

Influence of the COVID-19 Lockdown on High School Mathematics Teachers' Beliefs About Using Digital Resources

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This study examined the impact of COVID-19 on the beliefs of high school mathematics teachers in Pakistan regarding the use of digital resources. Participants were six mathematics teachers from both private and government schools with varying years of teaching experience. The responses indicate that despite facing issues, teachers' beliefs have significantly changed due to COVID-19 online teaching. Teachers' beliefs are subject to the opportunities and constraints that exist in the social context of teaching mathematics, which includes the influence of students, parents, schools, peers, and senior teachers. The regular practice and use of digital resources may further deepen teachers' beliefs and their use in mathematics teaching.

Introduction

During the COVID-19 pandemic many teachers became more interested in digital resources (Scully et al., 2021). Their positive beliefs and attitudes supported the transition and substantially increasing the use of digital resources (Alberola-Mulet et al., 2021). However, the transition was not easy. Especially, for developing countries such as Pakistan the challenges were gigantic. The quick transition was largely dependent on the availability of digital resources and internet connectivity at both ends of the teaching and learning spectrum. Secondly, it required changes in curriculum, content, teaching methods, and teaching skills (Clark-Wilson et al., 2020). Later, however, more essential and "deeper changes" were required i.e., changes in "teachers' beliefs" towards using digital technologies.

In Pakistan, mathematics teachers traditionally rely on direct teaching approaches (Amirali & Halai, 2021). Due to the COVID-19 lockdown, there was a sudden and significant surge in online learning. Teachers were rushed into adopting and transitioning to online education and ensuring students' educational needs were taken care of during the pandemic. Principally, the school closures stimulated the use. However, teachers' social contexts, digital skills, and their confidence in working in an online environment may also have played an important role. Which poses a significant question for researchers: how, and if so to what extent, has the sudden transition to online education and use of digital resources influenced teachers' beliefs about digital resources in Pakistan.

Historically, at the school level, the use of technology is not common. Mathematics teachers may possess strong subject content knowledge, but they have been inadequately trained in the use of technologies and lack the confidence to integrate digital resources into teaching and learning mathematics (Asad et al., 2020; Jafri, 2020). Additionally, previous literature (pre-COVID-19) about Pakistan's high school mathematics teachers never predicted or measured the unprecedented level of mental readiness that could support a fully online teaching environment. Limited literature exists that measures teachers' beliefs related to curriculum, assessments and the nature of mathematics (Amirali & Halai, 2021), and there is also a lack of research on teachers' beliefs and the changes in beliefs relevant to the integration of digital technology. Therefore, after almost 18 months of school closure and managing to teach and learn online, it appears to be an appropriate time to understand Pakistani mathematics teachers' beliefs about digital resources.

The Purpose of the Paper

The purpose of this paper is to present the qualitative findings of mathematics teachers' beliefs and changes in beliefs towards digital resources due to COVID-19 online teaching and learning. The findings are part of ongoing doctoral research designed to understand the digital competencies of mathematics teachers in Pakistan. The main study has two phases: Phase 1—an online survey and Phase 2—semi-structured interviews of mathematics teachers. This paper focuses on Phase 2 data obtained from interviews conducted with six mathematics teachers. The following section presents a brief literature review concerning teachers' beliefs towards mathematics and the use of digital resources in mathematics. After a brief description of the methodology, the paper proceeds to the findings and discussion.

Literature Review

Understanding teachers' beliefs has been a focus of attention in educational psychology (Ernest, 1989; Pajares, 1992; Schoenfeld, 2011). To understand why teachers do what they do and how they behave in response to different pedagogical situations, there is a need to understand teachers' system of beliefs (Schoenfeld, 2011). Teachers may hold identical or different beliefs based on their personal life experiences, socio-cultural and religious contexts. Teachers' beliefs provide understandings, judgments, evaluations, and justification of their teaching practices (Pajares, 1992).

