly?

#2: Upper administration was kind of like, "Yeah, you can do it if you want" because they thought that I would do it and then I would want to not keep them, like they thought that it would go horribly and that I wanted to send them back. So, from that, they didn't really push back too much, but then when they found out later that I was still doing it, they were like, "Oh, well like how's that even going?" So, they didn't push back too much then but the counterpoint to that is they're not appreciating or pushing for any of the kids in special ed. who are pulled out to get pushed back into any of the other grades. It's not like they took what was happening in my circumstance and thought they should encourage and have our special education students be pushed in for science stuff. It's not like they use that as a learning experience which is what I was hoping for. As I told you in the beginning, I have the general and special ed. degrees, so I feel much more comfortable and confident with our special ed., but for teachers that don't, they just would rather not. They just see this more of a challenge for them.

Interviewer: Have you heard from the parents of those kids at all about anything they've seen in their children?

#2: The parents of the kids that are with me, they are just obsessed. When I send them messages about stuff that we do or pictures where there's things they are working on that day, they are obsessed. I don't really hear anything from the younger grades; all I hear is like when I get a kid who for multiple years has been missing out on science and STEM, and I get them and I get to

talk to their grown-up, they're like, "Oh my gosh, Jake loves this so much. I wish he got this when he was younger!"

Interviewer: So, most of your students with special educational needs, this is like really the first time that they've had STEM instruction?

#2: Yes, it is, absolutely, yes.

Appendix D- Interview #3

Interviewer: Could you tell me about your educational background, so any degrees or certifications, your classroom setting, and your classroom population?

#3: I graduated my Early and Special Education certification in December of 2019. I also went through the iSTEM program when they first started it, so I was one of the first group of people going through it. I went through, but I didn't get certified in STEM, but I always knew I wanted to eventually be a STEM teacher. I started off as a general education teacher for two years and did special ed. in the summers for the extended school year. Then, this is my second year now with STEM.

Interviewer: And what grades do you teach?

#3: I teach kindergarten through sixth grade, but in my elementary schools we have all the 6th graders, so I teach all those.

Interviewer: Are most of the students that you have general education, or do you have some that would have special educational needs?

#3: So, I have all general ed. I do have at my one elementary school, so I go back and forth between three, they have, it's called adaptive specials, so, I have life skills and autistic support students in my room.

Interviewer: The next question is: what are some of the most prominent learning needs and learning strengths in your students?

#3: So, we learn problem-solving skills, which is slowly becoming a strength but it's still a need. These students have a hard time trying to problem solve on their own without having an exact

answer, so that's definitely a need that we're trying to work on. Strengths- they are very creative, they love hands-on, they love to figure things out, and try to solve problems that way. Anyway, so that's why I'm like, "They're slowly getting to the point I where I see them becoming better with it," but they love the hands-on part of STEM and just making mistakes and failing and learning as to, "OK, why did that happen?"

Interviewer: I know you mentioned problem-solving, but are there any other skills that you're most focused on fostering within your classroom?

#3: We look at the engineering design process a lot. That's like my main thing with them, so pretty much in kindergarten like just getting used to what STEM is, and slowly in first grade and all the way up throughout with like learning what it is, how we use it and, again how yeah, we use it with problem-solving and everyday life as well. We really focus on that as well as group work and teamwork because we have sometimes 20 or more students, so we have partnerships, we work in groups, so learning how to work together, learning how to collaborate well. That's also part of the struggle sometimes too. Some kids have a hard time communicating how they feel without showing emotions about it, so learning that too.

Interviewer: What are the teaching methods you have found to be most effective and ineffective?

#3: So, I only have my students 40 minutes. I see them once every 6 days, so when I'm with them, we like we get started. So, at the beginning of the year, I do a lot of talking to them. "OK, let's talk about this." We'll collaborate on things and then getting more towards like student-based, or like, "Here's your problem, here's what you need to do your criteria, go solve it," kind of step back and let them explore. So, when I step back, it could be good or bad depending again on the grade, on the student because some kids need more redirection and more direction on

where to go, and other kids just if I let them go, they're fine they can figure it out on their own. So, just adapting to the student need as well as the grade as to what they need from me- that's what I've been doing mostly.

Interviewer: Within the school as a whole, could you rank the subjects in the order of how much instructional time is spent on each, and then if that differs for the students in the district who have special educational needs, how would that instructional time differ for them?

