Using enaction to evolve from pre-Covid to post-Covid pedagogy: A case study with South African mathematics teachers

Ronel Callaghan, Jody Joubert, Johann Engelbrecht
University of Pretoria

Abstract
The Covid-19 pandemic and subsequent national lockdown in South Africa induced a rapid, albeit challenging, implementation of blended learning (with a strong online focus) at all educational levels. During this time, a group of teachers were involved in a specialised computer integrated education course, preparing them for the design and implementation of technologically enhanced modes of teaching. In this research we considered the positive impact of the situation during the pandemic on these mathematics teachers' practice, as well as their conceptualisation of the way forward for technology enhanced mathematics education. We conducted an explorative survey study, employing an enactivist approach, to investigate their experiences of addressing procedural and conceptual aspects of mathematics education, as well as their observations of learners' reactions to these changed practices. Our findings show that participants experienced their exposure to technology as creating an environment they foresee will have a lasting impact on their teaching practice. Participants emphasised the importance of using educational technology meaningfully as a cognitive tool that allows for learners to learn with the technology and not from the technology, which impacts on the importance of learner-centred teaching strategies and the development of high cognitive level interactive learning activities.

1. Introduction

The development of digital technologies is seen as a significant event of the current century, which impacts on the preparation of teachers in using appropriate and integrated educational technology in their teaching (Marpa, 2021). Every aspect of mathematics education is also influenced by this development, what and how mathematics is taught and learnt, and how it is assessed. Mathematics educators need to be abreast of the possibilities of digital technology applications (NCTM, 2020). They need to learn how to utilise different digital instructional tools for their practice.

The history of using educational technology in the teaching of mathematics through centuries (for both computation and representation) was outlined by Roschelle et al. (2010), particularly focusing on how it can support conceptual understanding of mathematical ideas. The nature of mathematics, its capacity to compress information into abstract and usable forms, makes it ideal for a face-to-face teaching environment (Khirwadkar et al., 2020) in which educators unpack mathematical concepts for students using problem solving, inquiry based teaching, or collaborative strategies (Khirwadkar et al., 2020).

The global Covid-19 pandemic, however, widely affected education across the world and unprecedented scenarios, that required expeditious responses, had to be addressed (Chirinda et al., 2021; Engelbrecht et al., 2020b). Educators and students on all levels of education had to make drastic changes to the traditional face-to-face teaching and learning approach, working and learning from home. The education community had to rely on digital technology to conduct lessons and other teaching and learning

activities. Students were in remote locations off campus, and teachers connected with them using technology. They had to live with this reality, which is now referred to as 'a new normal' (Engelbrecht et al., 2020b).

Learning and teaching in this new normal is referred to as *emergency remote teaching* (ERT) (Chirinda et al., 2021). ERT has been described as "a temporary shift of instructional delivery to an alternate delivery model due to crisis circumstances" (Sulistyani et al., 2021, p. 2). At many institutions, ERT offerings included employing learning management systems (LMS), procurement of devices for students who did not have access to computers, and providing free data for accessing the course material to ensure that online learning did not become prohibitive to students and educators in terms of affordability (Engelbrecht et al., 2020b). The ERT environment differs from country to country and even from institution to institution. In most cases, however, lessons, assessment tasks, engagement with students and meetings have become digital. Moving to online teaching may have negative implications such as political and socio-economic consequences, evoking student protests rather than being experienced as pedagogical innovation (Czerniewicz, 2020). Positively, in some countries, online teaching can assist students, who have not had proper access to education before (Engelbrecht et al., 2020b). Digital literacy and attributes that were previously difficult to address, can be fostered in students to help them successfully navigate the twenty-first century (Engelbrecht et al., 2020a).

The new educational situation has been referred to (tongue-in-cheek) as *panic-gogy* (panic + pedagogy) (Engelbrecht et al., 2020b). Panic-gogy means addressing the question of how educators are moving into this environment with their teaching approaches. It is more that just the didactical approach—it also includes understanding and addressing students' practical resources and problems, such as availability of digital devices, internet access, family responsibilities, students sent home who need to find a new place to live, and financial constraints (Engelbrecht et al., 2020b).

The aim of this research, using an enactivist approach, was to investigate how mathematics teachers adapted within this current new teaching and learning environment (Khirwadkar et al., 2020) and the impact of ERT during Covid-19 on technologically enhanced education in South African schools. With this in mind, we investigated how the ERT during the Covid-19 pandemic contributed to technologically enhanced teaching in schools and what mathematics teachers' conceptualisations were of the way forward for technologically enhanced practice. Following an enactivist approach, this investigation shows the pedagogical changes that we can anticipate after the Covi-19 pandemic.

2. Literature review
The review introduces the following: the South African background; literature regarding ERT before and during the pandemic; teachers' experience of their participation in ERT; and attempts to develop a theoretical background for ERT.

2.1 South African background
Many countries, including South Africa, still struggle with socio-economic problems such as teacher shortages in mathematics, poorly or under-qualified teachers, lack of infrastructure, large classes, poverty, and social and political inequity (Stols et al.,

2015). The apartheid policy of the former South African government created serious inequalities and, unfortunately, that legacy largely persists today (Chirinda et al., 2021). Although mathematics education is a national priority in South Africa (National Planning Commission, 2012), after more than two decades of democracy, the legacy of inferior mathematics education offered to many learners in the apartheid years is still prevalent in many public schools (Stols et al., 2015). The South African pre-Covid-19 education context had some deficiencies that pre-existed, sometimes called "societal comorbidities" (Black et al., 2020). Furthermore, between 2015 and 2017, South African universities were disrupted by student demonstrations. Czerniewicz et al. (2020) equate these disturbances to the current Covid-19 disruptions, contending that the same fissures and inequalities in teaching and learning in South Africa are as visible now as they were then.

