Elementary Teacher Self-Efficacy with Design-Based Learning in Virtual and Blended Educational Settings

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Abstract

This study investigates the effect of the COVID-19 pandemic on teacher self-efficacy with delivering design-based learning to elementary students in online or blended settings. This study also identifies what resources and supports teachers need to engage elementary students in design-based learning in online or blended settings. The population for this study was elementary teachers teaching STEM content and included a sample of four elementary STEM teachers from rural and suburban communities. Each participating teacher completed a semi-structured interview consisting of queries targeting both research questions within the study. The results of the qualitative analysis revealed a temporary decrease in teachers' self-efficacy at the beginning of the shift to a virtual environment. A lack of student access to resources at home, the teachers' lack of control and support for the student in a synchronous manner, and a shift in priorities for STEM education contributed to the temporary decrease in the teachers' self-efficacy. To remediate this, teachers reported condensing activities and the Engineering Design Process. They cited fellow educator support, previous coursework, additional time, and access to teacher resources as supports that would be beneficial in the current environment.

Keywords: Integrative STEM Education, Design-based Learning, Teacher Self-efficacy, Elementary Education, Virtual Learning, Blended Learning, Professional Development

Introduction

In Spring 2020, the global education system experienced a shockwave with regulations and precautions implemented to prevent the spread of Coronavirus Disease 2019 (COVID-19) (Dibner et al., 2020). Many schools nationwide went into a virtual format, requiring students and teachers to connect through online platforms (Ferdig et al., 2020). While task forces addressed this urgent global pandemic, teachers faced the action of building a boat as they sailed it in a virtual environment across K-12 education (Dibner et al., 2020). Regulations developed due to the global pandemic were primarily mandated at the state level, forcing school districts to reevaluate their priorities to continue student academics and teacher professional development (Hartshorne et al., 2020). With many K-12 schools transitioning to virtual learning during the end of the 2019-2020 school year, assessments were at the forefront of many teachers' agendas. The U.S. Department of Education worked swiftly to establish guidelines for the Elementary and Secondary Education Act, placing the question of whether or not standardized assessments would continue in the state's hands (U.S. Department of Education, 2020).

With the broader education system reevaluating its' approach to education, the focus on STEM education across K-12 education lost momentum. This study aims to identify the changes of teacher self-efficacy in delivering STEM content using design-based learning throughout the stages of the COVID-19 pandemic, and gain insight into what teachers need to feel more supported in delivering this instructional strategy virtually. Interviews conducted in this research will explore the changing and present realities in implementing Integrative STEM Education at an elementary level, whether students receive in person, virtual, or blended instruction. This study will also reveal the current status of virtual design-based learning as a specific approach to Integrative STEM Education from elementary teachers attempting design-based learning in a virtual setting to identify the gaps that need to be addressed to support teachers using this approach in a virtual environment.

Design-based learning allows students to build upon their analytical thinking required to contribute to a STEM workforce (Change the Equation, 2012). Through design-based learning, students can plan, collaborate, design, construct, and analyze the topics they cover (Fortus et al., 2004). The analytical piece to design-based learning is fundamental in developing higher-order thinking skills. While this pedagogical approach historically takes place in a hands-on environment (Doppelt et al., 2008), the current educational environment demands a shift to virtual strategies for K-12 instruction. Teachers are being asked to push the boundaries and innovate new means to deliver instruction in these unprecedented times (Tsui et al., 2020).

STEM education experiences are necessary for young students as they enter the STEM pipeline in their K-12 education. Sanders (2010) believes the loss of interest in mathematics and science in a child's formative elementary years could form barriers to the STEM pipeline. Foltz et al. (2014) report the elementary years are critical to a students' career development and understanding of career choice. Ball et al. (2017) report the start of the STEM pipeline occurs during a student's elementary years. Elementary-aged students are in the midst of their formative years where STEM education, particularly design-based learning (Doppelt, 2009), is a crucial factor in developing the skills for the future workforce, also known as 21st century skills.