Partly integrating differing characteristics of teachers beliefs articulated by Ernest (1989) and Pajares (1992), mathematics teachers' beliefs may be defined as, opinions, dispositions, (pre)conceptions and philosophies that mathematics teachers hold about the nature of mathematics and its teaching as a whole, and which influence their approach to mathematics teaching and learning. For example, a teacher could develop a self-confirming bias about a particular teaching practice or give preference to mathematics textbook because this is how they learned as a student. Such biases and beliefs may inhibit their desire to changes teaching practices (Pajares, 1992) and are normally unaffected by new information (Karatas, 2014). Beliefs change when the social context of the teaching situation and the teacher's level of thought processes and reflection change (Ernest, 1989). Influenced by the social context, teachers are likely to adopt the same teaching methods despite holding differing beliefs about mathematics. It also plays an important role in the adoption of technology. As such, witnessed during the pandemic, the change in social context and settings (COVID-19 restrictions—social isolation and distancing) intensified the personal and professional uses of video conferencing, virtual collaboration, and social networks, and other digital resources. Teachers' views also changed, for example, Morge (2020) used screen-sharing during online video conferencing for problem-solving that improved teachers' confidence in digital resources. Similarly, Carey et al. (2020) observed changes in teachers' beliefs towards online teaching when they employed breakout rooms for collaborative problem-solving. This suggests transformation of beliefs happen when changes in teachers' practice produce expected teaching/learning outcomes consistent with their social context.

Pajares (1992) argued that whoever uses “beliefs” to define teachers' practices and decisions need to find a clear distinction between teachers' beliefs and knowledge because “it is difficult to pinpoint where knowledge ends and belief begins” (p. 309). When compared with knowledge, teachers' beliefs are disputable, inflexible, and less dynamic. Therefore, they are not easily persuaded or changed by reason or argument. Beliefs changed when teachers saw the pattern of pedagogical reality change or when teachers' fundamental approach or underlying assumptions were changed, i.e., a shift in teaching paradigm (Pajares, 1992), whereas the knowledge provided both affordances and constraints regarding what a teacher can and cannot do in a pedagogical situation (Schoenfeld, 2011).

Negative or positive beliefs about digital technology can influence its use accordingly. The evidence suggested that during the pandemic positive beliefs and affordances increased teachers' confidence in digital technology and its potential to enhance outcomes for learners (Scully et al., 2021). Teachers were able to create innovative and supportive communities, collaborate for problem-solving, hold online conversations, and share resources thanks to the affordances of persistence, visibility, spreadability, and searchability made available by accessible technologies (Carey et al., 2020). However, Christopoulos and Sprangers (2021) suggested that although the pandemic served well to enhance teachers' digital skills, it was important to keep an eye on concerns and constraints as they affect teachers' beliefs. Calder et al. (2021) found that during the pandemic, teachers were unable to find support related to digital applications. Reich et al. (2020) identified that many teachers struggled to motivate students during online sessions. Teachers who were unfamiliar with digital tools felt isolated and suffered a loss of self-efficacy and professional identity. Also, less privileged students from developing or poor countries with limited or no access to digital resources, became victims of social and economic inequalities and were unable to continue education during the pandemic (Ndambakuwa & Brand, 2020). These are important social contexts and constraints relevant to teaching online, which may affect the beliefs of teachers who experienced similar issues during the pandemic.

Pakistani Mathematics Teachers' Beliefs

In the context of Pakistani mathematics teachers, mainly socio-religious experiences, school education, and pre-service training experiences shape their beliefs about teaching mathematics (Amirali & Halai, 2010). They regard mathematics as a constantly evolving discipline, where mathematicians continuously revise their invented body of knowledge while everyone else consumes it (Amirali & Halai, 2010). They use direct teaching methods with a strong emphasis on delivering textbook content (Amirali & Halai, 2021). Technology is infrequently used in teaching because teachers believe it to be complex, expensive, and scarce (Dundar et al., 2014). Whether good or bad, these are traditional beliefs that contribute to low student achievement levels throughout Pakistan, as evidenced by the fact that a significant proportion of school leavers (especially from government schools) do not achieve the minimum standards in mathematics that are required by the curriculum (Dundar et al., 2014). Interestingly, most teachers regardless of their professional role (government or private), gender, or teaching experience, hold identical beliefs (Amirali & Halai, 2021).

