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Embracing a Culture of STEM Education: A Qualitative Research Study

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Abstract

The purpose of this study was to explore teacher and administrator perspectives on STEM education and how they demonstrate characteristics of STEM education. The five schools in this study are part of a greater network of elementary, middle, and high schools that collaborate and learn together. Data were collected through interviews with teachers and administrators and observational notes from meetings and other events. Interviews were recorded and transcribed and then coded to look for themes in the data. Findings indicate teachers and administrators view a supportive leadership, teacher buy in, and comfort in teaching STEM as essential to the implementation of STEM initiatives. Without these necessary components, inequities may arise and lead to less opportunities for students. Overcoming obstacles may require a change in mindset to embrace a culture of STEM teaching and learning. Understanding how teachers and administrators view the importance of STEM and benefits of participating in a community of STEM can help understand how to shift the culture of a school to one more inclusive of STEM education.

Keywords

STEM education, teacher perspectives, administrator perspectives, characteristics of STEM, interviews, observations

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Background Information

Through a collaborative approach between schools, the central district office, and community teams, a network of schools focused on science, technology, engineering, and math (STEM) has been established throughout the school district where this research takes place. This network allows schools access to district and community resources to positively impact STEM teaching and learning. Funds are set aside for the schools to hold STEM Family Nights to encourage family and community engagement. The schools are also provided with funds to purchase technology and other resources in the first year after joining the network. The STEM network schools are expected to collaborate with each other, build a STEM identity within schools and create a common vision for STEM between schools, include stakeholders as part of a STEM community, provide opportunities for students to engage in STEM events and competitions, provide equitable STEM experiences to all students, and prepare students for the STEM workforce.

There are four collaborative groups of schools in the greater STEM network. The collaborative groups are organized by geographic region inclusive of all grade level bands. All groups have one high school, one or two middle schools, and at least three elementary schools. All schools in this study are part of the same collaborative group. Each group meets monthly to discuss STEM initiatives and share ideas about STEM education. Meetings are facilitated by district-level staff and schools are expected to send at least one representative. Most of the schools in the STEM network are not magnet schools with any special programs. Many of them are Title I schools and/or located in areas with high populations of English Language Learners

(ELLs). One of the primary goals of the STEM network initiative is to provide opportunities to students who are members of groups underrepresented in STEM fields.

As there have been many attempts at definitions and confusion surrounding exactly what STEM education means (Bybee, 2013), I used the definition of STEM education used by the school district in this study. The district states all students should have opportunities to integrate the different disciplines of STEM to develop skills such as problem solving, critical thinking, communication, collaboration, and creativity. In addition, students should have opportunities to participate in STEM competitions and events to apply content learned in the classroom.

Purpose and Rationale

The purpose of this qualitative research study was to explore teacher and administrator perspectives and how characteristics of STEM teaching and learning are demonstrated in their schools. The following research questions guided this study:

- What are teacher and administrator perspectives on STEM education?
- How are schools demonstrating characteristics of STEM teaching and learning?

The inclusion of STEM pedagogy and practices is essential to education because this provides students with opportunities to prepare themselves for a 21st-century workforce (Bybee, 2013). Utilizing STEM pedagogy can prepare students for the future by teaching them skills such as critical thinking to address societal issues. In addition, participating in STEM activities in the classroom and in out-of-school clubs and activities can help students build a STEM identity and improve attitudes towards science (Chan et al., 2020; Dou et al., 2019; Means et al., 2015; Sorge et al., 2000), which is linked to the likelihood of pursuing STEM careers (Dou et al., 2019; Means et al., 2015).

Although the network of STEM schools has been established, the fidelity of the implementation has never been evaluated. This study was designed to explore how the schools were displaying characteristics defined as necessary to a successful STEM education. This information will be used to better support these schools moving forward to continue to successfully implement the STEM network concept and apply this concept to other schools and districts.

Literature Review

The conceptual framework that supports this study is based on teacher and administrator perspectives on what STEM education looks like. I discuss each in turn and then show how they are combined to guide the study.

Characteristics of STEM Education

Some characteristics of STEM education identified in the research literature include building a foundation for STEM teaching and learning (El-Deghaidy et al., 2017; LaForce et al., 2016; Toefel-Grehl & Callahan, 2014), increasing collaboration between faculty (El-Deghaidy et al., 2017; LaForce et al., 2016), including various stakeholders (El-Deghaidy et al., 2017; LaForce et al., 2016), reaching a wide variety of learners (Eijwale, 2013), and supporting teachers in implementing STEM pedagogy (Asunda & Walker, 2018; Eijwale, 2013; El-Deghaidy et al., 2017; Felix & Harris, 2010; Thibaut et al., 2019). This research supports the characteristics of STEM identified by the district. In this district, STEM pedagogy

refers to science and math practices that are hands-on, inquiry-based, rooted in technology when appropriate, and based on engineering design principles. Engaging with STEM pedagogy allows students to practice the skills of scientists and engineers by utilizing critical thinking, problem solving, and collaboration.

