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Teacher Perspectives on Engaging SPED Students in STEM

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Abstract

The purpose of this research is to learn more about the teacher perception of student engagement during STEM (science, technology, engineering, and math) activities, specifically for students with disabilities. Additionally, this research enhances the understanding of which accommodations teachers perceive to be beneficial for students with disabilities, specifically during STEM curricula with an engineering component. To accomplish this purpose, the results from eight teacher interviews were analyzed qualitatively, being treated as case studies. Each of the teachers currently teach a STEM class incorporates at least one unit with a design challenge. Seven themes from teacher interview data are identified as communication, difficulty with math, working with others, success in project-based classes due to hands on opportunities, the importance of understanding students as individuals, student relationships, and helpful modifications. From these themes, there were three key ideas for the success of students with disabilities in STEM related classes: creating hands on opportunities, knowing students as individuals, and creating helpful teamwork opportunities.

Introduction

Since the space race caused the push for an increase of employees in STEM fields, professionals have been discussing the most effective ways to educate students in the STEM subjects (science, technology, engineering, and math). Much research has been completed to show the benefits of using an integrated approach to STEM education with one method for integration being the use of project and problem-based engineering projects (National Academy of Engineering and National Research Council, 2009). This has led to some advancements in STEM education and integrating engineering in the K-12 curriculum was emphasized with the Next Generation Science Standards. The Next Generation Science Standards emphasize creating

equity in the teaching of STEM which includes ensuring students with disabilities can engage with STEM opportunities.

Evidence from more recent research indicates that using an integrated approach in which students learn about all subjects within the context in which they are used in the world today supports student learning and develops 21st century skills (National Academy of Engineering and National Research Council, 2014). These scenarios can also increase student interest surrounding STEM as they can better understand what opportunities are available within these fields (National Academy of Engineering and National Research Council, 2014). Although research on STEM education is extensive there is still much to learn. One area where there appears to be a gap in knowledge is the understanding of how to best assist students with disabilities with their STEM learning. Personal observations seem to show that students with special needs tend to engage better in STEM lessons during hands on components, but research is needed to determine if this is actually accurate.

This project aims to gather teacher perspectives on the areas in which students with special needs excel and struggle in STEM education, as well as accommodations that can be used to better support their learning. Classes that incorporate engineering design are the focus of this report as engineering design allows for the integration of all STEM disciplines. The primary research questions addressed are:

1. How do teachers engage students with special needs during STEM activities?
2. What accommodations do teachers perceive to be the most supportive during STEM activities for students with special needs?

Findings from this research can help individual teachers gain ideas from how other teachers have provided support to students with disabilities in their classrooms during STEM activities. Teachers can then apply these ideas in their own context which could help students with disabilities better engage with STEM activities.

Background

Current Research on Integrated STEM Education

Prior to discussing the idea of engagement and accommodations to help students with disabilities succeed in STEM integrated classrooms, the current state of STEM education and STEM integration must be explored. In 2012 the National Academies released *A Framework for k-12 Science Education* which detailed many best practices in STEM education (National Research Council, 2012). Much research has been completed to better understand the effects of different methods of STEM education on students' growth and learning (Moore et al., 2015). This research centers around both students' growth from a content understanding perspective as well as students' growth in interest and identity as participants in the field of STEM. Both the intellectual and emotional growth must be considered because students must not only have the knowledge to perform the activities required for STEM but also must be willing and interested to engage in these activities which is why identity and interest are so crucial (National Academy of Engineering and National Research Council, 2014). The method that has received the most recent attention in research for STEM education has been an integrated approach where students are simultaneously engaging in all STEM fields. These approaches often center around engineering design to incorporate all fields, but this is not the only approach.

Research on integrated STEM education often focuses on curriculum that incorporates engineering design because it is one of the most natural ways to incorporate science, technology, engineering, and math at the same time. Engineering design-based curriculum requires students to not only understand the different subjects individually, but also understand how they relate to each other and can be used together. The research on engineering design-based curricula has demonstrated numerous benefits of this teaching pedagogy including increases in learning in science and math, the development of 21st century skills, and an increase in student interest identity, and motivation (National Academy of Engineering and National Research Council, 2014).