In South Africa, the pandemic came on top of these pre-existing inequalities in the education system. The outbreak of this pandemic was followed by schools and universities closing in most parts of the world, precipitating the sudden need for ERT. More than 90% of the world's registered learners (1.5 billion) were left without education (UNESCO, 2020). South Africa recorded its first Covid-19 case in March 2020 and began its nationwide lockdown in March 2020 to mitigate the spread of the virus (Chirinda et al., 2021). The South African government decided to close all schools, forcing school authorities to move from traditional face-to-face instruction to online learning environments (Engelbrecht et al., 2020b).

2.2 ERT before the outbreak of Covid-19
Disruptions to education are not new because crises in education have happened in many countries, during which times educators have implemented various forms of ERT and learning through different channels (Chrinda et al., 2021). Examples include the Syrian conflict, where educational technology was developed to provide some form of learning during the conflict (Tauson & Stannard, 2018), and Afghanistan, where educators adopted radio and DVDs to disseminate education when schools were closed due to the conflict in the country (Davies & Bentrovato, 2011).

A critical challenge faced by many countries with emerging economies (including South Africa) —even before the Covid-19 outbreak—is mathematics teachers' lack of confidence in using educational technology (Stols et al., 2015). Before Covid 19, although many teachers had access to the internet, they often refrained from using available online resources to improve the quality of their own teaching (Stols et al., 2015). As in many countries, most teachers at public schools had not performed online teaching prior to the pandemic, and thus ERT provided a challenge.

Some of the methods suggested to address this challenge are discussed here. *Further training:* In a study in South Africa, Stols et al. (2015) found that although, on a personal level, participating teachers embraced technology and believed that it could improve their own content and pedagogical knowledge, they often refrained from using available online resources to improve the quality of their own teaching. Teachers were hesitant to utilise technology in their teaching, even though they realised its potential value (Stols et al., 2015). A strong need for further training was identified among the participants.

Collaboration opportunities: In a study in Australia, Brown (2017) investigated in what ways secondary mathematics teachers' participation in a technology in mathematics education research project led to their perceived change in the nature of technology use. She found that amongst other factors, on-going opportunities to collaborate with teachers and researchers, also contributed to their changing their teaching.

Adoption of alternative teaching practices: In a survey in Belgium, Germany and the Netherlands, Drijvers (2020) found that with their heavy engagement in distance teaching approaches, teachers may have neglected some of the mathematics tools and didactic approaches, and recommended that mathematics teachers should adopt rich, didactic and interactive distance teaching practices.

Impact on learning: The impact of well-structured exposure to digital technology and pedagogy in mathematics learning was reported by Mulenga and Marbán (2020) as creating the opportunity for learners to own their learning and to study in the comfort of their homes.

2.3 ERT during the Covid-19 pandemic (panic-gogy)
Because of Covid-19, ERT, including educational technology, was adopted in many countries, also to teach mathematics. A wide array of media and technology was introduced to create hybrid forms of teaching, enabling educators to create learning experiences that involve the students actively, and meaningfully engage students in course content (Engelbrecht et al., 2020a). Amongst others, themes included e-learning, mobile learning (Naciri et al., 2020), flipped classrooms (Tang et al., 2020) and online meeting applications.

Teachers' responses during ERT were discussed by Chirinda et al. (2021). They engaged a social justice framework to explore the teaching and learning of mathematics during the Covid-19 lockdown in a context of historical disadvantage in South Africa. Their findings provided insights into how mathematics teachers became learners themselves as they had to adapt to digital teaching, find solutions to unfamiliar problems and acquire knowledge from a larger mathematics education community around the globe.

2.4. Teachers' attitudes, views and emotional experiences during ERT
Although now it is becoming an essential part of teaching and learning mathematics, the use of digital technology in mathematics education has been developing over decades. Researchers have been investigating teachers' attitudes towards use of technology in the mathematics classroom. Marpa (2021) mentioned evidence of a connection between computer-supported leisure activities, positive attitudes towards mathematics, progress in mathematical learning, and student success through technology in teaching.

Worldwide, however, the transition to an online teaching and learning environment has not been conducted without challenges. Some challenges mentioned in reports of research are summarised as follows:
- Teachers' lack of confidence in the use of educational technology (Stols et al., 2021);
- Unfamiliar teaching methods and pedagogies (Flack et al., 2020);

- Challenges with real-time feedback and assessments (Kalogeropoulus et al., 2021);
- Catering for learner diversity (Kalogeropoulus et al., 2021),
- Promoting learner independent work (Kalogeropoulus et al., 2021);
- Learners' lack of social contact and isolation (Flack et al., 2020);
- Welfare of learners (Flack et al., 2020);
- Challenges with technology (Kalogeropoulus et al., 2021);
- Insufficient access to devices and connections (Mulenga & Marbán, 2020).

Despite these challenges, many positive experiences emerged due to ERT, such as the following:
- Experimentation, adoption and development of various tools and teaching strategies (Chirinda et al., 2021; Drijvers, 2020; Mulenga & Marbán, 2020);
- Exploring the connection between purpose and meaningful use of educational technology (Marpa, 2021);
- The need for and development of well-structured training (Stols et al., 2015; Mulenga & Marbán, 2020);
- Opportunities created for teachers to collaborate (Brown, 2017);
- Opportunities created for learners to own their learning (Mulenga & Marbán, 2020);
- Learners' positive experiences during ERT (Kalogeropoulus et al., 2021).