#3: So, I'm a specialist, so they come to me for STEM, so I focus mainly just on STEM things. So, a lot of it, again, it's just the engineering side of it and then it also incorporates all different parts of it. We always talk about what it is; I show them how is STEM integrated into this. So in engineering, how is there math in this, how is their STEAM? And then as a district. what I've been seeing a lot is the kids have a pretty big ELA block and math block. The shortest amount of time they spend on something is science and social studies, especially science. So now with the STEELS standards getting pushed out, trying to become more integrated with science in the regular classroom, but that's becoming and is still an issue because there's just not a lot of time. Usually, schools have like 30 minutes to do science, so it's not a big push.

Interviewer: I know you said within the one building, you have some students with special needs come to you, but is that usual within your building?

#3: Yeah, so my school district is tiny, so we have two elementary schools, and we have like a junior senior high combined. So, for me, I bounce back and forth, so I'm at one school for three days, one school for the other three days, and at the one school they have life skills and autistic support just at that school. So that's why I have them just at that one school. At the others, they're not there. But I have a lot of learning support like IEPS and that too, so a lot of things I

have to adapt and work with them. I have students that are ESL, so making sure they're able to it to. I have like worksheets or something that they are able to read it and understand, so stuff like that too.

Interviewer: You said you have some like unique individualized supports for the students. Could you mention what those were again?

#3: Yeah, so I don't do worksheets as much, but I have packets that the kids use to like to put their information when they do the engineering design process. It kind of breaks everything down, to their planning stage, their drawing, their brainstorming, all that stuff, so it's just kind of like I'll adapt based on need. So, I'll make sure it's not as much writing, I'll make sure when we go through it, I have it on my board, I'm walking through it. I walk around on to make sure they understand, like I'll check in with my groups, like, "Do we have questions? What are we confused about?" stuff like that. My older kids will do notes on things, so I'll have like adaptions, like I might have a couple of words that are missing to fill in or it's totally blank, depends on the student.

Interviewer: How would you describe integrative STEM, like how would you define it, and then what would its role be in your classroom?

#3: So, when I went through college, I always thought integrative STEM was integrating STEM in your normal classroom, like general ed, how can you incorporate it in ELA, how can you incorporate STEM and social studies? And, so, when I was general ed., I found myself doing that and making sure I have like STEM stuff, and the kids love it. Even if they had like free time or we do like Daily Five, I'd have something to do with STEM, but now, I'm just solely focusing on STEM, so it's like my whole thing. So, I feel like everything is just integrated because that's what

I focus on, but I also allow myself, like I've helped the other teachers, as well if they want an extra STEM or they're like, "Hey, I want to do this in class like with our CLPA unit, like what can I do?" So, I also am able to collaborate and help them like integrate it more into the classroom too because I know how much the kids love it and how else can you do it for this certain reading topic? They might hate it, but it might make it a little better because it's more geared toward STEM.

Interviewer: So, using integrative STEM, what effects have you seen on your students' learning and also their soft skills development?

#3: So, as a district with them, I've seen a lot of the kids becoming more confident in trying new things and challenging themselves, like I said you still have some kids that are afraid to make mistakes, afraid to fail, they always want to do well, but even then like they slowly come out of their shell and they're like, "You know, this might seem silly, but let's just try it and see what happens," and so I see that a lot. They're willing to take risks, they're willing to try because sometimes the kids are just like, "Yeah I don't want to do it, but like let's just try it," so that's really cool.

Interviewer: And then for the students who are learning support kiddos or in your adaptive class, are there any effects that you've noticed in them?

#3: So, with my adaptive class, it's kind of a combo. I do more like follow direction because they need more, "Oh, put this here, place that here, let's build this, follow the instructions," and sometimes with my other students, it's a combo, I have younger/older kids, so sometimes it's like, "Here's this, figure it out," so it kind of, I do different things every time I see them and I just kind of see what they can and can't do because if they have certain goals that we're working on in

the classrooms, I always tell their teachers, "Whatever you're working on, I'll add that into the curriculum." But my autistic support kids, they have a harder time being more creative with things, so I usually like I said, do more with them like, "Let's make this, let's follow directions, follow me, do what I do," because they like to copy what we do. With my life skills kiddos, they're able to kind of be more creative, and if I say, "Well, here are some materials, let's build this out of it," but it could be all different types of things, so they're able to pick and choose what they like. And my autistic support kids can too, it's just more they need more one-on-one help with it and they have paras with them that do help them.

Interviewer: Awesome. Have you noticed any areas of growth in the students from when they before they came to your class to now?