Increases in Learning in Science and Math

The first, and arguably most important benefit that research has shown from engineering design-based curricula is an increase in learning in science and math (National Academy of Engineering and National Research Council, 2014). The National Academy of Engineering and the National Research Council of the National Academies published a report in 2014 that highlighted numerous research studies on integrated STEM education and its merit to increasing student achievement in science and math. Most of the studies investigated curriculum that used problem, project, or design-based tasks to allow students to learn science and math in an applied context that related to how these subjects would be used in professional fields. The results of the studies were mixed but overall, it was observed that there was some learning growth for students in both science and math (National Academy of Engineering and National Research Council, 2014). Overall, more improvement was shown in science than math which the researchers attribute to the sequential nature of math being broken up by the science topics. Other studies reviewed in the report showed substantial growth in science understanding. The researchers

argue that this may be due to the importance of expressing scientific phenomena using mathematical models (National Academy of Engineering and National Research Council, 2014). Because of the importance of this form of scientific modeling, teaching math alongside the science concepts bolsters the students' understanding of science concepts as they can better understand representations given to them as well as create their own. One caution given by this same report is that when teaching science and math through engineering design the concepts can become highly contextualized unless clear connections are made to other contexts. Another report compiled by the National Academies in 2009 focusing on Engineering education expressed similar ideas to the 2014 report. In this report, the studies reviewed showed more mixed results, so few conclusions were drawn regarding science and math learning when teaching using engineering design-based curricula. However, there was some evidence to support increases in science and math learning in integrated approaches. This report specifically discussed the increase in learning that can be shown for underrepresented students when they engage curricula that incorporate engineering design-based activities (National Academy of Engineering and National Research Council, 2009).

Another possible reason for increased learning when teaching using an integrated method which incorporates engineering design is embodied learning. One study that demonstrates this idea examined college students' understanding of angular momentum and torque (Kontra et al., 2012). Participants were separated into two groups, the action group which was taught a lesson on these concepts while having the opportunity to manipulate a pair of bicycle wheels on an axle under various conditions, and the observation group which received the same lesson but did not get to manipulate the wheels themselves. Both groups were given a pretest and post-test and the action group showed significant improvement on the post-test while the observation group did

not (Kontra et al., 2012). This provides evidence for the possibility for increased learning when teaching using engineering design curricula due to hands on opportunities.

Development of 21st Century Skills

A second benefit of integrated STEM education is the development of twenty-first century skills. In the 2009 report published by the National Academy, the engineering habits of mind are highlighted as a major factor that contributes to the development of these skills. The engineering habits of mind include systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations which align closely with what many consider to be some of the most important skills to have today (National Academy of Engineering and National Research Council, 2009). This highlights the importance of integrated STEM curricula and engineering design beyond even the content being taught. Although this may be perceived as less crucial than the content, it is extremely vital as not all students will go on to have careers within STEM. These skills can be used by all students, even those who choose to pursue other ventures in their lives by preparing them to be more effective citizens and well-rounded individuals. Outside of the engineering habits of mind, these skills are also naturally developed through the nature of the engineering design process. The engineering design process is highly iterative and requires both investigating phenomena and applying that understanding to design a solution to the problem at hand (Brophy et al., 2008). This process can develop twenty-first century skills as students learn to problem solve and learn from their failures to improve.

Increase in Student Interest, Identity, and Motivation

A third benefit of integrated STEM education that comes from utilizing engineering design is the opportunity to increase interest and identity within STEM. When discussing interest

and identity, interest refers to the desire to engage in STEM related activities while identity refers to the sense of self-efficacy that students feel as participants in STEM fields (National Academy of Engineering and National Research Council, 2014). Interest and identity are important in STEM education because they empower students to engage with and excel in these fields by fostering a sense of belonging and personal motivation. By completing project or problem-based STEM projects, students can increase their interest and identity within the fields of STEM (National Academy of Engineering and National Research Council, 2014). Using engineering design-based curricula can increase curiosity by drawing on the intrinsic desire students have to understand how things work (Brophy et al., 2008). Interest and identity are examined in the 2014 national academies report which emphasizes that nurturing students' curiosity plays a pivotal role in enhancing their interest and identity in STEM. Various studies on engineering design-based curricula reviewed in this report have demonstrated that when students are able to engage in STEM activities that they view as relevant to their lives, their interest in STEM fields increases (National Academy of Engineering and National Research Council, 2014). When students see the activities as relevant, their inherent curiosity about the task can facilitate the learning of essential STEM concepts they need for completing the task. This itself can increase student interest in the field of STEM and can also be used to increase student identify in STEM (National Academy of Engineering and National Research Council, 2014). The studies on identity reviewed in this report revealed that when teachers and community members conveyed to students the value of their personal experiences and research in STEM, the students showed an increase in identity within STEM (National Academy of Engineering and National Research Council, 2014). One long term study on a group of students who completed a project related to the urban heat island effect on their city showed that even after completing the project,