In a comparative study of Pakistani government and private school mathematics teachers, Shiraz and Qaisar (2017) found that teachers' beliefs are not entirely aligned with their teaching practices. These factors, such as classroom environment, resource availability, senior teachers and career opportunities, influence Pakistani teachers' teaching practices, hence they make decisions against their beliefs (Shiraz & Qaisar, 2017). Christopoulos and Sprangers (2021) regard these factors as first-order barriers to successful technology integration efforts in schools, while beliefs, attitudes, confidence, and skills are second-order. However, any of the first or second-order barriers, a piece of new knowledge, or a situation may influence teachers' use of technology for teaching (Christopoulos & Sprangers, 2021). As evidenced by the COVID-19 situation, many teachers, regardless of their beliefs, employed digital resources for online teaching and learning (Alabdulaziz, 2021). Their beliefs and attitudes changed as they experienced the "ease of use" and recognized the "perceived usefulness" of digital resources in mathematics teaching (Scully et al., 2021). Therefore, it is important to consider the influence of both "situations" and "factors" that bring changes in teachers' beliefs and, consequently, the teaching-learning process.

Methodology

As mentioned earlier, this paper presents COVID-19 related qualitative findings, which are part of an ongoing mixed-methods doctoral study. The main study collected qualitative data using semi-structured interviews. The participants were mathematics teachers who volunteered for individual interviews during an online survey. The aim was to recruit high school mathematics teachers with varied years of teaching experience from both government and private schools in Pakistan's rural and urban areas. Based on the criteria six teachers were selected and coded as T1 to T6. The final six included two (02) teachers in private schools and four (04) in government schools. Two (02) were female and four (04) were male with teaching experience ranging from four (04) to twenty (20) years. Due to COVID-19, the interviews were conducted and recorded online using the Zoom video-conferencing application. The data were collected using the following specific questions related to COVID-19 teaching and learning:

1. *What beliefs do you have about digital resources? What do you say about using digital resources in mathematics teaching?*
2. *To what extent, if at all, have your beliefs about the use of digital resources changed due to COVID-19?*

The data were analysed using themes and sub-themes that emerged from larger data collected during the mathematics teachers' online survey (Phase 1 of the study). The aim was to look for connections within data and identify thematic patterns.

Findings

This section presents the findings of the interviews conducted with mathematics teachers. The two main themes are explained using the interview codes. The first theme explains teachers' beliefs about digital resources in Pakistan. The interviews were conducted during the COVID-19 lockdown, their responses are, therefore, most likely to have been influenced by how they needed to cope with COVID-19 and may reflect some anxiety as they began using digital resources for teaching that they may not have used before.

Beliefs About Digital Resources

In response to the first question, the majority of teachers agreed that digital resources play an important role in mathematics teaching and learning. Most of the teachers indicated that they "never used" digital resources before the pandemic because they were not available at their school. The pandemic presented a unique opportunity to "self-learn" the use of digital resources with the "help of peers" and enhanced their "digital skills". For instance, T2, a male senior teacher, teaching in an urban government school for 20 years, mentioned:

I had never used digital applications before COVID. We didn't have them at school, not even at home. Recently, I bought a ThinkPad in instalments. My friend showed me how to use it. Now, I can send links, digitally write and solve math problems, share pictures and notes. If a student asks a question, I can write, type, and share the answer on the screen. Now I see how useful and comfortable it is.

He further added:

As COVID is all over these days, you can't survive without digital things. Students are at least connected with education If not 100%, then at least 50 % are learning... Today I took the Zoom class from home in which 50% of students were present. Digital resources are very useful for students who want to learn. Those who don't want, don't even study in the face-to-face physical environment ...

T3, a female teacher, facing issues of "lack of digital resources," explained:

We can't use digital technology much. If we used audio-visual aid in our school, it would definitely help students and teachers, but we can't use them.

In Pakistan, the state of technology infrastructure and funding in private schools is better compared to that in public schools. However, T3's response was contradicting the general presumption. Therefore, the researcher asked her to elaborate further. She replied:

Because there is no system, there is no such thing (digital resources) right now in the school. The real problem is that we can only teach here with a textbook and whiteboard. We don't have any other tools here At the same level at which we learned from our teachers, we are also teaching our students. Actually, digital learning is not so much appreciated here. I know I can use them if I want to But we have to follow what the headteacher tells us to do or use ...

A teacher at a government school (T4), who was previously teaching in a private school, replied by comparing private and government school students' ability to "access technology."