#3: Probably, like kind of using their voice in a way, like saying, because there are some things I call it "Tinker Time" like I have different like tinker toys to build things, so I'll be like, "What do you want?" like something that, I used to just give it to them, and then they started finding things they really enjoyed, so they have more chance of like using their device. They tell me, "I want this," or point to it or they'll like reach for something when they want that, so they have more of a voice that I've noticed.

Interviewer: So, while integrative STEM's presence in elementary schools has been growing, there's definitely still some room for growth. What are some of the barriers that you've encountered or noticed to implementing integrative STEM?

#3: So, for me personally, so that's still a really new thing, which I'm hoping these STEELS standards kind of help that, especially other districts that don't have STEM, but there's no set curriculum. There are standards, but you can take those standards in so many different directions.

I don't know if you've seen the STEELS standards, but I feel like they're more geared towards teachers to help them plan, so I'm hoping that this will be a step in the right direction with helping teachers like, "OK, here's science, how can I incorporate into ELA or social studies and allow it to have it more in the classroom?" But definitely not having a curriculum, like if you're a specialist for music or gym, you have certain things that kids need to work on, but it's a good and bad thing. You kind of have more of an open field in a way, right you can choose what you want, but then I feel like some kids might not get as much of one thing or another depending on the teacher.

Interviewer: Would you say that like a lot of teachers who haven't gone through the minor or something, do you think that they don't know like how to integrate it, like without the curriculum?

#3: Without the curriculum and what I've seen in my experience, like I said, science is not a big thing, and I don't really have a lot of teachers I know that would like to teach science like when I was a general education teacher and was like, "Oh, I love science!" They were like, "You could do science, like you can focus it, you tell us what to do," like it wasn't a big thing back then. Right now, I feel like younger teachers are more incorporating STEM because they know about STEM and learned it, but it's still yeah. I feel like, just kind of like a special ed., like if you have a special ed. background, you kind of have like additional help with understanding it and how to accommodate and modify things for them, which you still can as a general ed. teacher, but you have more in-depth understanding with a special ed. background. Same with STEM or science. If you don't really have that background or understand it, it makes a little bit harder, but I feel like incorporating or even learning about it a little bit would be beneficial.

Interviewer: If you were to give suggestions to first year teachers, or even like veteran teachers, who are trying to implement integrative STEM into an inclusive classroom, what would you share with them?

#3: I think STEM is a big area, so focusing on exactly what do they want their kids to accomplish or learn from this, what is it that they're trying to focus on because there's a lot of stuff, like science, there's so many things out there for science and technology, but it's like how do you find that equilibrium between all of them and adding that into the classroom? I think just finding those goals, like what do you want them to accomplish, because that will get them to the right place, and if you're just like, "Let's do STEM!" it's just like, "Well, where do you start?"

Interviewer: Is there anything else that we did not previously discuss that you'd like to add or share?

#3: I don't think so.

Appendix E- Interview #4

Interviewer: Could you please tell me about your educational background, your classroom setting, and then your classroom population?

#4: So, my education background is I went to Millersville. I was an Early Childhood degree with a STEM endorsement. Right now, I'm at [school name] Charter School, and so we serve a lot of the downtown [town name] and [town name] school districts, so we have a very wide range of diverse needs and everything like that. We're, I think, like the top charter school, top diversity charter school.

Interviewer: And by diverse, are you talking more like racial/ethnic background or ability levels?

#4: Both. We have a very big autistic support program and like learning support as well.

Interviewer: Then, what is your role in the school?

#4: So, I'm a K-2 STEM teacher. They come like come to my classroom like for 40 minutes at a time, twice a cycle which is a six-day cycle, so every like three days or so.

Interviewer: And are any of those students in autistic support?

#4: Yeah, they're all coming in with the general education classes.

Interviewer: So, what are some of the most prominent learning needs and learning strengths within your students?

#4: So, one of the needs for my students is that we need to stay focused because like sometimes a friend might disrupt another friend, or an A.S. friend decides to like rip out a toy or start playing with materials. Most times, I'm flexible about that because we can't control that or sometimes,

we have to evacuate the classroom, which is not fun, but it's necessary to make sure everyone safe. Sometimes, it's just frustrating when they like don't want to the activities that I have planned for them and they're like, "I want to do this instead."

Interviewer: And then what about some of their strengths?

#4: My population is very good at computer science, like working on coding and being able to like do step by step instructions because like sometimes their brains work like that, and they're like, "Oh, I actually understand like if I do that, it this does this then I can do this," or something like that like first-then.