their view of themselves as experts on the material was carried into new cities where they completed further community-oriented projects (National Academy of Engineering and National Research Council, 2014). This serves as a great example of how student interest and identity can allow student success to move beyond the classroom and impact the communities around them.

Current Research on Students with Disabilities in STEM

Understanding the benefits of integrated STEM education is very important but it is also important to ensure that all students are experiencing these benefits. One group of students who may require special attention in this regard is students with disabilities. Previous research has shown that students with disabilities are more likely to pursue STEM majors in college than students without disabilities (Lee, 2011). If students with disabilities are choosing STEM majors more often, that could indicate that they enjoy these fields. Engaging students with this kind of learning could therefore be beneficial to their learning and their engagement in school. Additionally, if it is known that students with disabilities are choosing STEM majors more often, educators within this content should ensure they are preparing students effectively for STEM programs.

Hands-on Opportunities

One area highlighted by previous research on students with disabilities in STEM education is the success experienced due to the hands-on and active nature of STEM education, specifically problem or project-based activities (Klimaitis & Mullen, 2021). Research has shown that students with special needs seem to prefer this kind of learning as opposed to more traditional learning styles. In a report examining a yearlong STEM program, there was a pattern in post-survey data of students with disabilities wanting less lectures and more activities to fill

free time (Lam et al., 2008). The students still desired direction and guidance, but in a more open learning environment with opportunities for hands on learning. A similar theme can be viewed when looking specifically at career and technological education which utilizes high amounts of hands-on training in specific fields. A study reviewing enrollment numbers in career and technical education (CTE) showed that although students with and without disabilities were equally likely to participate in CTE and STEM-CTE classes, students with disabilities earned more credits in CTE classes than students without disabilities (Gottfried et al., 2021). Both studies suggest that students with disabilities appear to gravitate towards opportunities to engage with hands on learning. Other studies have also shown similar results. Teacher responses in a study interviewing teachers regarding their experiences teaching students with disabilities suggested that incorporating hands-on activities is very beneficial for students with disabilities (Klimaitis & Mullen, 2021). Another report detailing useful accommodations highlighted that creating opportunities for student movement is more beneficial than using a sit and listen model of instruction (Fiore, 2014). These many studies show that students seem to respond well to hands on opportunities which could potentially be incorporated into STEM related courses.

Relationships With Students

An area that previous researchers have highlighted as important is building relationships with students with disabilities (Klimaitis & Mullen, 2021). Building relationships with students can help teachers learn about student interests and better understand the variety in learning styles of their students. In the same teacher interview study completed by Klimaitis and Mullen, many teachers highlighted the importance of both building relationships with students with disabilities and understanding student interest (Klimaitis & Mullen, 2021). This allows for better teaching as teachers can provide different modes of instruction to students. Research has shown that

providing students with multiple modes of representation is extremely important for students with disabilities and can increase their ability to learn material (Basham & Marino, 2013). Having different modes of representation also allows the teacher to incorporate student choice within learning. Student choice within learning has been identified as an important factor for increasing student engagement and understanding (Klimaitis & Mullen, 2021). When teachers have a relationship with students and understand their interests and abilities, they can create better opportunities for students to learn through modes of representation that they benefit from. Knowing students and understanding their strengths can also help teachers view student strengths and gifts. Research has shown that a major factor in student success is teachers seeing strengths and moving away from a deficit mindset which may be common regarding students with disabilities (Fiore, 2014). By building a relationship with students, teachers can avoid a deficit mindset to effectively see the strengths and interests of students with disabilities to provide effective instruction.

