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Science Teaching Excites Medical Interest: A Qualitative Inquiry of Science Education during the 2020 COVID-19 Pandemic

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Abstract: The national or local lockdowns in response to COVID-19 forced education systems to rapidly shift from in-person to distance learning. The hasty transition undoubtedly imposed tremendous challenges on teachers, students and distance learning infrastructure. The purpose of this study was to investigate how high school science teachers who had previously been trained in flipped-learning and advanced educational technology through the Science Teaching Excites Medical Interest (STEMI) program perceived their transition to distance learning during this pandemic. In this study eleven teachers were interviewed with a semi-structured interview guide. Data were analyzed using the deductive-inductive content analytic approach. Our results indicated that teachers reported having more confidence in using technology for teaching online due in part to their participation in the STEMI program. They also reported internet access as one of the most significant barriers, both for students and teachers. While some teachers thought that students may feel more in control of learning due to absence of time and place limits with distance learning, others may struggle to stay engaged without the classroom support they would normally have received. Teachers generally experienced increased workloads and harder work–life balance with online teaching. In spite of the unforeseen challenges, the pandemic situation afforded teachers with opportunities to adopt different technology in teaching and foresee the need for technology integration in order to better prepare for the unexpected in the future.

Keywords: COVID-19 pandemic; distance learning; science teachers; online teaching; technology; qualitative

1. Introduction

The global COVID-19 pandemic affected almost all aspects of life. Of particular importance is the stress and strain on education, both from the teaching and learning perspectives. With traditional face-to-face schooling posing health concerns to all involved, many institutions rapidly transitioned away from in-person to distance learning. While distance learning is not a unique pedagogy to many in the United States education system, it can be argued that many prefer to deliver content in the traditional classroom setting and were unprepared for the quick transition.

From the teaching perspective, this transition occurred rapidly and caught many teaching institutions unprepared for the challenge [1]. The process has been described as hasty and haphazard, highlighting insufficient access to technology and the internet in many locations [2]. Experienced online teachers indicate that benefits of online learning occur due to thoughtful planning and experience [3] but for many it became a strategy of "emergency remote teaching" rather than a planned experience. Adding to the difficulty is that almost all teachers were required to move online rather than a select few making a choice to move to online, putting additional strain on limited resources [4].

With proper and adequate planning, online teaching can be as effective as traditional learning strategies conducted in face-to-face environments [5]. However, the COVID-19 pandemic left few with adequate time to plan and prepare for the transition. To make matters worse, many locations in the United States began to issue shelter in place orders in the middle of the spring academic term, necessitating a rapid transition. For most teachers, the transition had to happen quickly, with less emphasis on making the transition effectively [1,6].

Professional development and technology-based outreach programs may have helped curb some of the difficulties associated with the rapid transition. One such program, The Science Teaching Excites Medical Interest (STEMI) program was developed to foster a collaboration between faculty at an academic medical center with local K-12 science teachers [7]. The STEMI program, which began in 2016, brought these groups together to create flipped-learning modules focused on health literacy topics relevant to Mississippi. The program had several goals, including promoting health literacy by creating science lessons centered on specific health issues such as obesity or diabetes, providing professional development to the teachers through science content updates, research methodologies and pedagogical skills, building collaborative efforts between the K-12 teachers and the STEMI investigators, and making available the various technology resources at the academic medical center, as well as provide ways to adapt the teacher resources to suit the needs of flipped-learning. The teachers were trained in use of various technology resources including video recording and editing, and online course management systems. The program helped build various pedagogical competencies aimed at flipped-learning as well as identifying assessment principles for these competencies [8].

The pandemic brought about a unique opportunity for the STEMI teachers as Mississippi residents were ordered to shelter in place mid-March of 2020. Most schools closed in-person teaching, immediately limiting face-to-face interactions, and transitioned to distance learning. While the original aim of the STEMI program was not to prepare science educators to teach fully online, the program's training activities may have prepared the participants to successfully navigate this rapid transition in pedagogy. In order to examine the impact of this technologically focused teacher professional development program, we conducted an exploratory interview study with the teachers participating in the STEMI program. The aim of this study was to understand how these high school science teachers transitioned their teaching during the COVID-19 pandemic, with a focus on understanding what kinds of technologically engaged instructional methodologies were utilized.