What teachers, particularly elementary teachers, are doing to implement design-based learning, a traditionally in-person and hands-on instructional strategy, in a virtual environment is primarily unknown given the rapid change in the education system. Teachers are now receiving professional development through online or blended learning delivery, potentially affecting whether teachers are learning and still using design-based learning as an instructional strategy in their classrooms. This change may also affect whether teachers feel equipped with the tools and knowledge to implement this instructional strategy for STEM content in an ambiguous environment. The rapidly changing climate in education creates an opportunity for research in this traditionally hands-on instructional strategy. This research highlights the changing self-efficacy in teachers' ability to deliver design-based learning in a virtual environment and identify ways they have been able to navigate accordingly. This study will also shed light on what teachers feel they need to deliver design-based learning adequately in a virtual or blended learning classroom environment.

Definition of Terms

The following terms and definitions provide clarification for the subsequent literature review and study analysis.

STEM Literacy

STEM literacy refers to students' knowledge in STEM disciplines and how they apply to their world. STEM literacy is essential to producing an informed and critical thinking future workforce (National Research Council, 2012). There are various ways to equip students with STEM literacy, but the integrative approach in Integrative STEM Education provides students with opportunities to apply their STEM literacy in real-world challenges (Peterson, 2017).

STEM Education

The emphasis on STEM education, whether taught separately or in an integrated approach, has been a focus of the United States education system for the past 25 years with a move toward more integrative practices (National Science and Technology Council, 2018). For this literature review, STEM education will refer to the broader efforts to increase students' access to instruction and experiences with all STEM disciplines, whether siloed or integrated.

Integrative STEM Education (I-STEM)

Integrative STEM Education (I-STEM) is an approach to STEM education that intentionally integrates technological/engineering design-based learning practices to teach STEM content (Sanders & Wells, 2010). I-STEM education allows for further integration beyond STEM disciplines as students pull on other subject areas for problem-solving to find solutions to real-world challenges.

Design-based learning (DBL)

Design-based learning, or DBL, is an approach to STEM education that allows students to explore content through a robust unit rooted in design where students apply the content they are currently learning to solve an authentic, real-world problem (Doppelt et al., 2008). Design-based learning is an integral part of Integrative STEM Education as students problem-solve through design and creation.

STEM Pipeline

The STEM pipeline refers to the hypothetical pipeline students follow to a future STEM career (Ball et al., 2017). Increasing access to the STEM pipeline and eliminating entry barriers for all K-12 students is emphasized in the education system as the demand for applicants for STEM jobs continues to increase.

Career Choice Development

Career choice development refers to students' development of interest in specific career fields throughout their early life. This literature review will explore factors that lead to students' career choice development and how this may influence students' entry or barriers to the STEM pipeline.

Self-Efficacy

Self-efficacy refers to one's confidence in their ability to complete a task accurately (Bandura, 1977). For this literature review, both student self-efficacy in STEM and teacher self-efficacy in delivering STEM content will be analyzed to provide background information for the subsequent study looking at teacher self-efficacy.

Professional Development (PD)

Professional Development (PD) opportunities allow teachers to expand their knowledge in educational pedagogical practices or content knowledge through workshops, courses, or additional degrees pertaining to a specific field in education.

Literature

The literature synthesized for this study creates a foundation for the emerging elements explored in this research due to the COVID-19 pandemic.

Design-based Learning

Design-based learning is one of the pedagogical approaches for Integrative STEM Education in which students apply content knowledge to solve an authentic, real-world problem (Kolodner et al., 1998). Doppelt et al. (2008) define design-based learning (DBL) as, "DBL enables students to experience the construction of cognitive concepts as a result of designing and making individual, inventive, and creative projects, to initiate the learning process in accordance to their own preference, learning styles, and various skills (pg. 23)."