Working in Groups

Previous research has also highlighted that working in groups may be beneficial for students with disabilities (Klimaitis & Mullen, 2021). In the teacher interview study completed by Klimaitis and Mullen, teachers identified specific grouping as an important factor for the success of students with disabilities (Klimaitis & Mullen, 2021). Another article discussed a similar theme stating that small group work can be beneficial for students with special needs in the classroom (Fiore, 2014).

Summary

The themes of hands-on opportunities, building relationships to understand student strengths and interests, and student group have all been highlighted in previous research as keys to the success of students with disabilities. Although some previous research has been completed regarding students with disabilities within STEM education, much of the research on students with disabilities is general. Even research that is completed for the purpose of advancing STEM education incorporates teachers that do not specifically teach STEM classes (Klimaitis & Mullen, 2021). Research is lacking within STEM specific classes that utilize problem and project-based learning regarding these themes that are highlighted as useful for students with disabilities. Understanding how to best accommodate and engage students with disabilities within STEM classes is very important to ensuring that all students receive the benefits that problem and project-based STEM learning have to offer.

Methods

The purpose of this research was to investigate teachers' perceptions of student engagement during STEM activities, specifically for students with disabilities. Additionally, the researcher aimed to learn which accommodations teachers perceive to be beneficial for students with disabilities, specifically during STEM curricula. To accomplish this, eight teachers were interviewed. Prior to teacher interviews, the Internal Review Board approved the research design. A convenience sample was taken of teachers who teach classes with an engineering design component (Creswell, 2012). Seven of the teachers interviewed teach at least one engineering class that incorporated problem and project-based learning. The other teacher interviewed teaches a science class that incorporates an engineering design-based unit. The teachers interviewed teach grades ranging from 8-12. Six of the teachers work in an urban

setting, one works in a suburban setting, and one works in a rural setting. Seven interviews were conducted on Microsoft Teams, and one was conducted in person. Teachers were asked the same set of six questions with unique follow up questions asked based on teacher responses, see appendix for interview questions. Microsoft Team's transcribe function was used to transcribe interviews conducted on Microsoft Teams and transcriptions were checked by the researcher prior to completing data analysis. The interview completed in person was transcribed by the researcher. Transcripts of the interviews were analyzed using the Rapid and Rigorous Qualitative Data Analysis Technique (Watkins, 2017). Transcript excerpts went through two rounds of coding and then codes were distilled into themes. Teachers were randomly assigned pseudonyms for use in the presentation of results.

It should be noted that the small sample size in this research presents limitations in the findings presented. The interviews conducted were treated as case studies of specific classrooms and therefore may not clearly reflect broader trends observed in the educational world. Despite these limitations, the research still offers valuable insights into teaching students with disabilities and could be beneficial for teachers trying to determine how to better serve these students.

Results

When the interviews with teachers were analyzed, seven major themes emerged from teacher responses. The seven themes are communication, difficulty with math, working with others, success in project-based classes due to hands on opportunities, the importance of understanding students as individuals, student relationships, and helpful modifications.

Communication

There are many ways that teachers discussed the concept of communication which includes reading, writing, and verbal communication. Four different teachers mentioned that writing is difficult for students with disabilities. Across these responses, three included something about difficulties related to the mechanics of writing or not being able to form thoughts into words. Ruth stated that presentations made by students with IEPs have, “a lot of grammatical errors, lack of punctuation and clarity, things like that”. Paul highlighted that for students with IEPs specifically, “reflecting is not a problem. They can tell you verbally, but as a written document, that’s where the issues rise” and Ester expressed the same sentiment. These responses highlight that many teachers perceive that students with disabilities struggle with the mechanics of writing or putting their thoughts into words. Paul mentioned that one way to address this problem is through text to speech, while also noting that this method does have some associated technical errors.

Four teachers mentioned that reading can also be difficult for students with IEPs. However, they did not provide specific reasons why reading might be a struggle but simply mentioned that reading was challenging. Eve mentioned that the struggle could be due to having to read longer sentences but this answer was in the context of reading to copy material as opposed to reading for comprehension. John mentioned that one area where reading can become a barrier is when students are in the research phase of the design process stating, “We do a lot of research, so if all they’re finding is articles instead of videos, their research phase of their project tends to suffer.” John mentioned that for some, chunking the reading may help but said this is not true for all students with IEPs.