Promoting STEM with all stakeholders is important for effective STEM initiatives (El-Deghaidy et al., 2017). Part of building a STEM identity involves collaboration between stakeholders (El-Deghaidy et al., 2017). This collaboration leads to the development of a stronger community that can help students acquire a STEM identity (Dou et al., 2019; LaForce et al., 2016), learn more STEM content knowledge, and improve higher order thinking skills (Fan & Yu, 2017).

STEM programs need to reach a wide variety of learners to be inclusive (Eijwale, 2013). In the classroom, students should be exposed to teaching methods that include hands-on learning such as engineering and design challenges to increase student interest in STEM (Toefel-Grehl & Callahan, 2014). Reaching a variety of learners also requires exposure to programs out of school as well, such as after-school clubs and summer programs. Engaging in out-of-school time activities allows students to strengthen the content knowledge and skills they develop in the classroom.

Teachers sometimes need support such as professional development (PD) to utilize STEM technology and pedagogy (Asunda & Walker, 2018; El-Deghaidy et al., 2017; Felix & Harris, 2010; Thibaut et al., 2019). School faculty need time to collaborate and discuss ideas related to teaching and learning STEM before effectively implementing new strategies (Eijwale, 2013). Both teachers and administrators should be familiar with STEM pedagogy and practices to be able to successfully provide students with opportunities to engage in STEM activities (El-Deghaidy et al., 2017).

Teacher and Administrator Perspectives

Teachers and administrators have perspectives on STEM education that should be considered when evaluating the effectiveness of STEM initiatives (El-Deghaidy et al., 2017; Tofel-Grehl & Callahan, 2013). Previous research indicates that school personnel view STEM education as important (El-Deghaidy et al., 2017; Madden et al., 2016) and recognize the significance of engaging in STEM activities, such as engineering design challenges (Lesseig et al., 2017). Teachers and administrators acknowledge the importance of creating a STEM community within the school (Tofel-Grehl & Callahan, 2013). Teachers recognize the reasons for why STEM education is important, including providing students with real-life connections to school, promoting critical thinking, allowing for inquiry-based activities, and including technology into lessons (Madden et al., 2016).

However, although teachers see the importance of STEM education, they may not feel like they possess the skills needed to effectively teach using STEM pedagogy (Asunda & Walker, 2018; El-Deghaidy et al., 2017). For this to happen, teachers and administrators may need to engage in PD to enhance their understanding of STEM education so they can increase student learning and engagement (Hall & Miro, 2016). PD opportunities focused on developing skills related to STEM pedagogy can improve teachers' attitudes towards teaching STEM (van Aalderen-Smeets & Walma van der Molen, 2015).

We need to understand teachers' perspectives of STEM education to effectively implement STEM initiatives (Dare et al., 2017). Familiarity of STEM from students, teachers, and administrators is essential to integrating STEM into the classroom (El-Deghaidy et al., 2017). Therefore, teachers and administrators need to understand the importance of STEM and how to effectively implement STEM pedagogy in their classrooms and schools before they can be part of an effective network of STEM schools.

Conceptual Framework

This study was guided by a conceptual framework focused on teacher and administrator perspectives on what STEM education looks like. Foundational to discussions on how STEM education might be improved are the various perspectives on what STEM can look like (English, 2017). As described above, there are many characteristics of successful STEM schools identified by both the district and research literature such as building a strong foundation for STEM teaching and learning, including various stakeholders, giving students additional opportunities to engage in STEM out of school, and supporting teachers in using STEM pedagogy.

For STEM efforts to be successful, the support and buy in of school personnel is essential (El-Deghaidy et al., 2017). This means that administrators need to support teachers in implementing STEM practices in their classroom and give them room to try new things. In general, teachers and administrators feel STEM is important (El-Deghaidy et al., 2017; Madden et al., 2016); however, many teachers struggle with implementing STEM pedagogy (Asunda & Walker, 2018; El-Deghaidy et al., 2017). In addition, it is important to understand how teachers and administrators view STEM education before improvements to initiatives focused on STEM are implemented (English, 2017). Therefore, I conducted this study to understand the perspectives of teachers and administrators in relation to STEM education in the district so I could better support teachers and administrators in this network of STEM schools.

While some research exists on effective STEM schools and teacher perspectives related to STEM in general, there is little research on networks of STEM schools and how to effectively implement collaborative STEM initiatives. This study contributes to this topic by exploring perspectives not only on STEM education but being part of a collaborative STEM network. In addition, this study has the potential to help teachers and teacher educators understand what supports are needed to form an effective group of collaborative STEM schools.