Design-based learning gives students a fully immersive experience with a new idea, allowing for interdisciplinary education and understanding the interconnectedness of learning across disciplines using the Engineering Design Process. Instead of presenting students with the content and requiring memorization to regurgitate the concept, students interact with the idea, promoting authentic understanding (Fortus et al., 2004). The design component allows students to engage in an iterative process based upon inquiry to find a solution to a real-world problem (Kolodner, 2002; Sidawi, 2009). When applying their content knowledge, creative reasoning in design-based learning is another critical element that promotes student learning (Doppelt, 2009; Lee & Kolodner, 2011). Design-based learning provides students with opportunities to practice and develop 21st century skills essential in the future workforce as they work their way through the Engineering Design Process. To adopt design-based learning and be willing to implement it in their classrooms, teachers must understand the research on the benefits of this pedagogical approach, and be prepared to change their current instructional practices to adapt to the changing education system (Parker et al., 2015).

Integrative STEM Education

Authentic Integrative STEM Education uses design-based learning as an instructional strategy to build on STEM discipline connections, allowing students to see the STEM disciplines as interconnected and not as siloed subjects. Sanders & Wells (2010) define Integrative STEM Education as:

> Integrative STEM education refers to technological/engineering design-based learning approaches that intentionally integrate the concepts and practices of science and/or mathematics education with the concepts and practices of technology and/or engineering education. Integrative STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc.

Integrative STEM Education brings purposeful and intentional technology and engineering design-based learning to students to gain authentic experiences with the concepts they are learning (Sanders, 2013). When administered correctly, students can formulate their thoughts on a topic while simultaneously incorporating concepts and skills from the other science, technology, engineering, and math disciplines.

This approach to STEM education is appropriate across all grade levels, from kindergarten to doctoral students (Sanders, 2013). Sanders (2012) reports Integrative STEM Education as a best practice among STEM education approaches, allowing students to apply problem-solving skills across multiple STEM disciplines in an authentic and meaningful context. The intentional integration of the standards and content is critical (Wells, 2013).

Teacher Self-efficacy and Proficiency in STEM

Self-efficacy, or one's belief in their ability to be proficient at a task (Bandura, 1977), is vital for proficiency. For teachers specifically, their self-efficacy in their instructional delivery is critical to ensuring they are proficient in teaching, which ultimately boosts students' achievement (Barni et al., 2019). Prior research on elementary teachers' self-efficacy with STEM education shows low confidence levels when teaching STEM in an integrated manner (Havice et al., 2018; Bleicher, 2007; Wells, 2010; Wells, 2017). This is influenced by elementary teachers' lack of training in STEM disciplines or exposure to Integrative STEM Education and design-based learning (Wells, 2010). To get students to build upon their 21st century skills through design-based learning, elementary teachers must have sufficient self-efficacy in implementing it with their students. To address the gap in teacher experience in pedagogical and content knowledge with STEM education and engineering design (Guzey et al., 2017), high-quality professional development opportunities need to be available for teachers to build upon their STEM education toolkit and self-efficacy. Due to the recent shift in the education system to a virtual environment, these offerings must also be transferrable to online delivery. To do this, teachers must first feel that professional development is worth their time. Teacher buy-in is essential to successful professional development opportunities (Archibald et al., 2011).

Professional Development in STEM Education

As STEM continues to grow in the education system, demand before the COVID-19 pandemic increased for professional development in various STEM education methods. To feel adequately equipped to teach STEM education, many teachers sought professional development in the content areas of which they are least familiar. Professional development in engineering education has produced positive results in student achievement (Guzey et al., 2017). Preservice teachers also sought out opportunities for exposure to STEM education. Go & Kang (2015) found that science courses in higher education positively influence preservice teachers' self-efficacy with science content.