Interviewer: So, it seems like they have some reasoning skills. With the computer science, was that like before they started coming to your classroom that they like pretty strong in that?

#4: I don't really know because I have the kindergarteners like first-off, never came to the school before, but some of them come to me with good problem solving.

Interviewer: That's great! So, what are some of the skills that you're most fostered focused on fostering in your students?

#4: Some of the big things that I want to foster in them is creativity, like being able to see the problem and come up like solution in their brain, like be able to draw it out, talk about it with their friends. I work a lot with collaboration in my room; that's a big component towards like including everyone. Then, they come up with solutions and then like they even get to test those solutions.

Interviewer: It's almost like going through the engineering design process.

#4: Yeah, a lot of my A.S. friends actually do go through that process too, like it's a little modified but like that's expected.

Interviewer: What are we teaching methods that you found to be very effective and ineffective in your classroom?

#4: Things that's really effective for my room is doing small group activities, so I can like, because most classrooms have like an instructional assistant with them, so they're able to like work with us like us. I can work with a group, and they can work with a group, and then like the other ones work independently or like switch halfway through, just being able to be flexible. I've found that whole group instruction has not really worked with it.

Interviewer: With the instructional aides, is that just like in most classrooms or like within small groups?

#4: We have instructional aides with kindergarten, first, and then I co-teach with my second grade other STEM teacher. We work together on like lessons and we're able to divide the class in half so we can monitor the behaviors and like make sure they're focused on the activities.

Interviewer: Then what's been ineffective?

#4: Definitely large group. Teaching large group in kindergarten is definitely not the way to do it, and most of the other grades are like, you can't like just expect them to be sitting that long. Just being able to do hands-on activities with them, that's definitely what we need.

Interviewer: And then what are some of the activities that they're most engaged in?

#4: Definitely like the building. They love just being able to use any of the materials in my room, just to build whatever they want yeah. That's actually what they did today while I was off. I got a

text saying, "Oh, this person loved to be able to build whatever they want." I'm like, "Great, that's exactly what I want!" Just like this, "Go build just make sure you clean up before you leave."

Interviewer: Could you rank the subjects in order of how much instructional time is spent on each, so that could even be like within your classroom what would you spend the most time on, but then within your school in general as well?

#4: So, my classroom really just focuses on STEM, so like that was #1 put in my room. but I do bring in English Language Arts. For like the literature, bringing design briefs from there. We do math, sometimes like bringing like numbers, like counting spots and stuff like that when we're coding. We bring in history, using a STEM person of the day, so just being able to expose them to different people throughout the history of STEM and technology and stuff like that.

Interviewer: You said the design briefs are sometimes based off ELA as well, so is that like based off books?

#4: So I read a story and then explain something like, "Oh, we didn't get the finish, there's a challenge part of it!" We read *How to Catch a Leprechaun*, so I read the story and was like, "Oh my gosh, he's coming next year! We have to try to catch him!" and that was like the biggest thing for kindergarten last year, like we got to catch it.

Interviewer: Yeah, I did that for my children's engineering class, like the for the STEM Bowl lesson plan as well. Then, within your district, what's like the order of how much time is spent on each subject?

#4: So, I think we have like about an hour and a half or more and about the same for math. So mine is like a special area class, so they come like twice a cycle, so I only got like 40 minutes twice, so every so if it's say one day 4/2, so like 80 minutes a week.

Interviewer: Is there like any science instruction that would be happening in their classroom?

#4: I think it's only like 30 minutes. They finally just implemented that again this year, so it was not taught before in the classrooms, like Wolfgang would not be happy, like I told him that he's like, "What." Social studies is really not taught much either because they say they integrate in, which is not correct it's like very interesting, yeah like, I'm surprised that like they get away with that.

Interviewer: With the students who have special educational needs, does that differ at all, like would there be even less time on certain things?

#4: Sometimes, a lot of our special ed. kids, they do get pulled during my class for like special services and stuff like that, which gets on my nerves a lot because like I would rather them, because that's their strengths, so I'd rather them not get pulled out of. But they were like, "We need to, that's the only time we can pull." The other thing is, too, like we're pulling out the card that PSSAs are going to be assessing STEM though, so like if we want them to actually pass these PSSAs, then you can't pull them.

Interviewer: So, is that like a lot of times that they're getting pulled from your class?