Researcher Reflexivity

Because I work for the school district in which this research was conducted and part of my role is working with our network of STEM schools to promote the use of STEM pedagogy and practices with all students, I wanted to explore how to better serve these schools in the implementation of STEM. I felt that I first needed to understand teacher and administrator perspectives before focusing on how to support them in the integration of STEM. The STEM network schools were purposefully selected because they exist in communities with a student population that is typically underrepresented in STEM career fields. As a district, our goals of equitable STEM practices align with promoting STEM careers and opportunities to students in these areas. No research has been done on how the school sites in this study are providing STEM opportunities to their students so my purpose was to explore how teacher and administrator perspectives could help me make better decisions in supporting these schools.

Materials and Methods

Study Setting

This study took place in a large school district located in the southeastern United States from February of 2020 to February of 2021. Although there are 28 schools in the greater STEM network, I focused on five elementary schools located in the same geographic area and part of the same collaborative group. Demographics for all schools selected for the study are similar,

with a high Hispanic population, averaging about 76% of the student population. All the schools are also classified as Title I, with approximately 90% of students receiving free or reduced lunch.

Until mid-March of 2020, all students were attending school face-to-face. During the 2020-2021 school year, schools were required to offer a face-to-face and virtual option for attending school. All schools in the district were facing struggles with how to teach STEM remotely. Therefore, during this study, many of the typical STEM network initiatives were on hold or altered to allow for safety protocols. However, because the interviews were completed during February and March of 2020, most of the interview data reflects how teachers and administrators viewed STEM prior to the pandemic.

Participants

I recruited participants via email and during collaborative group meetings that I facilitate as part of my role in the district. Teachers and administrators were asked to take part in an interview and told it was entirely voluntary to do so. To ensure they did not feel pressured to participate, I was deliberate in only asking once and leaving it up to them to reach out to me or sign up electronically if they wanted to participate.

I ended up with seven participants from five elementary school sites. Five of the participants were STEM teachers and two were administrators at the same school. At the time of the study, Frannie had worked at Caslin Elementary for three years. Frannie taught and supported other STEM teachers. Dayna fulfilled many roles at Craslow Elementary but primarily taught and supported other STEM teachers. Susan supported STEM teachers at Tauber Elementary. Jane and Patty were both administrators at McCarthy Elementary. Shirley worked with small groups of students and supported STEM teachers at McCarthy. Finally, Lucy worked in a similar role as the other teachers and her role was to support other STEM teachers at Wells Elementary.

Study Design

I used a qualitative approach in this study to explore teacher and administrators' perspectives on STEM education and how school faculty exhibited characteristics of STEM.

Data Collection

I collected data through semi-structured interviews, notes from meetings, and observational notes from events such as STEM Family Nights. Multiple sources of data allowed for triangulation and a greater understanding of teacher and administrator perspectives on STEM (Creswell, 2013).

I designed interview questions based on the goals of the research questions. Therefore, I asked teachers and administrators questions about the background of their schools, STEM initiatives, how parents or community members were involved in STEM at their school sites, how they interacted with other STEM network sites, and benefits or struggles with being part of a STEM network site. A semi-structured interview approach allowed participants some flexibility in answering questions (Galletta, 2013) and allowed me to ask follow up questions to further explore teacher and administrator perspectives on STEM education. Interviews for this study began in February of 2020 and extended throughout that Spring semester. Two of the interviews were conducted face-to-face at the teachers' schools. I conducted the remaining interviews via Zoom because in mid-March, the school district shut down due to the Covid-19

pandemic. In either case, the interviews lasted between 20 and 30 minutes. As the sole author in this study, I conducted the interviews, and I also recorded and transcribed all interviews.

I recorded observational notes during meetings and STEM Family Night events, which were used to supplement what I heard and interpreted during the interviews. Meetings were face to face until March of 2020 when they stopped for the school year due to the increased teaching demands of the pandemic. These meetings were continued via Zoom at the beginning of the next school year in September. Events were postponed at the beginning of the 2020-2021 school year, but all schools in this study planned and implemented a collaborative virtual STEM Family Night event via Zoom that was held at the end of January 2021.

Data Analysis

I used a combination of direct interpretation and thematic coding to analyze the data. I first made jottings, or notes, to record preliminary interpretations as I conducted the interviews and observed meetings and events (Emerson et al., 2011; Miles et al., 2014). After these preliminary interpretations were made, I coded data using a hybrid approach of inductive and deductive coding to establish patterns (Creswell, 2013; Fereday & Muir-Cochrane, 2006). Prior to data collection, I created an initial a priori codebook from the research questions, research literature on STEM education, and the district's definition of STEM education. The codes included broad categories focused on teacher and administrator perspectives and STEM education in general. As the research progressed, I coded data using the initial codebook as a guide and additional inductive codes were added (Fereday & Muir-Cochrane, 2006; Miles et al., 2014). The codes were then collapsed into themes, which were used to describe teachers' and administrators' perceptions on STEM education and how STEM was represented in their schools.