It is easy to teach online to the students in a private school. They can afford digital technologies, but not public-school students. The majority of them complain about not having Internet access at home.

T5, a male government schoolteacher from a rural area, mentioned that they do not have the "facilities" and their "teaching method or style" does not require digital resources:

We should learn the use of digital technologies. Neither do we have the facilities, nor do we do the type of teaching that requires digital tools. Especially when we talk about the government sector, there are no such things as digital resources. We only use WhatsApp to communicate with each other.

T6, another male but fairly young teacher in a government school also mentioned "limited or no use" of digital resources. He explained:

I think digital resources are very helpful, especially videos are very good. But unfortunately, we don't have much use for these resources, and we also don't have ideas about their uses.

Changes in Beliefs

In response to the second question, the majority of the teachers agreed that their beliefs about digital resources have changed after teaching online during COVID-19 lockdown. T2, experienced a significant shift in his beliefs about digital resources. The "affordances" of "video conferencing application" (Zoom) and "ease of use" impacted his beliefs, he explained:

But since I started using the digital resource, it seems that the world is not over. Your home could be your classroom via Zoom Honestly, before COVID, I was not aware of the potential of digital resources... I used to travel a lot to give private tuition in the evening. Now I can give them using Zoom while sitting at home with my family. It's very easy ...

T3, a female teacher at a private school not only observed changes in her beliefs but also in "peers" and the school leadership (principal). However, she thinks the senior teachers were resistant to change and were not motivated to learn new digital skills. She described:

More than me, the beliefs of my colleagues and principal have changed. They have realised that if it were not for smartphones and the Internet, we would not have been able to teach students. Now they think that technology is good. Before COVID, some (senior) teachers did not even know how to use the Internet (Zoom) ... they were not skilled and did not want to learn, so we had to take their classes.

T5, a rural government schoolteacher recognised digital resources and online learning as an aid to "self-learn" skills that the government is unable to provide. He explained:

My beliefs have changed quite a lot. Because of online education during COVID, now I know how I can improve my skills using online education, where to download resources and how to use YouTube channels. Now, I use online content for learning and teaching. I also share links with my students.

T6, another male teacher at a rural government school acknowledged that the use of technology has increased due to pandemic, he explained:

Before COVID, nobody was talking about digital resources in Pakistan, but now everyone is talking about Zoom and WhatsApp. Recently, many students told me that during COVID they were taking classes online and learning from YouTube. The use of digital resources has increased quite a lot.

However, T1 and T4 did not evidence many changes in their beliefs. Both teachers considered online learning needs time to take effect. For T4, the role of “parents” was the key to the successful implementation of online learning, whereas T1 thought face-to-face teaching needs to be further enhanced with digital resources rather than focusing on online teaching and learning.

I still believe that students should not be allowed to use digital devices such as smartphones. It is very hard to monitor the activities of (high school) students on smartphones. They are adults and know how to dodge their parents. Children from lower-middle-class families attend government schools. The parents have no understanding of how to use or monitor digital technologies.

T1 proposed:

After teaching during the lockdown, I think online teaching and learning is too early for our students. We need to find ways to increase the use of digital resources in our face-to-face classrooms.

Discussion and Conclusion

This paper reports on an investigation into Pakistani mathematics teachers’ beliefs about the use of digital resources and how the sudden transition to online education and the use of digital resources may have impacted their beliefs. The findings suggest most teachers hold positive beliefs about using digital resources for teaching and learning mathematics. In general, this is consistent with other studies related to mathematics teachers. In contrast to previous studies (Dundar et al., 2014) in which teachers find it complex and difficult to use technology, the majority of teachers in this study found it relatively easy to transit to online teaching and learning. This indicates that teachers already had knowledge and positive beliefs about the digital resources. Regardless of professional role (government or private), teaching experience, and gender, all teachers share a common belief that lack of resources, funding, and internet connectivity are the main barriers to the use of digital resources. These barriers exist for both students and teachers. Christopoulos and Sprangers (2021) called them the first order barrier, which impacts teachers’ beliefs on the use of technology. For government teachers, the type or style of teaching could be another factor that influences their beliefs, as T5 mentioned that the “type of teaching that requires digital tools” is not practised at government schools. Nonetheless, this is mainly due to the unavailability of technology and professional support at government schools, along with teachers’ financial ability to arrange digital resources for personal use (Dundar et al., 2014).