2.5 *Attempts to develop a theoretical basis for ERT*

The development of digital technology introduced the personalisation of the internet through social media, personal devices and other artefacts, transforming the classroom, as we know it, from a physical area with defined boundaries to a virtual environment including various components that are probably determined by the student rather than only by the teacher (Borba et al., 2016; Engelbrecht et al., 2020a). In this transformation, the efficacy of current teacher practices and traditional classrooms are questioned and social aspects of the internet become increasingly relevant and notions such as 'humans-with-media' emphasise that as media change, the entire knowledge-acquiring process may change. In this process, these changing media seem to transform and 'construct' a new human (Borba et al., 2016).

During ERT the use of these remote teaching solutions strongly emerged for instruction that would traditionally be delivered in a face-to-face or in a blended format. Sulistyani et al. (2021) is of the opinion that we will return to the traditional format once the crisis or emergency is over. Chirinda et al. (2021) also see ERT as a non-permanent shift in teaching under an anticipated circumstance that is different from online teaching and learning that has existed for years (Hodges et al., 2020). Chirinda et al. (2021) consider the important distinction between ERT and online teaching and learning, because embarking on learning under incorrect assumptions can lead to errors in an education system.

Tarling and Ng'ambi (2016) reported on how teachers change their pedagogy of teaching with emerging technologies. They developed, what they call the *teachers' pedagogical change framework* as a diagnostic tool for locating and mapping how teachers' change. The framework maps teachers' existing pedagogies and uses of technology, and designs a pathway for a change process to effect the desired change.

One such framework by Khirwadkar et al. (2020) emphasises the importance of harnessing the lessons learnt before and during ERT experiences to support the transformation of educational practices. They suggest an *enactive* approach to reimagine research in mathematics education in order to understand how the mathematics environment and the community co-evolve in this time of crisis—since existing formulae to create a mathematics environment limit viability. In enactivism it is claimed that cognition emerges from a network of interactions among agents and their environment, rather than dualistic views of mind. Rather than only reacting to the problems of the pandemic, the community should see an opportunity for all stakeholders (policy makers, teachers, students and parents) to jointly address issues that need to be addressed and re-imagine mathematics education within the constraints of the Covid-19 situation (Khirwadkar et al., 2020).

According to Hoyles (2018), although it is a challenging process, mathematics teachers must be part of the transformative process as co-designers to transform mathematical practice using digital technologies. Involved in this process of reimagination, is the re-thinking of the use of educational technology and new pedagogical approaches, as discussed in the literature review.

The construct *pedagogical technology knowledge* (PTK) comprises teachers' perspectives on the technology, their familiarity with it as a teaching tool, and their understanding of mathematics and how to teach with it (Thomas & Lin, 2013). Teachers with high levels of PTK focus on mathematical concepts, appreciate the mathematical benefits of using technology and take a multi-representational approach, whereas teachers with a low level of PTK focus on operational matters, procedures and technical skills (Brown, 2017). Before the pandemic, teachers were either using technology to a limited or more sophisticated extent. Those with a low PTK, used it to a lower extent (as mentioned in the literature review) and focussed on operations, and procedural and technical aspects of technology use. Others, with a higher PTK, used technology with a more multi-representational approach.

3. Framework for research

In an enactivist perspective, the dualistic, binary views of mind, such as knowledge and action, mind and body, human and world, are challenged and cognition emerges from a network of interactions among agents and their environment (Khirwadkar et al., 2020). Pre-given prescriptions on how to develop a mathematics environment limit the viability of an intervention. So, in an enactivist perspective the point of departure is that the mathematics community does not simply react to the pandemic. The transition to online teaching and learning of mathematics is not regarded only as a problem that has to be reacted upon—it is seen as an opportunity for the mathematics community, along with teachers, students, parents and policy makers, to work together, exchanging ideas, views and experiences to identify the relevant issues that need to be addressed along the way and to adapt and redesign mathematics education within the constraints related to the pandemic.

Involving the teachers as well as experts running in-service courses for teachers, we followed an enactivist approach—interactions among agents and their environment— to move from the pre-pandemic pedagogy to the panic-gogy phases during ERT, and again to move from the ERT panic-gogy phase to the post ERT pedagogy.

Based on the work of Khirwadkar et al. (2020), Tarling and Ng'ambi (2016) and Hoyles (2018), we proposed a simple framework to investigate the transformation of mathematics education pedagogy. The framework suggests three phases of development, namely, pre-Covid pedagogy (introduced in Section 2.2), panic-gogy during ERT (introduced in Section 2.3), and post-ERT pedagogy. Our investigation was prompted by the enactive approach (Khirwadkar et al., 2020) of investigation into the transformation between these phases, emphasising the importance of harnessing the lessons learnt before and during ERT experiences to support the transformation of educational practices. Using this framework based on enactivism, we envisaged that cognition emerges from the interactions among the different agents. This approach takes into account the recommendation by Hoyles (2018) that teachers should be part of the entire process, and also the teachers' pedagogical change framework, developed by Tarling and Ng'ambi (2016). The framework is illustrated in Figure 1 as a *pedagogy transformation investigation framework*.
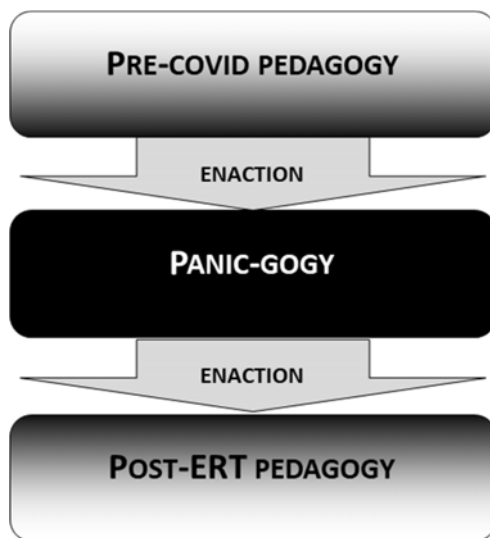