Trustworthiness

Trustworthiness depends on detailed description and explanation (Janesick, 2003) so I used details when reporting findings and interpretations to accurately represent what occurred during the study (Creswell, 2013). This was further achieved through using multiple data sources (Lincoln & Guba, 2007). By looking for patterns among different sources of data, I compared information across data sources to provide a greater accuracy to my findings. Finally, as my role in the district may have influenced how I interpreted the data, I remained reflexive throughout the study and continued to reflect on my researcher bias that may have shaped my interpretations in the study.

Ethical Considerations

Prior to conducting this research study, I obtained approval from the district's Research and Evaluation office. I also obtained a signed consent form from each participant prior to conducting any interviews. When obtaining informed consent, I explained to each participant the research is completely voluntary, the purpose of the research, and any benefits they may gain from participating. I maintained confidentiality throughout the study by using pseudonyms for teachers, administrators, and school sites.

Results

Teachers' and Administrators' Perspectives on STEM Education

In general, teachers and administrators expressed positive views towards STEM education and being part of a network of STEM schools. The themes I identified in relation to this research question are: (1) embracing the importance of STEM; (2) benefits of being part of a STEM network; and (3) overcoming obstacles of teaching STEM.

Embracing the Importance of STEM

Teachers and administrators at all sites in the study understand and embrace the importance of STEM and they promote the use of STEM pedagogy and practices school wide. This looked different at each school, but some examples include integrating robotics activities, doing engineering design challenges, allowing students to use the makerspace at the school or having one in the classroom, and using technology such as 3D printers.

In their interviews, Susan and Lucy discussed how STEM is happening every day, in all classrooms. Susan mentioned, "there are lots of opportunities and most [teachers] feel comfortable enough to participate at some level." Lucy commented that STEM is infused throughout the school in all content areas, including "special" subjects such as music and art, "Wells for sure has a very STEM-oriented culture of having the makerspace and the [3D] printer and working with specials to have STEM things" and "the whole school has that mentality." This shows how faculty at Tauber and Wells have encouraged and embraced STEM by providing opportunities for teachers and students.

All five schools had individual STEM Family Nights the first year of the study where teachers from all subject areas came together to showcase STEM opportunities to families. Jane also mentioned in her interview how McCarthy, Tauber, and Wells collaborated on an in-person STEM Family Night during the first year of the study, "I think that was one of the coolest things to see everyone come together to put on an awesome night." Because of the Covid-19 pandemic preventing them from coming together in person, the schools held a virtual STEM Family Night in January of 2021. While many other schools in the STEM network and the greater school district put STEM on hold because they did not have Covid-19 safety protocols in place or felt they needed to focus on individual content areas, this speaks to the importance these five schools place on providing STEM opportunities to students, families, and the community.

Even throughout the 2020-2021 school year, with meetings being held remotely, the notes I took at each meeting show there was someone present from each school who participated and brought information back to their school site. This indicates the faculty at these schools place an importance on participating in the STEM network.

Benefits of Being Part of a STEM Network

All participants mentioned that being part of the STEM network has benefits for students, teachers, administrators, and the school in general. These benefits range from student achievement related to assessment scores, socio-emotional capacity of students, knowledge growth of teachers, and population growth of the schools.

One of the major benefits to students is achievement in math and science based on assessment scores, which was acknowledged during interviews with participants. Susan mentioned Tauber's assessment scores "continued to go up, so something is working with us." Jane said they saw this at McCarthy as well, "last year we saw a big jump in [STEM]

achievement and last year's [state assessment] scores showed a decline in all areas except for our math bottom quartile and science." Frannie mentioned "kids who traditionally struggle in reading and math are finding a lot of success, so it is making them more comfortable and happier." The acknowledgement of the improvement in assessment scores indicates the teachers and administrators understand the positive impact their involvement in a STEM network had on student achievement.

Another benefit to students is the emotional growth gained through engagement with STEM. Frannie mentioned during her interview "it is also making [students] learn that it is okay to not be correct or right...their emotional ability to fail has happened because of being part of a STEM [network]." Frannie also discussed being able to learn by doing is particularly beneficial for ELL students and has "broken down a lot of barriers for our monolingual students because they can build without language." This is a significant statement because all schools in the study have a high ELL population so this may be a similar benefit in all schools. These examples demonstrate how Frannie understands that engaging in STEM benefits students by helping them grow as individuals.