2. Materials and Methods

For this study, teachers participating in a longitudinal teacher professional development program, STEMI, were invited to participate in semi-structured interviews. We

used purposive sampling as it is a widely used technique in qualitative studies due to its effectiveness in identification and selection of individuals who have rich knowledge in and experiences with a phenomenon of interest [9].

Briefly, the STEMI program offered an intensive summer professional development experience focused on developing instructional skill utilizing flipped learning methods. The participants were high school science teachers in Mississippi. Due to their participation in the STEMI program prior to the COVID-19 lockdown, many had already delivered some course content online and begun incorporating a variety of technologies within their classrooms to enhance student learning.

The semi-structured interviews utilized an interview guide that consisted of a mix of 16 open- and closed-ended questions (included as Appendix A). The purpose was to gain insight on how schools adapted to distance learning, technologies utilized by teachers for distance learning and the impact of distance learning on teachers as well as their perceived effects on students. This study was approved by the University of Mississippi Institutional Review Board (protocol #20-203) prior to recruitment and data collection.

Teachers were invited to participate via email. A description of the study, a link to schedule a time for an interview, and an information page and recording release form were included in the emails. Teachers could schedule an interview at a time convenient for them. The interviews were conducted via telephone and were recorded if consent was given by the interviewee prior to beginning the questions. The interviews ranged from 15 to 30 min. Recordings were transcribed using Trint (an automated transcription service) and then edited by researchers for potential corrections to transcriptions.

Data were analyzed using deductive-inductive content analysis [10]. Guided by this analytic approach, all interview transcripts were analyzed by three researchers. In the first phase, content analysis with codes established by the study aims was conducted. The process was continued with an inductive approach, continually modifying the existing codes, and creating new codes based on the study data. Each researcher independently completed coding, and then compared their analyses, examined the overlapping or shared themes, and came to an agreement on the final findings.

3. Results

A total of 11 teachers were interviewed (64.7% response rate). The majority of the participants were white (81.8%) and female (90.9%).

Four themes emerged from the interviews: (1) school adaption to teaching during the lockdown, (2) teacher perception of student experiences during the transition, (3) teaching challenges during the transition, and (4) the impact of the pandemic experience in teachers' professionalism. Alphanumeric characters followed by each quote represent participant numbers in our anonymous coding, for example, P1 represents participant number one.

3.1. School Adaption to Teaching during the Lockdown

All participants reported that the learning format in their respective schools was modified to a mixed format, including online delivery and paper packets for students who did not have access to the Internet. Internet access was a significant issue especially in rural areas, and drove the decision to utilize a mixed format:

> *A lot of our students didn't have (Internet) access and maybe didn't even have the technology needed to complete online coursework . . . so what we did for them was a paper packet.* (P2)

The teachers reported using different technologies to conduct online teaching. The teachers utilized Zoom or Google Hangouts as the primary communication tools. Camtasia and Screencastify accounted for screen recording software used by the teachers while Edpuzzle was used to create interactive videos. The teachers reported using Canvas as their primary learning management system.

Considering the varied technology tools that were used in most of the teachers' work, the teachers' STEMI experience was reported to have facilitated the transition during the pandemic in multiple ways:

(STEMI) It's taught me how to network with other people of like minds. Several of us in the STEMI program have shared resources back and forth to use with our classes. (P6)

I have a lot of confidence as far as setting it up . . . I think with STEMI, what happened was that it gave me the confidence to say, OK, this is what we're going to do and commit to it and get it done. (P8)

(It helped me) most definitely, because I learned a lot from the two-week summer program that we had as far as where to find information and how to use the information to present it to the students. (P3)

Using the technology from the STEMI program and experiencing the flipped classroom approach, I knew I had a lot of resources I could pull from. (P4)

The teachers' reported involvement in decision making process regarding the teaching format varied for different schools. While some teachers had a say: " . . . we were asked, and teachers did discuss together what to do." (P2); some others were invited to watch only: "We were invited to watch the board meetings online, but as far as I think it was just them, as far as making the decision." (P3).

Additionally, an issue identified was grading consistency in different schools, referring to schools applying different grading standards during the pandemic time:

"I wish that there would have been more of a consistency with the grading across the state, just so the students could all have the same some opportunity." (P7)

3.2. Teachers Perceptions of Student Experience during the Transition

Some positive aspects of online classes for students, from teachers' perspectives, were the ability to re-watch the content for students struggling with classes, the extended possibility for optimal time management related to classwork, offering a more optimal learning environment to introvert students, and being a valuable experience for mastering the online skills.