Many teachers have reported the importance of collaborating with other teachers during professional development implementation (Parker et al., 2015; Kyza & Nicolaidou, 2017). In a study conducted district-wide by Parker et al. (2015), teachers expressed the need for a cohort to feel a sense of community as they approached a new educational strategy. Collaboration, whether through a cohort or through working together during a workshop, encourages teachers to provide feedback and insight from their colleagues, resulting in more self-efficacy with the material covered. Teachers have expressed collaboration as a critical factor in professional development. It is associated with a positive effect in subsequent student results following their teacher's involvement in this collaborative practice (Kyza & Nicolaidou, 2017).

With the past research on the benefits of various professional development methods on teacher self-efficacy, there is a growing field of research in how professional development can support teachers in the virtual and blended learning settings mandated during the COVID-19 pandemic. While many school systems resumed in-person instruction as federal and state mandates were lifted, virtual and blended learning remain as educational settings that gained significantly more exposure as a result of the pandemic.

Demand for Online Education

As the education system evolves, so does the method of delivery across educational fields. Online or distance education for students has become increasingly popular and mandatory due to the COVID-19 pandemic (Ferdig et al., 2020). During the unprecedented global pandemic, online professional development has also been leveraged (Hartshorne et al., 2020). Both online education and online teacher professional development have been used for many years (Renninger et al., 2011), with the evolution of methods in online delivery. Even before the pandemic, many teachers appreciated the convenience factor in online professional development, allowing them to participate from any location with connectivity (Collins & Liang, 2015). In some cases, it allows them to participate whenever it is most convenient with asynchronous delivery. Crepon (2014) also found online learning or 'e-learning' to eliminate costly materials and time limitations. As mentioned, some teachers may continue to elect this delivery method following the COVID-19 pandemic due to convenience.

Online education has been present for over a decade, yet the demand continues to increase rapidly, even before the shift to virtual education settings to accommodate the COVID-19 global pandemic (Klemm et al., 2002). Mackey et al. (2012) conducted a case study in New Zealand to highlight the use of blended learning to address limitations for strictly in person instruction due to a lack of infrastructure caused by earthquakes. Beatty (2019) also developed the Hybrid-Flexible (HyFlex) course design using an approach to blended learning to accommodate students in crises, unable to attend physical classes regularly, or for schools unable to provide proper infrastructure to meet the needs of a growing student body. Higher education institutions have also been utilizing this educational delivery method, increasing demand from students for courses offered online (Snart, 2010). Regarding teacher professional development, teachers have reported the benefits of convenience when participating in online education (Parsons et al., 2019) and the benefits of accessibility for those who are disabled or in remote geographic locations (Kusmawan, 2015). These factors contribute to the literature on the benefit of this method and contribute to the increasing demand for online course offerings in higher education and professional development opportunities for in-service teachers. As the education system evolves and the need for virtual connections increase, the benefits of researching online teacher professional development will become increasingly important to support this increase in demand.

Research Questions

With an increase in the demand for online and blended learning (Snart, 2010; Fullan & Langworthy, 2014), there needs to be an increase in research studies analyzing virtual and blended learning for elementary teachers delivering STEM content in virtual and blended settings for students. Educators involved in online professional development have listed both benefits and challenges to this delivery method (Collins & Liang, 2015; Dede et al., 2005). Past research also highlights the impacts and progress of online and blended learning across K-12 education (Kennedy & Ferdig, 2018).

This study analyzed the evolution of teacher self-efficacy in design-based learning for elementary teachers due to limitations presented by the COVID-19 pandemic to identify the current state of STEM education at an elementary level. The researchers gained perspectives from elementary teachers to provide education stakeholders with information on what is needed to assist elementary teachers as they continued to teach in a new environment. The research questions guiding this study were 1) What is the effect of the COVID-19 pandemic on teacher self-efficacy with delivering design-based learning to elementary students? 2) What resources and support are teachers seeking to administer online or blended learning delivery of design-based learning with elementary students in the current environment?

Methods

This qualitative research followed a phenomenological approach to study elementary teachers' self-efficacy with delivering design-based learning in online and blended learning settings as a result of the COVID-19 pandemic through interviews.