#4: Most, like one kid gets pulled every single STEM for like ELA extra support. I'm like, "No, like this is not going to benefit him. He needs a break and like recharge."

Interviewer: How would you describe integrative STEM and its role in your classroom?

#4: I just like I feel like that's like a natural thing for my classroom, but like I definitely see it sometimes, like when they do their science lessons, they can actually bring that knowledge in from like their science lesson and bring it to my room, like, "Hey, we learned about this today!" I was like, "OK great, let's dive a little deeper."

Interviewer: And then if you're like defining it to a teacher who's not their specialist teacher, like they're regular, but how would you define it for them?

#4: They would be so confused. The thing is like a lot of my colleagues they love STEM, they love that we have it here, but they don't understand it. I tried to explain it many, many times and they were like, "What are you talking about?" STEM is everywhere. We can integrate it, like even in a PE lesson like talk about the bone structure, like bones and stuff like that, like running and stuff like that they don't realize those natural connections between like the different subject areas.

Interviewer: So, if you use integrative STEM, which obviously you do, what effects have you seen on your students' learning and their soft skills development?

#4: They're flourishing, like just being able to like to come up, because we're doing airplanes right now in our first-grade class, and I'm able to see like them like at first like, "I'm not sure, I'm not sure how to do it." I'm like, "OK, that's why we're going to practice these skills, like practice makes progress." By the end of this unit, I have like 24 unique airplanes that they designed, and they are very proud, their ownership of it and stuff like that. I emphasize a lot of ownership with these kids because I make sure that I'm like, "This is your design, this is not my design. You could take some of my ideas, you could take some of your other friends', like I want you to be yourself."

Interviewer: And then using it for your A.S. kiddos have you noticed any specific growth areas?

#4: Some of my friends they pick up like things very quickly, like if I like sit one-on-one with them, I'm like, "OK, we're going on this skill today" and like after the first two times with me, they're able to do it independently. But like sometimes there's behaviors and they like act up because that's natural for them, and the I.A. jumps in and is like, "OK, let's redirect," and go with break. But they definitely pick up things a lot slower, but that's completely okay because that's how their brain works.

Interviewer: Have you noticed any like collaboration growth or communication growth or anything?

#4: Yeah, like I had one little boy. He was working with me and he never, like he didn't talk at all, and then once he started like working with the others as a group, he was able to express his ideas that he had because he was shy and thought his ideas weren't good. Now, he won't start talking about his ideas and like even after, I'm like, "Clean up," to the group, he just kept telling me ideas.

Interviewer: Alright, so obviously there's still room for growth with integrating STEM into elementary schools. What are some of these like barriers that you've noticed to schools implementing integrative STEM?

#4: The lack of materials and experience because I feel like they say, "Oh let's implement this STEM lesson," and it's just like glorified science. Like what Wolfgang says, you need to make sure you integrate effectively, not like just for the fun experience for the kids.

Interviewer: Do you feel like most teachers would even like know how to implement integrative stem?

#4: Most of my teachers do not, but the thing is, I'm able to like support them and that kind of thing, and be like, "Hey, like why don't we just try this lesson instead of this one?" like just give them a little feedback.

Interviewer: Is there any like professional development or anything that's like helping them learn?

#4: Not really, which I feel like that should be a big thing that we should do. That's what they're pretty much talking about at this conference, like they're like saying that like we need more teachers that embrace the STEM fields, and then you need to put more professional development for it.

Interviewer: So, if you were to give suggestions to first year teachers who are trying to implement integrative STEM into an inclusive classroom, and I think not just like a specific STEM teacher, what piece of advice would you share with them?

#4: Be flexible with it because you might have the perfect lesson, and you think it's going last 40 minutes because that's what you have, but it's not going to last that long. Be flexible. I feel like a lot of times, teachers like to go say, "Oh, I implement this STEM activity," to the kids, but the kids are like, "But we want to keep going, like we're not stopping here, we have to keep improving, and trying to make it better." Like that's what I feel like homerooms, like because when I was in my undergrad, we implemented like some STEM in my student teaching and we did like some robots and the water cycle, and all the kids were like, "We want to expand this and

like be able to have a robot go through other adventures and teach about other cycles." I think kids like just that hands-on feel of teaching.

Interviewer: Then is there anything else that we haven't already discussed that you would like to share?

#4: I don't think so.

After the interview had stopped being recorded, the educator and interviewer continued in casual conversation where he shared about students with special needs expressing frustration when pulled out and the way the parents of these students have raved about the growth they've seen in their students.