I was really shocked with how well the introverts really preferred this way . . . They were doing incredibly well because they could regulate their own way of doing things. There were also a lot of students that would normally struggle just because they can't keep up with the pace in the class. I could tell those students were doing incredibly well because they could re watch any content that they needed to. (P5)

I think they've already mastered that to where they'll be much better able to adapt if they have to continue online. (P9)

However, there were also many distance learning challenges that the teachers thought students had due to the transition, such as the lack of self-discipline among students, loss of nonverbal cues in communication, lack of social interactions, and potential increased risk of distress.

We were just told to put stuff online and let it be self-paced. I'm finding very quickly that the kids that I teach need me behind them to push them. And the idea of self-paced doesn't really work. (P6)

We have had a decrease in content knowledge because no matter how much you go over it. You can't read their expressions to see if they're comprehending. (P1)

. . . Those are social learners. And so, you know, all of a sudden, they're by themselves or they're with their siblings or whatever, but they are definitely missing just that whole rounded classroom atmosphere. (P2)

My concern is they didn't do, a lot of them, didn't do the work. The kids that did not need the grades were the ones that did the work, and my other concern was the kids that

needed school as an outlet, from basically getting away from whatever problems at home, they were probably overwhelmed. (P11)

Additionally, teachers reported challenges of students with learning disabilities during the COVID-19 pandemic. One teacher mentioned that these students need the structure at school and people to check on them, making sure they are on the right track, but they were lacking this attention, and this did not translate well in students' success. Another teacher reported to have had more individualized conferences with some students who had anxiety and needed to be guided through more organized work. Furthermore, social concerns, such as students living in multi-family apartments, and students that had to work for income and pause the education process, were reported by teachers as well.

3.3. Teaching Challenges during the Transition

The process of transition to an online teaching format was accompanied by many challenges reported from the teachers, for example the time-consuming lesson planning process, technical and connectivity issues, challenged work/home balance, the lack of a collaborative environment, and the lack of in-person interaction with students.

The main challenge for me was the time that it took. I mean, a lot of time and effort went into switching over into this format of distance learning. (P2)

I don't have Internet . . . didn't really attempt the video where I can talk to the kids and just video work or Zoom or anything, because I'm not someone that had the capability to do something like that. (P10)

It was really hard just turn off work . . . that was a struggle because it was always here. Like there was no excuse. Every single thing that I needed was right here with me. (P5)

I'm so used to sitting down collaborating with my colleagues. That was kind of hard . . . So, it's hard to collaborate and say, OK, this is what we're going to do, this is what we need to work on. (P11)

To get a sense of closure has been difficult for me personally and for a lot of the kids, too. I've gotten a lot of messages from the kids. That's been hard. (P6)

3.4. The Impact of Teaching during a Pandemic on Teachers' Professionalism

Many teachers reported that their technology skills have been improved because of the online teaching format during the COVID-19 pandemic. For example, one teacher expressed:

"I would say it helped me to grow . . . I mean, the longer you do it, I think the more you're exposed to, the greater your abilities become in that area and you feel more comfortable." (P9)

Additionally, the pandemic was reported to change the teachers' outlook on their pedagogical practices and content delivery formats.

It has changed my outlook on more student pedagogical practices and what are the best ways that I can be doing things, even if we do go back . . . I think I'll probably always use 100% flipped and still have those engagement times in classes, because it gives every kid the opportunity to see all that content in the way that they do best. (P5)

Furthermore, this teaching format revealed another realization from teachers' perspective, highlighting the advantages in engaging more with parents. One teacher explained that all stakeholders have to be involved for better success:

"I think it needs to be engaging with parents if the parents are able to . . . I think this pandemic probably reminded us more so of anything that everybody needs to be involved to help out. I don't think you can rely on just one group." (P5)

Finally, after going through the transition process to the "pandemic teaching format", which included both paper packets and online teaching, teachers expressed the need of a plan for such situations in the future.