Participants

The population for this research is elementary teachers teaching STEM in an integrated manner. A purposeful sample was required for this study due to the COVID-19 pandemic and the additional pressures on teachers in the evolving education environment. The study sample included four elementary STEM specialty teachers with varying levels of years, from to four to thirteen, teaching STEM education. The sample consisted of teachers who volunteered to participate in this study based on their eligibility as an elementary teacher of STEM content, workload, and ability to participate. The sample included one teacher who taught in a suburban school district and three teachers in rural school districts. Due to the COVID-19 pandemic and participants' locations across the nation, all participant interactions took place in a virtual format.

All teachers who volunteered for this study completed the Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey (Friday Institute for Educational Innovation, 2012) prior to their interview to provide the researcher with additional information on their experience with STEM education. This survey did not contribute to data analysis for either research question. Still, it was instead used as descriptive statistics to provide additional information on the self-efficacy in STEM education of the elementary STEM teachers who volunteered for this study. This survey provided descriptive statistics that all four participants who teach STEM at an elementary level reported an overall high self-efficacy with the Likert scale items regarding Efficacy and Beliefs and Elementary STEM Instruction in the survey tool and are therefore on a very similar level of self-efficacy when analyzing interview responses.

Procedures

Following recruitment for participants, the four elementary STEM teachers received instructions for arranging a one-hour time slot most convenient for the interview participant. For the interviews, all four participants promptly attended during their pre-arranged interview time slot and were guided through the semi-structured interview protocol. For confidentiality purposes, the participants were identified and are referenced in this article using pseudonyms with the key only accessible by the researchers. After the interview, the researchers submitted the interview recordings stored on a Sony Mono Digital Recorder to Rev, a subscription service approved by the institution's Institutional Review Board. Once all four interviews were completed and transcribed, the researchers proceeded with data analysis.

Interviews

Eight pre-determined interview questions addressed both research questions to provide an in-depth analysis of the teachers' self-efficacy, in addition to what they need to feel supported in delivering virtual design-based learning. The interviews followed a semi-structured interview protocol with pre-determined questions for both research questions that were carefully crafted to evoke robust responses and allowed for open-ended discussion. This semi-structured protocol was designed by the researcher based on qualitative protocol recommendations and methodologies set forth by Creswell (1998) and Strauss and Corbin (1990). Six questions guided the participants through their evolving self-efficacy to address Research Question 1, and two questions asked participants their input to address Research Question 2.

Interview Questions

Research Question 1. How comfortable, or familiar were you with implementing design-based learning in your classroom prior to teaching virtually, or in a hybrid format? In the initial stages of teaching virtually, what were your thoughts and experiences with design-based learning as an instructional strategy? As teaching virtually evolved, how did your feelings toward implementing design-based learning with your elementary students evolve, if at all? What is your current comfort with using design-based learning as an instructional strategy with elementary students connecting through a virtual platform? What resources have you used to assist with implementing design-based learning in a virtual format? How has attending professional development affected your comfort with delivering design-based learning virtually?

Research Question 2. What resources do you need to deliver design-based learning virtually with elementary students? What support do you need to deliver design-based learning virtually with elementary students?

Following the teacher interviews, the researchers proceeded with obtaining a transcription of all four interviews. The researchers developed the qualitative codebook and performed the coding to stay rooted in the research and to immerse themselves in the data to help find the common emerging themes. After identifying all possible themes, the researchers developed the codebook to determine the prevalence of each theme across the interviews. Once the coding was complete, the researchers analyzed the coding results for the most common emerging themes among the participant responses (Creswell, 2014). The emerging themes from interview responses are discussed in the results section.

To ensure the trustworthiness of this study, the researchers practiced reflexivity when interacting with the participants throughout all phases of the study. Reflexivity allows the researchers to recognize the experiences they are bringing to the interview process to eliminate any potential for bias (Mallozzi, 2009). The researchers for this study were a doctoral student in Integrative STEM Education with a profession in STEM education, and an assistant professor in Integrative STEM Education. Acknowledging this and practicing reflexivity throughout the study as the researchers interacted with teachers during the recruitment and interview period prevented researcher bias from impairing it.