One area where there were some contradicting opinions amongst teachers was verbal communication. Two teachers mentioned that they perceive students with disabilities to be

successful with verbal communication while four teachers mentioned that they perceive students with disabilities to find verbal communication difficult. Ester stated that, “they can sit there and tell me what they’re trying to say and what they want to put into words on paper” and this idea was echoed by Paul. This illustrates the idea that some teachers perceive students with disabilities to experience success with verbal communication. However, other teachers perceived that students with disabilities struggle with verbal communication. For example, when Eve was discussing an experiment where different shapes of cars were being raced against each other she said, “if we said an answer like the time of the car and we just said it and they couldn’t see it somewhere, they might have gotten behind.” This illustrates how some teachers perceive that students with disabilities may get behind when there is an emphasis on verbal communication being used. It should be noted that the teachers stating students experienced success with verbal communication were mostly referencing students communicating to others while those perceiving a struggle were mostly referring to students being communicated to. However, this was not the case in all instances. It should also be noted that Ester mentioned students struggling to express problems they are running into as they move through the engineering design process, although this was not specific to reading, writing, or verbal communication.

Difficulty with Math

Six teachers mentioned that they perceived students with disabilities having trouble with math. It should be noted that Mark did specify this as being true for multi-step problems stating, “what I have found is with kids with IEP/504s, what really trips them up is anything that takes more than 3 steps to accomplish. This is especially true for math.” The other five teachers all mentioned math in general as a perceived difficulty. John specified that, “we do a lot of like thermodynamics and some of the equations can be really intimidating, especially to students that

have issues with, you know, or IEPs related to...their math ability or their reading comprehension." Another specific example of math being difficult was understanding large numbers. Eve stated:

> I said which shape had the lowest drag? And I read the numbers, and they did not know the answer. 1172 and 1200 and nobody could answer me, so I had to then just change the number and say, OK, what if it was 100 and what if it was 200.

Working with Others

Another major theme discussed by teachers was the way that students with disabilities work with other students. Five teachers mentioned that students with disabilities benefit from teamwork. One of the most common ideas teachers expressed within teamwork was that student grouping is key to success for students with disabilities. Mark highlighted that mixed skill level groupings can be beneficial stating, "this kid's IEP says they struggle with writing, but they are great at recalling information. You take that kid and pair him with someone who is good at writing." Ester echoed a similar sentiment about grouping students with complementary strengths but also mentioned that it is extremely important to match students based on personality, "Personality in general, I consider when I do grouping now, it's not just associated with IEP or 504s, but personalities, plus having a learning deficiency or learning disorder, that can kind of ignite problems even more so." The end of this quote from Ester also highlights that there are some key difficulties that students with IEPs may have with teamwork. In another quote, Ester highlighted communication as being a potential barrier, "So it's really about communications. So, I watch the way that peers communicate with each other in general and how they treat that student." Mark also stated that they perceive giving grades for group work as dangerous stating:

> Not group grades, I want to be very clear, I think the whole concept of group grades for an IEP kid is a dangerous concept. Because what ends up happening is the kid who is motivated to get the A will end up overcoming all of the things the IEP/504 kid is trying to do and just say you don't know what you are doing, I will just do it for you.

This quote further explains that students with disabilities may be left behind by other students who do not have the same barriers, such as taking longer to process tasks, which was also stated by Ester.

Within the theme of working with others, four teachers also mentioned that peer tutoring and feedback can be beneficial for students with disabilities. Mark elaborated that they believe this could be due to peers being more honest with each other than adults stating:

> Peer involvement and peer evaluation I think is number one because most students are more likely to give honest effort and honest responses to peers than they are to adults so having that within the class, having that accountability to peers.

Adam mentioned that the intervention specialists have even reached out regarding this form of peer-to-peer help:

> There's a number of times I'll get a heads up from the intervention department. You're going to have this kid next year and they've kind of learned and witnessed the buddy system. Can we be thinking about having someone for this kid?

On the flip side, Luke stated that students with IEPs acting as peer tutors helped them grow:

> So, he can take and teach those guys certain things that he knew, you know. And that's the thing. And I think not only does that help my freshman, I think it also helps him. He starts to get that confidence again. He was a kid that he, I wanna say he had a maybe a C third quarter. And he had an A in the fourth quarter.