Be prepared. Yes. Always be prepared. Have many extra copies of material, which might be a flash drive to start at your house . . . You can have stuff ready just in case something like this happens. (P10)

From this transition, I think it's going to be important moving forward that every teacher already has something like Canvas, some type of plan to where if something unforeseen happens and you have to go to online, your students are already aware of how to do it. (P9)

4. Discussion

The global education system was severely impacted by national or local lockdowns in response to COVID-19. In Mississippi, schools were forced to close in the middle of the spring semester in 2020. The unforeseeable shift from face-to-face to distance teaching and learning undoubtedly imposed tremendous challenges on teachers, students, and distance learning infrastructure. All teachers interviewed reported that their schools made a rapid transition to a mix of distance learning and paper packets. Though some considered this shift to be necessary and important for the continuity of student learning [1,11,12], many other practicing educators reported that the shift was abrupt, difficult, haphazard, and left them unprepared [1–3,13]. The shift was especially challenging for those who were in areas without adequate distance learning infrastructure and Internet access. Half of Mississippi's population lives in rural areas [14] and not having Internet access was reported as a significant barrier during this transition. Similar issues were reported in other areas in the US and countries around the world such as Canada, Italy, Spain, Egypt, South Africa, Nigeria, Pakistan, Israel, Singapore and Indonesia [2,3,6,13,15–20]. During the transition process, our participants reported that decisions were normally made at the leadership level with little to no consultations with classroom teachers. Such practice was also seen in other studies [6,21,22].

Teachers in the present study indicated the most popular technology platforms to include web conferencing software such as Zoom and WebEx, Google suite for education such as Google classroom, Google Docs and Google Hangouts, and learning system management applications such as Canvas. Similar preferences for use of these distance learning platforms have been reported in other studies in the literature [18,20]. How to use such technology sufficiently and effectively has been cited as one of the main challenges in the pandemic for both educators and students [1,18]. One of the key findings of this study was that our participants already had training on the use of a variety of technology software and the flipped classroom model. These training experiences were designed to enhance their STEM teaching through the STEMI training program prior to the pandemic [7]. This training may have better prepared them for this transition compared to their teaching peers who had not participated in this kind of professional development. These teachers also indicated an increase in confidence in being able to transition to distance learning, aided in a variety of technologies that they were able to adapt for their use.

From the students' perspective, the participants in our study observed both positive and negative experiences of students, which was consistent with the literature. Distance learning set no time and place limits. Students were in control of the pace of their learning. Others have reported this freedom to increase students' participation, promoting greater interest in the learning materials, and improving both student learning efficiency and quality of learning [1,17,19,23]. These positive attributes were balanced by the fact that other students, especially students with learning disabilities, struggled to stay engaged without the classroom support they would normally have received. In-person social interactions and social cues, critical for their success, were not as available in the remote learning environment. Psychological studies by Besser et al. [3,24] revealed that online learning induced negative emotions including anxiety, boredom, frustration, motivational deficits, and disengagement. Through a sociological perspective, the school serves as a social system where students interact with others and occupy social roles [25,26]. School closures

during the pandemic made this social system unreachable, hence created unprecedented social isolation and negative psychological effects [27].

From the educators' perspective, the sudden shift from in-person to distance learning added exponentially to their workload as they were re-conceptualizing their teaching practice to suit the online platform and experiencing the learning curve of new technology in an already difficult pandemic context. The shift was so rapid that teachers were not provided with sufficient resources and training to be successful. Internet access and connectivity issues were reported to be the biggest challenges to maintain teaching continuity and connection with students. Work–life balance became obscure as work and life took place at the same place—their homes. Collaborations with peer educators became less attainable due to physical separations. Girelli et al. [6] reported similar findings, indicating this is an important issue to consider in planning for future potential educational disruptions. The current study's findings may highlight a significant challenge for quick transitions to distance learning. Teachers need access to technology resources and time to adequately plan. Even if a teacher is knowledgeable in the technology, having to work at home may limit access to using these resources, particularly if they require stable and fast internet connections.

Compounding the issues of the rapid transitions is that online teaching has been consistently reported to be more time-consuming than in-person teaching [28–30]. Delgaty [31] found that sixteen hours of staff time—11 h of academic work, one and half hours of administrative work and three and half hours of technical work—were needed for an one hour online student activity; and about four hours of moderating and facilitating time were required for each hour of online student time. Tasmanian researchers found that it took an average of ten hours to plan an hour online lecture [32]. In addition to the additional time commitment, online teaching also requires proficiency in technology use, course planning and organization, the creation of a supportive and collaborative environment, and communication skills [30]. As a result of time strains and competencies needed, it was natural that psychological stress of educators has been reported to be higher during the pandemic [33]. On the positive side, the situation afforded educators opportunities to adopt new technology, practice online pedagogical strategies, and build partnerships with parents or caregivers that they would not have otherwise done under normal circumstances.