Results and Discussion

The results from this study and the subsequent discussion aim to bring awareness to teachers' self-efficacy and needs for delivering design-based learning in virtual and blended learning settings.

Research Question 1

As stated, the first research question explored the effect of the COVID-19 pandemic on teacher self-efficacy with delivering design-based learning to elementary students. While the participants did allude to their evolving self-efficacies in their interview responses, the participants mainly discussed the barriers they came across and are still enduring. They also discussed the remedies they have implemented to try to circumvent these barriers.

Evolving Self-Efficacy. The first research question's focal point, teacher self-efficacy, presented itself as an emerging theme as participants referenced their confidence in using design-based learning, Integrative STEM Education, and STEM education as a whole. All participants reported significant experience and high self-efficacy in teaching STEM education prior to the COVID-19 pandemic. Almost all participants reported being well-versed in design-based learning and Integrative STEM specifically. While all participants discussed their initially high self-efficacy in delivering STEM content, all participants also referenced the barriers, limitations, and struggles they have encountered since the beginning of the education system's shift to a virtual environment due to the COVID-19 pandemic. One participant, Sarah, summed up the evolution of their self-efficacy by stating, "The twist with the remote learning, I feel is the materials. So that's where I feel my confidence goes, 'Doing good, doing good.' and then that's where I take a dip." Another participant, Tiffany, referenced their ongoing struggle with self-efficacy in the virtual environment by stating, "... it's just I'm still stuck on how do you do it virtually basically. I have no problem and doubt that I can do it. It's just taking the time to figure it out and making it work." The significant number of barriers the participants referenced as factors contributing to their self-efficacy decrease are discussed in detail below.

Barriers to Self-Efficacy. As a new educational environment to many, virtual and blended learning classrooms presented various barriers for the participants in this study. One of these barriers included the teachers' inability to support elementary students in person or manage what they are doing synchronously. Tiffany referenced their temporary dip in self-efficacy, stating:

> Because when they're in my classroom, I have control over what they're hearing, what they're learning and how they're interacting with each other. But in virtual, I don't Zoom with them. I don't see the kids unless they post a video in Canvas of themselves explaining. But I have no control over if they, number one, if they actually listened or watched the videos or read the lesson, you know what I mean? And then complete the challenge. I think right now it's just figuring that out. I'm confident that I can figure it out.

All participants in this study taught STEM as a specialty course for elementary students. All participants referenced a sudden shift in the priority for students to attend their regularly scheduled STEM course at the beginning of the change to virtual schooling. Tiffany also stated, "...there wasn't an expectation for the kids to complete any specials." They found this as a significant change, stating, "I can say for certain last year before March, STEM was pretty high up on the list."

Remedies. To adjust to the virtual environment at the beginning of the shift to online learning, all participants referenced using condensed or segmented versions of full-length activities or units. While design-based learning lends itself to fully integrate the STEM disciplines, participants referenced having to parse out the pieces of complete design challenges to get something the students could do independently. For example, Tiffany stated, "From March to June, there was very little design other than, like, mini design challenges they could do, but there wasn't like a whole unit." Participants also acknowledged the barriers of asynchronous learning with tackling full units. Another participant, Mark, stated, "And we found all these resources that the kids could work on at their own pace, at their own interests, and at their parents' discretion."

The Engineering Design Process, a key element in working through design-based learning, was referenced by each participant during interviews. Mark stated early on in their interview, "It's so hands-on based that it really handcuffs us in what we are trying to teach in that immersive collaborative purposely layout for how a STEM lesson or a design lesson should be." The struggle to shift from a hands-on approach to a virtual design-based activity was referenced, along with workarounds for ensuring students are still getting segmented experience with the Engineering Design Process despite limited interaction. Mark shared an approach their team has taken by focusing on different elements of the Engineering Design Process that do not require building, but instead require initial design or brainstorming. Taylor and Tiffany also referenced creating units that placed emphasis on the sharing piece of the Engineering Design Process with entrepreneurship.