Fig. 1. Pedagogy transformation investigation framework

4.   Research questions

Given the implementation of ERT and the knowledge available on teachers *attitudes* (the feelings or ways of thinking that affect a person's behaviour), *views* (the particular ways of considering or regarding an issue), and *emotional and other experiences* (relating to the degree of pleasure or displeasure the person experiences), in this research we addressed the following research question:

> RQ1: How has the ERT during the Covid-19 pandemic contributed to technologically enhanced teaching in schools?

This question is focused on the first two phases of our framework, namely pre-Covid pedagogy and the enactment towards the panic-gogy phase. The purpose of this research question is to veer away from the prominent focus on challenges in technologically enhanced teaching and learning and those brought on and exacerbated by the pandemic. This question is not stated in an attempt to be naïve about the challenges, but to identify the positive aspects that can pave a new way forward for technologically enhanced teaching in mathematics.

Research question 2 focusses on the enactment towards the third phase of our framework—the post-Covid pedagogy.

> RQ2: What are mathematics teachers' conceptualisation of the way forward for technologically enhanced practice?

With this question, in our research we aimed to gain an in-depth understanding of the way in which mathematics teachers envision the way in which their technologically enhanced practice will develop when going forward.

Some of the attitudes, views and emotional and other experiences of teachers' were also analysed in the study to enable us sensibly to position their feelings about the way forward.

5.   Methodology

The research was conducted following a qualitative approach through two surveys, consisting of open-ended questions. An inductive approach, using the data gathered from respondents to colour in the intricacies of the theory (presented in Figure 1) was followed (Hammersley, 2019). The research was further embedded in an interpretive philosophy that allowed us to make interpretations of what the research participants revealed as important, given the setting of the research being conducted (Schwartz-Shea & Yanow, 2020).

5.1   Context

The research is situated within a formal year-long course presented to in-service teachers. The course is on Bacalareus Educationis Honores level and the aim of the course is to expose the teachers to in-depth and applied aspects pertaining to computer integrated education. It is presented in two modules, as follows: Instructional Tools and Multimedia; and Computers as Cognitive Tools. The course is presented yearly to teachers studying at a university in Pretoria, and also in parallel to teachers in-service of the Western Cape Education Department (WCED). The teachers in this research are therefore all involved in further and structured training in the integration of technology in their own subject fields (Stols et al., 2015; Mulenga & Marbán, 2020). The majority of participants are in-service teachers, and a few are involved in subject advising for the Department of Basic Education. Their experience ranges from a few beginner teachers, to highly experienced teachers.

Since 2018, the course was presented in a blended (online combined with face-to-face) mode. During the 2020 course, when the country went into lockdown due to Covid-19, the course had to be adapted to a fully online mode. During that time all the teachers also started to teach fully online themselves and therefore experienced ERT not only in their studies, but also in their own practice. This research was focused on the 2020 and 2021 groups.

5.2   Participants

Four groups of students were targeted in the research, as follows: a 2020 Pretoria group; a 2020 WCDE group; a 2021 Pretoria group; and a 2021 WCED group. Two surveys were distributed—one comprehensive survey and one survey focusing on challenges. The structure of the surveys is discussed in the next section.

The comprehensive survey was distributed during the second semester of each year. Information on the sample population and the numbers of responses that we received, is summarised in Table 1.

The challenges survey was distributed at the beginning of 2021. We received 36 responses from the Pretoria group, and 75 from the WCED group, therefore 111 responses in total. In our reporting, participant responses to this question are indicated with CP (Challenges Pretoria) and CW (Challenges WCED).

Table 1. Participants in the research project

Comprehensive survey	Response ID	Population	Sample
2020 Pretoria	20P	30	9
2020 WCED	20W	31	9
2021 Pretoria	21P	45	16
2021WCED	21W	80	39
Total		**186**	**73**
Challenges survey			
2021Pretoria	CP	45	36
2021WCED	CW	80	75
Total		**125**	**111**

Half the responses to the school phase question, indicated primary school level—meaning that these teachers teach all subjects, including mathematics. The other 50% of responses indicated secondary school level, and of these 25% indicated that they were involved in teaching mathematics, science and computer science.

5.3 Data collection instruments
In the first, more comprehensive survey, which was administered in 2020 and in 2021, we used a questionnaire containing 12 questions (see Appendix for the full questionnaire).

The questionnaire contained contextual questions for the individual teachers, such as what subjects they were teaching and on what level (Q1), the hardware and software technology that they had access to and were using in their teaching (Q2), and about how unique their teaching style was, in other words, what aspects allowed them to teach differently from others (Q10).