Teachers appear to be self-learning the use of various digital tools with the support of their peers. A male teacher (T2) explained, “my friend showed me how to use it,” showing that teachers had insufficient (official) professional and technical support available during the pandemic (Christopoulos & Sprangers, 2021). With the rapid technological development around the globe, it would be difficult to predict how the teachers’ self-learning efforts could ideally keep their professional development requirements up to date. Therefore, it would be useful to further investigate the effect of “professional development versus self-learning” related to the use of digital resources. The findings also show, despite having positive beliefs about digital technology, the teacher (T3) decided not to use digital technology and preferred to follow the headteacher’s advice. This indicates that the teacher knew of the personal use of digital resources but lacked the confidence to make professional use of digital resources in school. The teachers believed initiating change might go against the pedagogical practices of senior teachers. T3, under the influence of the social context (peers and technological infrastructure), adopted the same teaching methods as peers in school (Ernest, 1989). Teachers are influenced by their social environment, which is shaped by students, their peers, parents, and seniors’ expectations (Ernest, 1989). Therefore, it is not surprising especially for early-career teachers to be influenced by their peers and seniors. The support and the role of senior

leadership (headteachers) did, however, play a critical part in establishing beliefs about using technology at school. Discouragement and lack of support from the leadership not only inhibited new ideas but also decreased the innovative use of technology among teachers (Scully et al., 2021). This pressure was released while working from home during the COVID-19 and teachers felt more autonomous about using technology and making changes in their practice.

With regards to the second question, COVID-19 played a major role in changing beliefs and increasing the use of digital technologies (Alabdulaziz, 2021; Scully et al., 2021). During the pandemic, teachers developed personal schemas, self-learned and created their own workarounds for teaching and learning mathematics (Carey et al., 2020). Beliefs do not need to be established in a physical classroom environment or within technology-related professional development programmes (Clark-Wilson et al., 2020); they can be established through the personal and professional use of technology (Jafri, 2020). As evident in the case of T2, teacher's beliefs originated after experiencing the ease of use and change in social context. The digital resources' affordances improved his agency and self-efficacy (Karatas, 2014). Further, the regular use during the pandemic improved their digital competencies and they were able to select the appropriate resources based on pedagogical and mathematical considerations and create documents to be used by the students during the online sessions.

In a particular social context (such as teaching students of low-income families), teachers' beliefs are hard to influence as exemplified in the T4's response, "I still believe ...". This finding suggests that the teacher's knowledge of students' extended social contexts (parents' financial capacity and digital skills) and students' online behaviour may play a role in shaping or retaining beliefs about students' learning with digital technologies. Unfortunately, in a post-COVID scenario, many middle-income families in developing countries could fall into low-income status due to worsening economic indicators. This could further dampen parents' financial capacity to afford digital technologies, which may drive teachers to hold the beliefs associated with these social contexts more strongly than other beliefs. Parents are an important part of the social context of the (online) teaching situation (Ernest, 1989). They conjointly work with teachers to organise, structure, and operationalise the online learning environment (McCarthy & Wolfe, 2020). Therefore, this finding suggests a relationship between parents' ability to create an effective home learning environment and teachers' beliefs about students' online learning. However, more information and further investigations are required to establish this result. Nonetheless, it appears that teachers holding positive beliefs about digital resources may create strategies enabling parents to become partners in adult students' online learning situations, such as COVID-19.

The recent transition to online education because of COVID-19 provided an opportunity to understand teachers' beliefs about digital resources in Pakistan. The study found that teachers with a higher level of thought and reflection may adapt and align practices as per the social context, situation, and perceived affordances of digital resources. Despite holding positive beliefs, the data may be insufficient to predict teachers' use of digital resources in future (post-COVID) Pakistani mathematics classrooms. Teachers may require training and resources to support and continue the online transformation. Teachers' beliefs and inclination towards digital resources may be subjected to the opportunities and constraints that exist in the social context (students, parents, schools, their peers, and seniors) and teaching situations (COVID-19). However, regular use of appropriate digital resources in different social contexts may facilitate teachers to construct new beliefs and find purposes that can serve their goals of teaching and learning mathematics.

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