Another barrier the participants unanimously brought up was a lack of access to resources for the students. Some of the barriers to resources participants referenced included a lack of access to technology, reliable internet connectivity, and online resources or physical materials needed to help with the hands-on aspect of design-based learning. Mark was able to attempt hands-on projects through common household items by stating, "We found at home, design build-it projects. Things you can do with toilet paper rolls and toothpicks." While many participants referenced a lack of capable internet connection for students, Tiffany found that students struggled to log in even with connectivity, stating, " They don't have the apps or the resources at home to do that. I have to think of something else that they can do at home."

Research Question 2

The second research question aims to gain insight on the resources and support teachers need to administer design-based learning with elementary students in a virtual or blended learning environment.

Teacher Support. All four participants emphasized the value of support from fellow teachers in a variety of forums. Support from teachers in their schools, social media Facebook groups, or networking was referenced multiple times across interviews. These types of teacher support ranged from receiving words of encouragement to having the opportunity to sit down together and brainstorm. The participants also mentioned the value of receiving ideas from or brainstorming with teachers while networking. Mark specifically referenced how networking has helped to re-boost their self-efficacy, stating:

> The more that you can collaborate with others and bounce ideas back and forth, the more heads are better than one type deal, that has definitely helped boost our confidence that we can get through this even in challenging times.

Sarah spoke to the power of fellow STEM teachers on social media for their brainstorming purposes, stating, "Seeing other examples of other people making it work, I think helps to inspire me". The value of fellow teacher support resonated strongly across all participant interviews.

Academia. While not explicitly asked in a question by the researchers in the semi-structured interview, three participants discussed pulling on knowledge obtained from their graduate courses in STEM education, some specifically in Integrative STEM Education. For example, Tiffany was still working through applying what they learned in a master's course to the virtual education environment, stating, "I had a class that focused on design-thinking and project-based learning and all that. I really try to, and I'm still trying to work through how that's going to look this year."

Time. During discussions on ideal conditions for implementing design-based learning in a virtual environment, two participants placed time to digest the current situation and strategize accordingly at the top of their list. When talking about shifting design-based learning units to virtual units, Tiffany stated, "It's just taking the time to figure it out and making it work." Mark highlighted another issue they have noticed with needing time during work hours, stating:

> Any of them are teaching full-time, so for them to take the time beyond teaching full-time, some are going home to their kids who they're catching up with their work then at night. And then on top of that, trying to figure out what the heck am I going to teach next week? That's very overwhelming for people.

Needing Access to Resources. The final theme which surfaced from the interviews was the need for access to resources for teachers. The needed resources mentioned across interviews include instructional resources, financial support, technological support and training, physical access to resources and the school building, and professional development resources. Taylor and Sarah specifically referenced the difficulties in providing education as a whole to elementary students in primary ages, given the need to have a certain level of reading comprehension to do most design-based or coding applications on the computer. When looking for access to professional development specifically, Mark stated, "There's professional development out there that we can't afford." Tiffany noted a lack of resources and confidence in asking for them due to shifting priorities, stating "I can say for certain last year before March, STEM was pretty high up on the list." She also stated, "Whereas now I kind of feel bad for asking for anything because I know it's not their top priority."