There were some questions on the general impact of technology on teachers' teaching approaches, before the pandemic (Q3), with ERT during the pandemic (Q4 and Q8), and how they saw their future use of technology in teaching (Q9 and Q11). Involving more details on the impact, teachers were asked to comment on the emotional impact of the changes in environment and educational approach on themselves (Q7), and also about subject content—what specific subject topics/content/processes they had to teach differently due to the impact of Covid-19 (Q5). Finally, teachers had to comment on the impact that the new learning environment had on their learners/students (Q6).

In a second survey, which was conducted only with the 2021 groups, we asked only one question, concerning the challenges they experienced during the lockdown in 2020.

Share with us the challenges you experience/d when preparing, planning, training and teaching whilst incorporating educational technology, especially in the last year during lockdown. These can be general challenges, as well as subject specific challenges.

5.4 Data analysis

The nature of the questions in the survey enabled us to distinguish in the responses between the different sections of the framework. The overall study is built on a *phenomenographic* basis, in which we looked at how people experience, understand and ascribe meaning to a specific situation or phenomenon (Bowden & Green, 2005). Phenomenography defines aspects that are critically different within a group involved in the same situation. The outcome of such a phenomenographic study consists of a set of categories or themes, and the relationships between them—sometimes called an *outcome space* for the research. To analyse the data from the questionnaire, we used an approach based on the phenomenographical themes within the subcategories of the framework that we used. These categories were used as a starting point, with the possibility of modifying or augmenting them if necessary.

The researchers studied each response separately and suggested categories describing the variation in respondents' experiences within the framework stages. Then the relevant themes and teacher experiences were discussed between the three researchers and decisions made on what themes emerged as relevant findings that should be reported, using a constant-comparison analysis (Onwuegbuzie et al., 2009) These different experiences are reported with appropriate illustrative quotes from the questionnaires.

We used our framework to organise responses that we received from participating teachers. Since this study is not quantitative, we do not report on the teacher responses empirically (Kennedy, 2018). That means that for each issue, we did not count the numbers of teachers who reflect the particular view or adhere to the particular phenomenon. In most cases these were majority views and the quotes that we use represent the views of most of the teachers. In other cases, the particular opinion or phenomenon was raised by only a single teacher or a few respondents. In some of these cases the relevant issue was considered as interesting by the researchers and worthwhile mentioning given its relation to the framework presented. This approach enabled us to deepen our understanding of different teacher experiences without overinterpretation of the data. This meant avoiding a distortion of the data to conform to the framework and misrepresent the statements made by the respondents (Kennedy, 2018). Our findings present a careful interpretation of themes and phenomena related to the insights of respondents through systematic content analysis of their responses to the surveys (Neuendorf, 2017).

6.   Findings

In this section we report the findings of the study without real discussion. The findings are grouped according to our framework. Section 7.1 and 7.2 present information focusing on teachers' experiences before and during ERT (RQ1), and therefore the first two phases of our framework. Section 7.3 focuses on teachers' views of the way forward (RQ2) and the last phase of our framework as in Figure 1.

6.1 Use of technology before Covid-19

The technology that teachers have access to for teaching and learning, includes laptops, mobile phones, tablets, smart boards and different types of projectors. A vast array of software technologies was used, including learning management systems such as Moodle or Google Classroom, communication software such as WhatsApp, social media such as Facebook and Instagram, YouTube, and many online educational applications and games (Q2).

Teachers were asked to elaborate on their use of technology before the Covid-19 pandemic and how their teaching practice changed during the pandemic (Q3). Two major themes emerged, namely extensive use before the pandemic and little use before the pandemic. The changes in practice between these two groups are noticeably different.

6.1.1 Extensive use beforehand—little change

Some teachers had been using technology in their teaching extensively, because they realised the value of integrating digital technology into their teaching all along.

> *My teaching did not really change as I've always had access to technology.*
> *(21P2)*

6.1.2. Little use beforehand—serious change

Most of the teachers, however, had not been employing technology extensively in their teaching before the pandemic. It was noticeable how most teachers were positive about the new development.

> *I have always used technology in class, but now I have learned that using technology in the correct way is very important. "Learning with" vs "Learning from" made me realise that I have not used technology to optimise teaching and learning. (20W1)*

6.2 Panic-gogy—use of technology during ERT

Four main themes emerged on the use of technology during ERT. These were linked to the following: the impact on general teaching practice; impact on mathematics (subject) teaching; impact on learners; and emotional impact on teachers. In our enactive approach the teacher experiences were made part of the research.

6.2.1 Impact of Covid on teaching practice

Teachers had to indicate to what extent the ERT teaching impacted on their general teaching practice, compared to a year ago (Q4 and Q8 in the questionnaire).

Most teachers were positive about how their view of teaching mathematics changed from only doing exercises, to better conceptual understanding.

> *I spent much of the lockdown time to search for and make videos and other activities to share with my colleagues for them to share with their learners. The biggest impact on me, was thus being made aware of how many resources there are available on the internet!! The biggest change I made, was to not only use the technology as the educator, but to start allowing the learners to use it more. (20W5)*

Teachers became increasingly aware of the problem that learners are not used to or equipped for working independently.

Our learners were NOT prepared for distance learning, … and least of all disciplined enough to learn independently. Again, the problem was the lack of contact time and the inability of learners to work independently. (20W4)

These teacher inputs indicate that the teachers also used an enactive approach, in that they accommodated views and experiences of their learners.

6.2.2   Impact on mathematics subject teaching
Teachers were requested to indicate subject topics/content/processes that they had to teach differently due to the impact of the ERT circumstances (Q5). They came up with new ideas to explain certain topics.