Success in Project-based Classes Due to Hands on Opportunities

The most mentioned theme across teacher interviews was the perceived benefits and positive engagement with hands on activities for students with disabilities. Three teachers specifically mentioned that they perceived a greater success in project-based classes. Ester teaches both traditional science classes as well as engineering design classes and stated:

> I've had students both in the classroom setting where they're in my class for 9th grade physical science and then I have them the same year, the same day even, I have them for one of my design classes, robotics or engineering and they're just a totally different person in that room because they're doing, you know, it's not classroom learning, it's their hands are on something and different skills are being tapped into and sometimes they're even more confident, you know, in that setting than they are in the classroom.

Seven teachers interviewed mentioned in some way that students with disabilities experienced success with hands-on opportunities. Adam highlighted this idea stating, "It's that second phase after they've watched me demonstrate it. And then them actually doing it themselves, that's where you can see it click."

The comments about hands-on opportunities can be broken down into two categories. First, students with disabilities experience success when a physical product is involved. Six teachers stated that they see more success and engagement with students with disabilities when

they are working with a physical product. Adam used the example of 3D printing and students improving their design after the first print:

> Some kids like spatially size wise. They're like, ooh, I thought that was gonna be a lot bigger than that is. I'm like, well, you know, 2 inches. Yeah, it's only about that big and you know, so the, the little thing you designed is only two inches long, right? I just thought that's how it looked on the computer I thought was gonna be bigger.

Similarly, John mentioned that they perceive students making connections to theory after building:

> So, when we got to the building phase, that's when you started to see a lot of the light bulbs go off, of like ok, so if we use these lenses or if we use these mirrors, this is what that theory that we were learning actually looks like.

It is also worth noting that Paul showed an example of a project where a student with an IEP was the first one to complete the building process.

Secondly, three teachers mentioned physical experiments as being beneficial for students with disabilities. Here is an example of a physical experiment used by Ruth:

> Calculating the beam deflection and using the mathematic and scientific data was difficult, but then we do something called walk the plank where we have a 2 by 4 beam laid out in class and it just flanked on either side with cinder block and they have to literally walk across it to see how much it will give or bow.

The Importance of Understanding Students as Individuals

Another theme that emerged from teacher interviews was the importance of understanding students as individuals. One aspect of this includes building student-teacher relationships. Three teachers interviewed mentioned that they perceive student-teacher relationships as an important factor in student success. Paul stated, “Talking to them and having conversations with them and you know, that’s the biggest thing, are the conversations just talking to them, finding out how they’re feeling, finding out, you know, what’s going well, what’s not going well.” Ruth highlighted both student-teacher relationships as well as student-student relationships:

> I really try to create a comfortable family atmosphere and with time and maturity in their own development, they get there. If I keep them all the way to the time they’re seniors, I mean its mind blowing the progress that they’ve made as an individual.

Five teachers stated that they perceive lower confidence levels for students with disabilities compared to students without disabilities. Some teachers highlighted that students with disabilities get quickly frustrated and appear to experience more disappointments compared to students without disabilities. Luke highlighted that the success of students with disabilities often depends on their level of confidence:

> It depends on what they’re comfortable with and what they think they can do; what they think they can’t do. But if I don’t tell the kids that, and I just say, hey, I want you to draw this thing on this computer screen. Just follow these steps. They’ll do it, you know, even kids with IEP, they’ll do it. And if they don’t, they don’t know how hard it is. You know what I mean? Because nobody told them this is very difficult. Things like that. So, they just jump right in and do it.

Student Relationships

Teachers perceived that students with disabilities experienced success when they had additional one on one time with the teacher and when they were working on a project that they could relate to in some way. Three teachers stated that they try to provide some extra opportunities for one-on-one time with students with disabilities. Five teachers perceived that students with IEPs enjoyed and were successful with relatable projects. Two specific projects mentioned were analyzing the sneaker making process and building a Bluetooth speaker. Adam also highlighted that some students with IEPs find success working with computers because it is something they are used to using at home:

> I have kids that it's just like being at home and they're gaming or they're talking to their friends via the computer and therefore they love mechanical drawing or engineering or whatever because they kind of see it as the same thing.