Conclusions

The findings in this research supported the previous research in elementary teacher self-efficacy (Havice et al., 2018; Bleicher, 2007; Wells, 2010; Wells, 2017), particularly with design-based learning, and contributed to the ongoing research on the effect of the COVID-19 pandemic on elementary teacher self-efficacy in design-based learning. When analyzing the impact of the COVID-19 pandemic on teacher self-efficacy with delivering design-based learning to elementary students, there was clear evidence across all interviews of a dip, or temporary decrease, in teacher self-efficacy. References to the causes of this temporary decrease in self-efficacy in participant interviews included students' lack of access to resources from home, the teachers' lack of control of the virtual classroom environment and inability to support students in person or real-time, and the sudden drop of prioritization for STEM education in schools. This dip in self-efficacy was mitigated through the teachers' ability to develop ways to integrate all or part of design-based learning in virtual or blended learning settings. Teachers reported condensing activities and the Engineering Design Process as ways they initially approached STEM education and design-based learning, if possible, in the shift to a virtual classroom. The shift to virtual learning due to the COVID-19 pandemic affected the participants' previously high self-efficacy in implementing design-based learning through Integrative STEM Education with their elementary students.

In investigating the resources and support the participants' cited needing to administer online or blended learning delivery of design-based learning with elementary students in the current environment, this study revealed several avenues that the education system can explore to support teachers in the current education climate. Participants referenced support from fellow teachers, academic coursework, time, access to resources and professional development as key to using design-based learning as an instructional strategy through Integrative STEM with students moving forward in this altered education environment.

The participants' reference to past coursework in Integrative STEM and design-based learning supports the findings from Havice et al. (2018) on the benefit of professional development with teacher self-efficacy in Integrative STEM and design-based learning specifically. The resources and support participants identified in their interviews are specific to these teachers but should be explored further by education stakeholders interested in supporting teachers during this time. Resources and support are critical when looking at how teachers can continue implementing design-based learning to ensure students experience 21st century learning through this Integrative STEM Education approach.

While a significant amount of the findings from this study revealed the participants' barriers, the participants also reference approaches they have implemented to overcome these barriers since the initial shift to a virtual environment. Supporting additional research and claims from the education community, this research adds to the body of literature supporting the notion that the education system can reinvent itself and pivot in times of a crisis (Lockee, 2021; Rayment et al., 2022; Tsui et al., 2020). The participants in this study developed a way to reinvent design-based learning to accommodate their situation after the initial onset of barriers. Through brainstorming sessions with their colleagues and offering words of encouragement, finding ways to adapt the Engineering Design Process, identifying online resources students can access from home, and carving out time to redesign their initial plans, the teachers participating in this study have already made attempts to reimagine the traditional hands-on approach to design-based learning. The findings presented in this study provide hope for this instructional strategy and offer insight into how teachers and the education system can use design-based learning as an instructional strategy, despite the shift to virtual and blended learning settings.

Recommendations & Future Research

Conclusions drawn from this study emphasize the importance of listening to what teachers need to deliver design-based learning with elementary students and supply them with the resources and support accordingly. From a practice standpoint, educators need access to quick and digestible activities and curriculum to implement in virtual and blended learning settings with their students. Providing teachers with a platform to share and collaborate is also essential in meeting their current needs. From a policy standpoint, schools and administrators must let teachers and preservice teachers collaborate within their teams and across other teacher networks. Allowing teachers additional time during their schedules to communicate with one another and plan accordingly may increase their self-efficacy in implementing design-based learning despite the hands-on limitations and ultimately increase their success in delivering design-based learning in a virtual or hybrid setting (Barni et al., 2019). From a research standpoint, there are apparent gaps where practicing researchers can continue Quick Response Research (Mackey et al., 2012) to meet teachers where they are, as discussed subsequently.

This study focuses on the current status of design-based learning in elementary settings due to the virtual and blended learning settings elicited by the global pandemic but does not limit itself to this unprecedented time in history. Virtual learning is a long-researched topic that many education settings have been leveraging for years (Renninger et al., 2011). As virtual and distance education becomes more prominent for elementary grades due to the current in person limitations, it can become a long-term option for some. If this is the case post-pandemic, research in elementary virtual learning and Integrative STEM virtual education will be needed. An extension of this study to include elementary teachers with varying self-efficacies in STEM education or include teachers in grades 6-12 would help build upon the research needed for STEM education in a virtual setting.

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