There are also benefits for teachers due to being part of the STEM network. These benefits seem to be mostly related to being part of a community of STEM. During her interview, Patty said at McCarthy, she could see benefits to faculty because, "it just puts you in the unique situation where you have a group of people who are closely connected to one common vision and goal." However, another benefit to teachers is being pushed out of their comfort zone to try new things with their students. Lucy mentioned in her interview it was a way for teachers to get out of their comfort zone, "I think that this STEM opportunity at our school really pushes teachers and show them like oh can use a Sway [or other technology]." These statements support the idea that school-based faculty appreciate the benefits to teachers.

Schools in general benefitted from having a STEM program that is attractive to potential families. Frannie stated in her interview, "enrollment always increases throughout the school year as parents realize the amount of STEM stuff we have over the charter schools in our area." Susan also mentioned the opportunities students have and the attention they get from the district "they tend to talk about what are we doing STEM-wise and it's easy to talk about that because there's so much going on." Increasing enrollment is important to school sites because the more students they have, the more monetary support they receive. This allows them to increase the number of programs they have, including STEM-related initiatives.

Overcoming Obstacles of Teaching STEM

Almost all the participants identified struggles with incorporating or using STEM pedagogy especially when using robotics or other technology such as game-based learning platforms. However, most were able to identify some way to overcome any obstacles they faced. Some of the struggles related to comfort levels with using technology. During her interview, Frannie noted Caslin "still has a group of teachers that are uncomfortable with the STEM tools or the STEM materials." Lucy also mentioned during her interview that technology was an issue at Wells because teachers are "so programmed to be like A+ or fail so they're like I can't do this because I don't know how to do it." She also said,

> Teachers can be very reluctant to use it because technology can be frustrating. How many times have you set something up and it doesn't work? And you're like well this sucks. And that one bad experience kind of taints like I don't want to use this platform anymore because it doesn't work.

When teachers feel uncomfortable using certain pedagogy and materials, they tend to avoid using it, which works against the implementation of STEM in these schools.

Another issue related to technology in the classroom is incorporating it into lessons. For example, all elementary schools have access to technology, such as coding mice, but with a lack of pre-written lesson plans, teachers must figure out how to use these resources to teach required standards. This issue was brought up during participant interviews. Lucy mentioned two of the more popular coding resources, "Botley and coding mice aren't integrated into the curriculum." Frannie also mentioned that "working them into the standards is a struggle cause it's not laid out very easy for teachers." Not having easily laid out lesson plans may also prevent teachers from integrating STEM into their daily classroom activities, which can also work against the implementation of the STEM network initiative.

According to Shirley, one of the struggles at McCarthy was trying to find a balance between integrating STEM with other content areas. As mentioned earlier, although their state-assessed science and math scores went up, there was a decline in other content areas. She stated in her interview, "we went full steam ahead as far as incorporating STEM; however, we found that we had a decline in our reading, we needed to find the balance." This shows how schools are struggling with keeping a focus on STEM while also maintaining learning in other content areas.

During the second year of the study, with many students learning from home because of the Covid-19 pandemic, teachers had to think outside of the box related to STEM. A frequent topic of conversations in meetings throughout the school year was how to provide students with equitable STEM experiences at home and safely face to face. The teachers have implemented ideas such as take-home STEM kits, using "found," disposable materials located around the home or classroom for engineering challenges, and sending home STEM bags with supplies for parents to use during the virtual STEM Family Night event. This push to continue to provide valuable STEM opportunities to students demonstrates how school personnel are willing to overcome some of the struggles they faced because they believe in the importance of STEM.

Characteristics of STEM

Findings suggest schools are demonstrating characteristics of STEM in different ways. The themes developed during analysis in relation to this research question are the following: (1) collaboration as part of a STEM network; (2) engagement in STEM activities; (3) teacher buy in to STEM initiatives; (4) stakeholder involvement in STEM; (5) STEM for all learners; and (6) support of school-based leadership in STEM initiatives.

Collaboration as Part of a STEM Network

Collaborating between and within schools is something that is expected of the STEM network schools. This is evident between all the schools based on attendance in their monthly STEM meetings. As previously noted, there is always a representative from each of these schools present. Susan talked about the monthly meetings in her interview, "we have been collaborating, especially our site, in sharing different resources, activities, lesson ideas, we've even shared materials among different schools." All other participants interviewed mentioned this collaboration in some way as well. Collaboration was also evident during collaborative STEM Family Nights because teachers teamed up to provide parents with STEM experiences like what students would experience in school. Collaboration also occurs within schools. Jane mentioned at McCarthy, the science and math coaches "had weekly meetings with different grade level teams to support STEM implementation." These comments show that teachers and

administrators recognized that collaboration was important to participating in a STEM community.