Mathematics: Geometry. I had to teach via Whatsapp, make movies, send voicenotes and create google forms, which I normally would not have done. (21W37)

Few teachers mentioned specific mathematics topics, and rather commented on teaching strategies.

I taught mathematics through WhatsApp. I presented content in a form of pictures and voice notes while interacting with the learners, then I gave them activities that are broken into modular pieces so that we can all ask questions based on similar things. (20P1)

6.2.3   Impact on learners/students
Teachers were concerned about the impact that that the pandemic was having on their learners (Q6), either through their being not interested, or scared of the technology.

My students were scared to do things involving technology. (20P2)

On the other hand, many teachers felt positive about what learners obtained from the new teaching environment.

Learners become active in class and they do the work. My learners never noticed the time go by and they did not even notice they were busy doing work. (20W9)

Teachers developed better understanding of learners' emotional and other problems.

I understand my learners more and can understand their struggles and can relate to them. (21W18)

Without being familiar with the theoretical basis, most teachers enacted with their learners in order to improve the new didactical approach, employing technology.

6.2.4   Emotional impact on teachers
Teachers were asked to indicate the emotional impact that the changes in environment and educational approach had on themselves (Q7).

Some teachers experienced stress because of the new environment and increase in working hours.

It increased strain as I felt I had to be there for my learners 24/7. Where there used to be office hours I now allow my learners to contact me any time. (21W37)

Some teachers experienced the absence of physical engagement with their learners as stressful, and others were scared of being infected, once the learners returned to school. But a substantial number of participants viewed the entire experience as positive. Some teachers experienced a change in their entire teaching approach, clearly moving to a stronger learner-centred approach, again spontaneously employing enactivist principles to improve their teaching.

> *I am enthusiastic about teaching again. I don't give lessons anymore. The learners discover the content. Learners come and ask me if they have questions. In the past, learners had to be quiet because I was talking. Now, I say nothing and learners have to talk. (20W9).*

6.2.5   Other challenges that teachers experienced with ERT

In our challenges survey, teachers were asked to mention specific challenges that they experienced when preparing, planning, training and teaching, whilst incorporating educational technology, especially in the time during lockdown. Aspects that emerged were linked to inexperience (of teachers as well as learners), lack of resources, issues with access, time (to prepare, experiment), and covering of the curriculum. These challenges correspond with challenges mentioned in the literature (Section 2).

One of the mentioned challenges was inexperience in the use of technology, of both teachers and learners.

> *The main problem I had as an educator was a lack of depth in the knowledge and use of technology on my part as an educator and this cascaded down to the learners. (CW1)*

The other main problem, mentioned by many teachers, was the lack of resources and learners' access to technology.

> *The biggest challenge is finding appropriate resources that can accommodate the socio economic climate our school is situated in. WiFi connectivity is not always available. (CW6)*

Some teachers, who had not had sufficient experience with employing technology, experienced serious challenges with the additional time that it required. Teaching time was decreased and work load increased, making it hard to have adequate time for preparation and implementation.

> *The lockdown did have a big impact on my teaching. I had to work out lessons to share via WhatsApp or email. I also felt this put my students at a disadvantage, because learners need repetition, repetition, repetition. (20P8)*

With schools that were closed, teachers were concerned about covering the curriculum.

> *The pressure to complete the syllabus was insane. I am extremely worried about the effects this will have on the next couple of years. If I have to be honest, I don't think the kids learned anything as all the topics were just rushed and there was no time for consolidation. (20W1)*

6.3   Post-ERT pedagogy

In this section we present teachers' future plans for the use of technology in teaching, as well as comments on the impact on their unique teaching styles that developed as a

result of their experiences. The main themes that emerged were technology, learning, teaching, and change/difference. The technology theme described the prominence of continued investigation and implementation of different educational technology options. The high connectivity to learning is an indication of the renewed emphasis on learner-centred teaching, and learner enjoyment of well-designed activities for learning with technology. The teaching theme was related to the impact on participants' planning, and design for technology integrated learner-centred teaching. The theme of 'change or different' expanded on participants' changed practice.

6.3.1 Teachers' future plans for using technology
Teachers were asked about their future plans for using digital technology in their teaching (Q9, Q11). Most teachers were excited about the possibilities, especially the technology features that were introduced in the course and their plans to move to a stronger learner-centred approach.

> *I will maintain these changes by constantly pushing myself to learn of more ways I can integrate technology in teaching to ensure I sustain my interactive learner centred teaching strategy. (21P5)*

Teachers reflected on the positive change in their emotional growth and desire to keep abreast of new technologies and applications as they come to 'move with times'.

> *I have mentally and professionally been stimulated to be creative and see a need to introduce more relevant materials in class to ensure that a learner's mind is… supported to become better problem-solver and innovative. (20P4)*

They proposed innovative ideas about how they intended to use the technology.

> *I intend to introduce project based multimedia learning next year. My idea is to place the learners in four groups and each group will work on a different project. One group will have to produce an e-book, another group a video series, another group a powerpoint presentation, and I think one group will have to design a website. (20W9)*

Some teachers were more realistic—they knew that technology will probably not be available at their schools soon—but they were still positive about possible developments.

> *Personally, the thought of not using technology in some way or the other in my teaching practise is really hard to fathom. However, … there are many different ways in which we learn and can still be incorporated. … This whole process made me question the way I teach and made me realise that I need to change my style. (21W17)*

Responding to whether the ERT teaching will have an impact on their teaching practice (Q8), the vast majority of teachers were quite adamant that the way that they teach had changed drastically.