Ruth also identified that student choice can be beneficial to helping student engage and relate.

Helpful Modifications

Many teachers gave examples of helpful modifications that they use for students with IEPs to address specific problems. Below are some examples of barriers students with IEPs face and modifications teachers use that they perceive to be helpful for removing the barriers.

One barrier mentioned was multistep problems and large projects. Three teachers mentioned that students can get caught up when having to complete long reading assignments or projects with a large scope. Two of these teachers identified chunking as a useful modification to helping students with disabilities work through these large tasks. For example, when discussing a

project where students must design a community center and may get overwhelmed by the volume of the task, Adam said:

> So, when you kind of break it down so we can do this, we can do this, we can do this and then we put all that together. It's not as overwhelming for some students just you know that when you hear you've got to do all of this, it's just it's overwhelming. So, if we break it down into small areas, small assignments, and then that all adds up to one thing, the success rate is exponential.

To help students who experience reading as a barrier to their success, John suggested using multiple modes of representation to help. One way he implements this is by allowing students to use modes other than literature for research. "They have the opportunity to use videos. They're allowed to form if they wanna test something physically, they can test something physically...So whatever kind of research they want, whatever kind of material they find, they're allowed to use."

One major barrier expressed by all eight teachers interviewed was timing. The teachers expressed that many students with disabilities take longer to process and complete tasks which makes timing an issue. There were a few different modifications teachers gave to help students who did not have enough time to complete tasks. One general modification referenced by many teachers was removing due dates and providing students with extra time as needed. For example, Adam stated:

> If they don't have to be bound by a due date of Friday, I have a greater success rate. If I just tell them, hey, you know when you get it done, you get it done. We gotta have it

> done by the end of the nine weeks. It's not hanging over their head, so they see a date, you know, that's a big one for a lot of students.

Another modification Ruth mentioned to help with timing was allowing students to take classroom materials home to work on things outside of class that are normally in class projects, “I have on a few occasions supplied some things, allowed them to take it home.”

The final set of modifications discussed by teachers involved the modification of assessment. Three of the teachers interviewed mentioned modifying the assessment or assessment targets in some way for students with disabilities. Teachers mentioned simplifying problems to meet standard requirements and shortening assignments as modifications made to assessments. Paul also mentioned that they believe students with IEPs should be measured based on the growth they made instead of being compared to the class:

> I don’t like measuring them according to the skills of let’s say the class. Because the students in the class have a very different set of skills than students with IEPs and 504s...so I like to look at each of the 504 and IEP students and just make sure that they’re growing and make sure that they’re trying.

When discussing tests, Ruth stated having intervention specialists take students with disabilities during testing is another useful accommodation:

> So, if they can be pulled out and meet with the intervention specialist one on one, even in small group, there was I think she took two or three for me last year and it’s just a much better environment for them.

Discussion

Throughout interviews, teachers gave many helpful insights into how they engage students with special needs during STEM activities as well as the accommodations they perceive to be supportive during engineering design activities. The perspective of the teachers interviewed is extremely beneficial since they all teach engineering design and therefore have a more substantial experience with these topics than a traditional science teacher might. Many of the answers given by the study participants align with previous research on the topic and provided specific examples and depth to these themes.

One clear example of this was the usefulness of hands-on opportunities for students with disabilities. Many teachers noted that there was a perceived increase in learning when students were able to build or manipulate a physical product. Multiple teachers mentioned that during these activities they perceived a ‘click’ where students finally understood the topic that was being discussed, which is consistent with previous research on this topic (Lam et al., 2008; Klimaitis & Mullen, 2021; Fiore, 2014). One example that was highlighted in teacher interviews was using 3D printing to allow for iterative design. This could be very useful in many classrooms because 3D printing is accessible in many schools today. Not only does it provide a hands-on opportunity after the model is printed, but it also provides a way for students to visualize their design while making the model in a CAD program.