Engagement in STEM Initiatives

In the first year of the study, teachers and administrators actively participated in STEM events and competitions. Many of these events are promoted throughout the district, but the STEM network schools are expected to participate in these activities. In interviews, participants discussed the school-based STEM initiatives during the first year of the study. Susan mentioned Tauber had an environmental club for students to clean up the surrounding community. They also have school-wide long-term investigations to engage all students in STEM that included a "garden, a pumpkin patch, thermometers, and rain gauges." Dayna, Shirley, and Frannie have robotics clubs at their schools and all participants discussed how robotics is embedded in their day-to-day classroom activities. Dayna also did solar car races with her students at Craslow. Frannie said at Caslin there was a "makerspace centered in our media center which is 100% exploration." In addition, I observed that long-term investigations, robotics, and makerspace activities continued during the second year of the study once the schools established guidelines for Covid-19 safety. These comments and observations support the idea that school faculty engaged in STEM initiatives to provide opportunities to students.

Due to Covid-19 protocols in the 2020-2021 school year, district events were put on hold or modified to meet safety requirements. However, the schools in this study still participated in these events as best they could. The district-wide STEM fair was held remotely, and Wells was the first elementary school to register for it. In one of the monthly meetings right before the STEM fair, we discussed the ways teachers and administrators supported students in using the virtual platform to submit their presentations. The Science Olympics events, which are normally a district-wide event held at a local museum, were school-based and virtual during this year, but all these schools found ways to get students involved and engaged in STEM through the various events. This perseverance through a situation which made hands-on activities challenging indicates that teachers understand the importance of engaging in STEM.

Teacher Buy in to STEM Initiatives

Buy in was expressed by participants as teachers' desire and effort in practicing STEM pedagogy in their classrooms. The schools differed in the amount of buy in they had from teachers related to STEM and identified this in interviews. Dayna and Susan were both confident in faculty's investment in the STEM network concept and noted this in interviews. Dayna said, "I think we have a lot more buy in from students as well as teachers" and teachers were "proud of" being part of a STEM network. Teacher buy in was mentioned by Lucy as well, "I think that the biggest struggle is just getting teachers on board...and it's not the young teachers but I would say more veteran teachers have a harder time." As the science resource teacher, Susan has spent some time working with teachers so they can see the importance of STEM.

> We saw a huge shift because the teachers realized by going to different data chat meetings, looking over data with me, talking about data themselves, they took ownership of the kids' scores knowing that we're at this STEM site, that we showcase that our kids can learn the science.

The faculty from McCarthy, Wells, and Caslin all noted the issue with teacher buy in was bringing an awareness of why STEM is important to the faculty. McCarthy experienced a lot of teacher turnaround in the year prior to the study, so they were struggling to maintain their STEM identity. Jane mentioned how the school has changed recently, "we had a core group that was really committed to what STEM meant and what it looked like…and now we're back at that same situation because we have a whole new group of people." They are working towards a more collective positive attitude towards STEM by providing STEM mindset trainings and increasing knowledge of STEM pedagogy, such as how to engage students in engineering design activities, throughout the school. These comments indicate that the participants see teacher buy in as important, but they need to put in effort to make sure teachers are aware of and trained in STEM pedagogy. Tauber did this through having data chats with teachers while McCarthy offered PD to increase teacher knowledge.

Stakeholder Involvement in STEM

All participants mentioned in their interviews that including stakeholders, such as families, in STEM initiatives was important. At McCarthy, Shirley provides "monthly STEM challenges to get the families involved." Jane agreed with this by saying "I think one of the biggest pieces are those family challenges they do monthly." Lucy and Dayna also mentioned their schools provide monthly STEM challenges for families and as Lucy said, "families are so into it." As mentioned, schools in the study have STEM Family Nights that allow parents to visit the school and engage in STEM activities with students. These nights are supported by community partners who want to offer STEM opportunities to students. Many times, community partners were observed at these events interacting with family members or managing exhibits related to STEM. Dayna talked about how Craslow has two STEM Family Nights per year, "we also have our family STEM challenges we do monthly and we're getting a lot of buy in with students and parents with that." The second Family Night is unique and Dayna described is as, "for our Spring STEM night, [the students] coordinate all of it; they plan it, the organize it, they do all of it." Jane mentioned McCarthy is using these Family Nights to integrate STEM and other subjects. She stated, "we did have a reading night earlier in the school year, but we had STEM activities available there as well just to show how they're always linked together." Including stakeholders such as community partners and parents help build the STEM community at the school sites.

STEM for All Learners

The district places an emphasis on ensuring all students have equitable access to educational opportunities. However, the teachers and administrators were divided on whether all learners really had access to STEM. Caslin was unique in that during the first year of the study, they had a STEAM lab that combined both art and STEM. Instead of going to a typical art class, all students used the STEAM lab. Frannie noted students had equal access to STEM through this opportunity but other than that, they did not due to the comfort level of teachers previously noted. Also, both teachers who ran the STEAM lab have since left due to other opportunities, so students no longer have access to STEM in that way. Shirley mentioned students "definitely" have equitable opportunities to participate in STEM, but Patty also mentioned McCarthy is still rebuilding their STEM program, so it was a work in progress, indicating that not all students were exposed to rigorous STEM opportunities.