> *It helped me think outside of the box and that there is no limit to anything! I learned that my only limit is my own imagination as there are so much resources and tools to utilise out there! (20P2)*

6.3.2 Unique teaching style
Participants were asked to comment on their teaching style—whether they considered it as unique, and to elaborate on details (Q10). In most reponses, the use of technology featured strongly.

> *My experience and eager use of technology and creativity definitely allow me to teach in a very different way than many of my colleagues. Learners are excited to see what I come up with next. (21W23)*

Some teachers mentioned the use of technology to enhance learners' experiences.

> *Internet access and connectivity all contributed to change my teaching methodologies and approaches. Thus the better the connectivity and positive mindset, the bigger and more manageable the newly aquired confidence and application will be. (21W16)*

Teaching philosophy was also mentioned by some teachers.

> *I think I place more responsibility at the feet of the learners than other teachers. I tend to be more optimistic that the learners have done what they have been asked to do. I have gotten better at gving them more autonomy instead of spoon feeding them. (21W30)*

Table 2. Summary of findings

RQ1: How did ERT during the Covid-19 pandemic contribute to technologically enhanced teaching in schools?

Pre-Covid pedagogy: use of technology before Covid-19	
Extensive use before	*Little change*
Little use before	*Extensive change*

Panic-gogy: use of technology during ERT	
Challenges	*Inexperience, lack of resources, access, time management, workload, curriculum coverage*
Impact on teaching practice	*Move towards a conceptual focus, collaborative learning, developing independent learners*
Impact on mathematics subject teaching	*New ideas to explain concepts, different teaching strategies*
Impact on learners	*Positive impact from the new environment* *Not interested or scared* *Awareness of learners' emotional and other problems*
Emotional impact on teachers	*Mostly positive experience* *Changes in approach to teaching and learning* *Stress due to new environment, longer hours, absence of physical engagement*

RQ2: What are mathematics teachers' conceptualisation of the way forward for technologically enhanced practice?

Post–ERT pedagogy	
Teachers' future plans for using technology	*Excited about possibilities, positive change in emotional growth, desire to keep abreast of new technologies and applications, innovative ideas such as project-based multi-media approach, teaching practice changed drastically, unique teaching style developed*

6.4   Summary of the results
In the framework that we used to organise the responses, we distinguished between practices before, during and after the ERT activities during the pandemic. We based our study on the enacting teachers' views (Khirwadar et al., 2020), also adhering to Hoyles' (2018) view that teachers must be part of the transformative process to transform mathematical practice using digital technologies. Our findings are summarised in Table 2.

7   Discussion and conclusions
We start this section by mentioning some of the limitations of the study. Firstly, the teachers that we targeted, teach other subjects as well—so these are not only mathematics teachers. It would therefore be good to replicate the study with a larger group of mathematics teachers, to confirm our results. Secondly, the validity of the results could also be improved by triangulation, conducting interviews with some of the teachers to clear up statements that were made in the survey. And finally, the target population were teachers who entered our course, teachers who have the desire to improve their teaching. This group probably does not represent the entire teaching corps in the country.

7.1 Pre-Covid Pedagogy
The findings show that before the pandemic, most teachers in the study did use technology for teaching. The majority of the teachers either replicated their normal courses online, or focussed on operations, procedural and technical aspects of technology use. Other teachers used technology extensively and in a more multi-representational approach. As also found by Brown (2017), these groups of teachers respectively experienced a high or low impact towards the change in technology use with the onslaught of the pandemic.

7.2 Panic-gogy
Moving from the pre-pandemic pedagogy to the panic-gogy phase during ERT, we observed various impacts that the sudden disruption of the pandemic had on teachers' teaching. These included an impact of Covid-19 on teaching practice, an impact on the mathematical content being presented, impact on learners, and some emotional impact on teachers and learners. We saw that the panic-gogy phase forced teachers to use technology for ERT, making use of the various technologies available to them and employing their varying levels of PTK to support ERT.

Teachers experienced serious challenges, such as inexperience in the use of technology by both teachers and learners, and lack of infrastructure—including the poor access that learners had to technology. Teachers were concerned about the additional time that the ERT approach required from them, and with school closures they were concerned about not covering the curriculum.

Regarding the change in their teaching practice, although teachers had to change drastically, with collaborative group work in particular, many teachers were positive about how their view of teaching mathematics changed from only doing exercises to a focus on students' better conceptual understanding.

Regarding enaction with their learners, although concerned about the learners' need for social interaction, teachers were also excited about what the learners obtained

from the ERT experience. They were impressed with how involved learners became when the internet facilitated communication.

Some teachers experienced stress relating to the new environment and increase in working hours. Others' stress came from the absence of physical engagement with their learners. Many participants, however, viewed the entire experiences as positive, experiencing a change in their entire teaching approach, from the previous push approach to a new student pull environment in which the teacher only facilitates the learning. Teachers reflected on the positive change in their emotional growth and desired to keep abreast of new technologies and applications as they come to 'move with the times'.

7.3 Post-ERT pedagogy

Although blurred, there is a transition from the panic-gogy phase to the post-ERT-pedagogy phase. Here it is understood that some teachers have mastered the 'steep learning curve' (Chirinda et al., 2021) and reached a point where their practice has adapted to include the lessons learnt from the impacts of ERT. Following this adaptation, we see technology used for the conceptualised 'way forward' for technologically enhanced teaching practice.