Another topic that was discussed with many of the participants as key to the success of students with disabilities is focusing on students as individuals to enhance learning. Previous research has highlighted that building relationships with students to understand student differences and interests is key (Klimaitis & Mullen, 2021). Participants also identified student choice as an important factor in creating student interest and buy-in which then can lead to

higher achievement which was also mentioned by Klimaitis and Mullen (2021). One example of student choice was allowing students to use different forms of research such as videos or physical experiments. This could be very useful, not only because it can create more student engagement and remove the barrier of reading, but also because it can challenge students to consider what the goal of their research is and how to best meet this goal. Another interesting pattern viewed throughout the teacher interviews was asset thinking. Many of the teachers expressed that they find it valuable to group students by strengths. This seems to indicate that these teachers are trying to focus on what each student can bring to the table which reflects an asset mindset as opposed to a deficit mindset which has been highlighted as an important perspective by previous research (Fiore, 2014).

Building on the idea of knowing students and having an asset mindset, teachers discussed that they pay special attention to grouping students with disabilities. Those who mentioned this saw it as extremely important which is supported by previous research (Klimaitis & Mullen, 2021). Teachers also highlighted that ensuring other students working with students with disabilities are patient is crucial as slower processing speeds can lead some students with disabilities to be left behind or feel disconnected from their group. Ensuring that grouping is not only based on students' strengths but also their personalities can be helpful for the success of students with disabilities.

Another specific example given by one of the teachers that unites working with other students and having an asset mindset was letting students with disabilities serve as peer tutors for students in classes they have already completed. This may be difficult for some teachers to implement due to scheduling and the specific needs of students, but it seemed to have an extremely positive impact. This is definitely an idea that could be explored more and possibly

implemented in other classrooms to learn more about the benefits and barriers that exist with this method.

One theme mentioned by the teachers that should not be neglected is the uncertainty in their responses due to the variance amongst different students with disabilities. Two teachers noted that students with disabilities must all be treated as individuals and therefore what is true of one student with disabilities may not be true of all students with disabilities. This can be viewed in the communication theme in which some teachers saw verbal communication as a strength of students with disabilities and some saw it as a barrier. Similarly, in the theme of teamwork most teachers identified working with peers as beneficial for students with IEPs but there were conflicting ideas about how to best establish groups. Two teachers also mentioned that it may be difficult to identify if students with disabilities experience a higher improvement with certain types of activities when compared to students without disabilities. These teachers highlighted that tasks that students with disabilities find challenging or beneficial are often the same across all students.

Conclusion

This research provided classroom examples on the best ways to engage students with disabilities in engineering design classes and what accommodations may help them experience more success. Much research has shown that students can benefit greatly from STEM classes that incorporate problem and project-based activities that integrate multiple STEM subjects such as engineering design classes. However, there is not as much research detailing how to ensure that students with disabilities experience these benefits. This research aimed to add to this

knowledge by interviewing teachers who teach classes with engineering design components to gain their perspectives on how to best engage students with disabilities in engineering classes.

Eight teacher interviews were conducted in which teachers shared their perspectives on engaging students with disabilities in engineering education. These interviews were analyzed through multiple rounds of coding and ultimately seven major themes were identified as communication, difficulty with math, working with others, success in project-based classes due to hands on opportunities, the importance of understanding students as individuals, student relationships, and helpful modifications. The analysis of these themes and teacher examples given shed light on specific ways that students with disabilities can be engaged in STEM related classes to offer more opportunities for success. Three ideas were identified to help students with disabilities experience success in STEM related classes: creating hands on opportunities, knowing students as individuals, and creating helpful teamwork opportunities. These ideas were consistent with findings from previous research.

The information gained in this research was extremely beneficial but was limited due to the small sample size of teachers who were interviewed. Further research could be conducted applying the suggestions made by teachers in this research to a larger number of students. This could shed more light on how to help students with disabilities experience success in STEM classes and reap the same benefits as students without disabilities.

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Appendix

Teacher Interview Questions

1. When teaching engineering curriculum, which lessons did students with IEP/504s seem to engage most with from your perspective?
2. What types of activities do students with IEP/504s appear most excited to participate in?
3. Are there examples of activities that appeared to be overwhelming for students in your class with IEP/504s?
4. What do you perceive as the barriers that exist for students with IEP/504s in your class engaging with STEM activities?
5. During STEM activities, what accommodations do you use that you feel are beneficial for students with IEP/504s?
6. On a scale of 1-10, how comfortable do you feel leading your class through STEM activities?