On the other hand, Lucy gave several examples in her interview of how Wells is providing STEM opportunities to all students. She mentioned one way was through the family STEM challenges and "with coding week, we had primary versus intermediate challenges so

everyone could participate." She also made a point to discuss partnerships with technology and computer companies that allowed teachers to get PD experience so they can share their knowledge with students. She stated, "we want to offer that opportunity to all of our students, not all of them have that opportunity outside of school." She did mention Wells was fortunate because "not all schools have the ability to have one-on-one with technology and students." During the STEM Family Night at Wells during the first year of the study, some of these partners were present with exhibits so parents could engage in some of the STEM opportunities students had daily. In the second year of the study, teachers in these schools were learning to work around limitations related to the Covid-19 pandemic by sending home supplies for students who are learning at home or using disposable materials in the classroom to ensure all students have access to hands-on STEM opportunities. These examples indicate that teachers and administrators are aware of potential inequities in STEM education and are attempting to move towards solutions.

Support of School-Based Leadership in STEM Initiatives

Every participant made a comment about the leadership at their schools and how supportive they were related to STEM. Schools with strong leaders who support STEM were important to the success of their STEM initiatives. During the first year of the study, the leadership at Caslin was particularly supportive of STEM, with administrators attending several of the monthly meetings and seeking out personal meetings with district personnel to evaluate their STEM initiatives, such as the STEAM lab. Frannie mentioned this in her interview, "our principal has pushed it hard with him actively going out to find donors for our stuff and funding we might not typically have." She also said at Caslin, the administration places "a strong emphasis on expectations for the classroom, for STEM." The principal has since left to take another position in the district, and the push for STEM continues, but due to the pandemic and loss of staff at that site, it has become less of a focus. Lucy mentioned at Wells, "it's very evident that they try very hard to make sure that the STEM part of our school is the biggest part...that's what runs our school." Dayna said more than once the administration at Craslow mostly supports STEM by providing materials, "pretty much anything we need, they're very open and willing to having that conversation and 9/10 it's like sure, no problem." Susan claims her administration has always been behind STEM right from the beginning of the STEM network initiative, "leadership has also been 100% backing even when they came and asked if the school wanted to be a part of it." Patty said, as the principal at McCarthy, STEM has always been an area of focus for her, "that is one of our priorities...that's something as we're speaking to students, we bring that into their mindset and talk to the students about it." Supportive leadership may be one of the reasons why these schools were so successful in participating in the STEM Hub concept. Based on my experience and observations, other schools in the network who were not part of this study, did not have as much success because a few teachers were driving the effort, not the administration.

Discussion

Related to the first research question, teachers and administrators had varying perspectives on STEM education. Based on their responses and my observations, having a supportive leadership, teacher buy in, and comfort in teaching STEM were important to these schools and how successful they felt they were in implementing STEM.

A supportive leadership can be key to the success of any school-wide initiative. Previous research demonstrates a lack of support from administration is detrimental in implementing and maintaining successful STEM initiatives (Asunda & Walker, 2018; Eijwale,

2013) but an administration with a focus on STEM provides the support needed for successful implementation of STEM programs (Lynch et al., 2017). The schools in this study have support from administration at both at the school and district level and from colleagues as part of the STEM network. This likely added to their success as STEM-focused schools. Moving forward, my focus as a district administrator will be to better support the schools that lack strong support in school-based leadership.

Results of this study suggest the comfort level of teachers may lead to less buy in and in turn, inequitable STEM experiences for some students. Previous research demonstrates students from underrepresented groups benefit from an inclusive environment that values hands-on and inquiry-based activities (Stubbs & Myers, 2016) and students in general experience greater confidence with science and math when exposed to STEM opportunities (Wang et al., 2011). Providing school-wide STEM experiences give underrepresented groups of students more opportunities to learn STEM knowledge and skills (Lynch et al., 2017). This is particularly important for these schools as they have high ELL populations, which is an underrepresented group in STEM.

Previous research supports the finding that many teachers struggle with implementing STEM pedagogy and technology (Asunda & Walker, 2018; El-Deghaidy et al., 2017; Wang et al., 2011) and may need additional support in the form of PD (Asunda & Walker, 2018; Hall & Miro, 2016; Lesseig et al., 2017). Furthermore, teachers have demonstrated positive attitudes towards teaching STEM when supported by PD programs (Thibaut et al., 2019) and teachers' attitudes and buy in influence the extent to which they will include STEM in their teaching (Thibaut et al., 2018; Wang et al., 2011). For schools to be successful in changing their mindset around the inclusion of STEM, teachers may need new conceptual structures to buy in to STEM education (El-Deghaidy et al., 2017). This would require the use of PD to demonstrate that STEM is useful and possible in classrooms of all content areas.