Based on the findings in the current study, we hypothesize that teachers undertaking technology professional development, such as STEMI program, may help teachers be better prepare for the unexpected in the future. Educators in our study expressed an increased confidence in using technology due to the STEMI program, but also cited the need to improve technology skills and integrate more online components into their everyday teaching. These concepts have been explored in the Technological, Pedagogical and Content Knowledge (TPACK) framework developed by Mishra and Koehler [34,35]. This framework provided a way to describe the knowledge teachers need in order to incorporate technology into their teaching. Technology is constantly changing and access to any specific technology is not consistent, as indicated by the teachers in the current study. Saubern and colleagues [36] made clear that it was not simply knowledge of technology that made effective teaching but rather that it was a unique way of thinking knowledge of technology was integrated with content and pedagogical knowledge. The interaction of these types of knowledge, produced 'flexible knowledge' that was essential to successful teaching with technology [35]. The current study found that exposure to a technologically focused professional development program was reported to be instrumental in teachers' pedagogical approaches during the pandemic. It is likely that the professional development program effectively improved the technological pedagogical knowledge of the participants. Xie et al.'s [37] TPACK evaluation after a one-year implementation of a technology-incorporated professional development supports this inference, as does Bicer & Carprao's study [38].

While this study provided in-depth findings and insightful information on the transition of STEM education from in-person to distance learning in Mississippi during COVID-

19 pandemic in 2019, it has limitations. First, due to the qualitative nature of the study design, the generalizability is limited and would need to be explored using quantitative research methods. Subsequent analyses using student performance data would also be beneficial for future studies. In addition, because our sample came exclusively from the STEMI participants, future studies should investigate a control group that has not had exposure to technology based professional development. Finally, due to the brief interactions with the teachers for the interviews, an in-depth exploration of their ideas was not feasible given their teaching responsibilities. The increased demands on the teachers' time required the researchers to be mindful of the teachers' time commitments to the interviews.

5. Conclusions

The rapid transition to from in-person to online teaching and learning due to COVID-19 unquestionably imposed substantial challenges for both teachers and students. This study explored the STEMI participants' experiences of their educational transitions from in-person to distance learning during the COVID-19 pandemic. Teachers participating in the STEMI program reported a higher level of confidence in transitioning to online, possibly due to the program's focus on technology use. Additionally, internet access was one of the most significant barriers for both teachers and students which may be more problematic for a rural state like Mississippi. During this transition, popular technology used included web conferencing software such as Zoom, Google suite for education such as Google classroom and Google Docs, and learning system management applications such as Canvas. Teachers reported that they perceived that while some students felt more in control of learning due to the absence of time and place limits with distance learning, others struggled because of lack of interest, self-discipline and in-person supervision. Teachers generally experienced increased workloads and harder work–life balance with online teaching. Despite the unforeseen challenges experienced by all, the pandemic situation afforded them with opportunities to adopt different technology in teaching and foresee the need for technology integration in order to better prepare for the unexpected in future.

Appendix A

Interview Guide

1. Are you 18 years of age or older? (If no, interview stops)
2. How has your school adapted teaching in this time? (e.g., Did you go online, students pick up packets, etc.?)

3. How was access to technology assessed for your students (Wi-Fi, computers, city/town bandwidth, homeless/displaced, low-income, rural)?
4. Were teachers involved in any decision-making regarding online learning before/during this pandemic? How so?
5. What kind of technology (hardware, software, online resources, aps) are you using in your teaching now? What was supported/provided by your school and what are things you are using on your own (e.g., school is a Google school, I am also using podcasting via a podcasting platform)
6. About how much have you spent out of pocket to adapt and teach? What were these costs for? How are these expenses different to other times you have purchased supplies for your classroom using your own money?
7. Has your participation in the STEMI program helped you make this transition? Describe how.
8. In general, how have your students done with this transition?
9. What do you think will be the impact on their learning?
10. How do you ensure students with learning disabilities can participate in online learning?
11. Do you feel teachers have a responsibility of taking additional measures maintaining contact with students who are at-risk academically?
12. What challenges have you experienced related to teaching you experienced in this transition?
13. Have you seen any positive effects for you and/or your students in this transition?
14. How will this teaching experience impact you as a professional? What technologies and/or practices, if any, will you continue to use in the future?
15. What lessons have you learned?
16. Any other thoughts/feedback about the project?

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