Related to the second research question, for characteristics of STEM identified by the teachers and administrators in this study to be exhibited and encouraged school-wide, this may require a cultural shift in thinking about STEM (El-Deghaidy et al., 2017; LaForce et al., 2016). A school culture that includes high expectations for STEM teaching and learning can lead to more successful STEM initiatives and student achievement in STEM subjects (Lynch et al., 2017). Even while addressing struggles related to integrating STEM, these schools were able to create a community that values STEM teaching and learning. This community includes not only teachers, students, and administrators within a school, but also stakeholders outside of the school including faculty from other schools, families, and community members. This supportive STEM community can help develop a positive STEM culture within individual schools and between groups of schools (El-Deghaidy et al., 2017; LaForce et al, 2016; Lynch et al., 2017).

The results of this study are something for me to consider as we move forward and add more schools to our STEM network. The support of the site-based leadership has an influence on the overall culture of the school, but without true teacher buy in, this initiative will lack the strength it needs to move forward, and this may perpetuate inequitable opportunities for students. As a district administrator, I will work to provide PD and support to teachers to develop a STEM-minded community at these and future STEM network schools.

Implications

This study is significant because it will help to understand teacher and administrator perspectives on STEM education to develop a plan so educators can more effectively embrace the implementation of STEM teaching and learning initiatives. Research shows elementary educators believe STEM education is important and there are various reasons for why they

think this is true (Madden et al., 2016). However, for STEM efforts to be successful, the support and buy in of school personnel is essential (El-Deghaidy et al., 2017). Understanding how teachers and administrators view STEM education can help to identify struggles and how to overcome obstacles to make STEM for all learners a reality.

While some research exists on effective STEM schools (Asunda & Walker, 2018; Eijwale, 2013; El-Deghaidy et al., 2017; Felix & Harris, 2010; LaForce et al., 2016; Thibaut et al., 2019), there is little research on STEM networks and how they can contribute to the effective implementation of STEM programs. This research contributes to this topic by further identifying characteristics and struggles of successful STEM-based schools that function as a collaborative network. The results of this study will be used to strengthen the model for STEM teaching and learning that includes a supportive leadership, PD for teachers to learn to use STEM pedagogy (especially as related to the use of technology), and the development of a STEM community that will support a positive STEM culture. Future research could focus on developing and applying the STEM network model in other schools and districts.

Limitations

While the goal of this study was to explore teacher and administrator perspectives on STEM education to increase the use of STEM pedagogy in all classrooms and schools, it represents just one school district's specific initiative. Therefore, the sample size of this study is limited to five elementary schools. Faculty at all 28 STEM network schools in the district were given the opportunity to participate but many of them showed little interest. Participation increased slightly during the second year of the study, but this data is still being analyzed and was not used for this article. However, this data will help to further understand teacher and administrator perspectives on STEM education.

Covid-19 made interviews easier because of the virtual requirements of the district at the time but halted some STEM activities in the district for several months. As stated earlier, many of the STEM events and activities were cancelled for the end of the 2019-2020 school year and resumed in a much different format at the beginning of the 2020-2021 school year. This made it challenging to evaluate the extent to which schools were participating in STEM during the second school year of the study. However, through monthly meetings, it became clear the teachers in this study were coming up with new ways to approach STEM education to address issues associated with the ongoing pandemic.

Conclusions

Findings demonstrate all teachers and administrators in this study understand the importance of and embrace STEM education. But they also identified struggles in their schools with implementing technology and pedagogy associated with STEM. This aligns with previous research that states that although teachers see the importance in STEM education, they may not feel like they possess the skills needed to effectively teach using STEM approaches (Asunda & Walker, 2018; El-Deghaidy et al., 2017). However, the teachers and administrators were able to identify some characteristics of STEM that could allow them to overcome some of the struggles they mentioned. Through collaboration within and between schools in the STEM network, stakeholders, and the leadership at their schools, a supportive STEM community exists to provide resources and opportunities to engage in STEM. This community has the potential to increase teacher buy in and engagement in STEM, which could lead to more STEM opportunities for students.

The teachers and administrators from the schools in this study all saw the importance in STEM education and providing students opportunities to engage in STEM activities. Truly

embracing STEM teaching and learning may require a cultural shift in schools. This culture requires a school-wide emphasis on the values of STEM education and for teachers and administrators to buy in to the process and communicate this to students and other stakeholders (El-Deghaidy et al., 2017; LaForce et al., 2016).

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