The course to which the teachers in our study were exposed, addressed the need for further training, as identified by Stols et al. (2015). Through their interactions with the course and their experiences in ERT, many teachers had reached a level of pedagogical maturity in using digital technology in their teaching of mathematics. Many of them were excited about the new opportunities that the use of technology offers them in their teaching. Observing the way the computer activities stimulated learners to enjoy what they were doing, encouraged many teachers.

Participants alluded to how the Covid-19 experience acted as a powerful catalyst not only to transform their integration of educational technology, but also their pedagogy. The majority of participants indicated that this experience, with the structured support, and also the course in which they were participating, created an environment in which they foresaw a lasting impact on their teaching practice.

Constantly and strongly emphasised by participants in their feedback, was the importance of using educational technology meaningfully as a cognitive tool that allows for learners to learn with the technology and not from the technology (Drew, 2019). This impacts quite substantively on the importance of learner-centred teaching strategies and the development of high cognitive level interactive learning activities.

ERT has contributed not only to teachers being exposed to using technology in teaching mathematics, but it has gone beyond that. It has contributed to teachers' general spirit and understanding of teaching, integrating technology as one of the teaching resources with other resources such as textbooks, the chalkboard, etc. Our findings lead us to support the view of Engelbrecht et al. (2020a), that the growing array of media and technology that is available to create new forms of teaching, enables educators to create learning experiences that actively and meaningfully pull students into course content, thereby establishing teachers' thinking that can break the walls of the traditional classroom associated with teaching.

There is a need to create an environment for mathematics teachers in the country in which they can design learning that fosters unregulated, dispersed interaction, and requires learners to actively engage with the learning process by creating, evaluating and analysing knowledge. We agree with Tarling and Ng'ambi (2016) that in order to change their practice, the restricted regulated use of technology needs to change to non-restricted dispersed ways, fundamentally informed by a change of pedagogical dispositions towards new pedagogies. Some teachers were employing technology in their teaching before the pandemic and for these teachers the only urgent change that is needed, is to focus on changing how they perceive and use technology in a stronger learner-centred approach.

Our findings strongly indicate that change is possible, and exposure to courses similar to the course that we mentioned in our study, can equip teachers with the necessary tools to design learning using a new, different pedagogical approach. Although technology is currently being used in many South African classrooms, there is evidence that indicates that many teachers still employ teacher-centred transmission pedagogies, using technology in support.

Although our findings show that teachers are gradually changing their pedagogical approaches, we perhaps need a dedicated drive to include in our teacher training programmes, a stronger focus on how to simultaneously use technology to foster deep and meaningful learning towards higher order teaching skills, and impact pedagogy to a stronger learner-centred approach, which will promote interaction between learners, content and teachers.

We identified the following three mutually integrating aspects for teachers to evaluate their teaching anew, employing educational technology:
- *trigger*: something that initiates this new thinking;
- *environment*: a created environment where teachers can think and experiment anew, which is mentally supported and encouraged; and
- *support*: support to strengthen this process; in this case there are two elements, namely, the educational technology itself (e.g. internet access, devices, software, etc.), and secondly the training support (self-learning, peer/group collaboration, and the formal training opportunities). Our framework, using pre-Covid pedagogy, panic-gogy, and post-Covid pedagogy, and our findings, illustrate the following.

Pre-Covid, our specific participants mostly had *support* opportunities; and there were some *triggers*, such as their own need for learning, promotion and requirements from the authorities. These triggers, however, were not as urgent as during Covid. Furthermore, the *environment* was not always really supportive. Maybe that is why adopting this new way of thinking was so slow before the pandemic.

During Covid, it was almost like a 'perfect storm'. All three elements were extraordinarily strong. The *triggers* were obviously very strong, the *environment* was extremely supportive, and the *support* was much better (in spite of some gaps).

Now after Covid we have strong lessons that we learnt during Covid and new habits that have formed. If one of the three aspects is not properly in place, it immediately slows down the process of constant renewal that is needed, especially when working

with educational technology. Our data show that teachers think differently now than they did before.

It is clear to us that now that teachers have experienced how technology can help them in their teaching, one of our biggest obstacles to getting people to think anew about technology and about their practice has been largely broken down, namely, the problem that teachers first had to convince themselves that technology might be the answer to their challenges. Everyone is forced into the 4IR, almost without realising it. And now they can really think about their practice. Whether this energy will be retained is another question.

So, yes, teachers were faced with many challenges with ERT. But what came as a positive surprise to us, and is novel in our study, is the positive impact that the pandemic had on teachers—they were forced to employ educational technology in ERT and many of the teachers experienced this exposure positively, as a new challenge in their teaching, opening up new and exciting avenues, not only in the actual media that they use, but even more so in their didactical approach to teaching mathematics.

Pandemic constraints provided an opportunity for the various stakeholders, teachers and learners, to contribute towards meeting the common objective of teaching and learning mathematics in the best way possible. They provided a diversity of ideas and experiences providing new innovative ways to teach and learn mathematics. Rather than just adapting a rigid prescribed curricula and traditional face-to-face pedagogical approaches, the enactivist approach took into account the contributions of stakeholders, and alternative pedagogical strategies were developed (Khirwadkar et al., 2020). With COVID-19, the mathematics community had to turn to new teaching practices with many teachers having had little experience with online teaching. A (hopefully) viable mathematics education system is in the process of being reimagined through this enactivist lens. Future research and experience will show how viable this new system proves to be.

To conclude, the following quote from one of the teachers summarises the main message of our study—that learners do not learn mathematics from technology, but they use technology to learn more of mathematics.

> *Should I ever have to teach without technology I would do so with ease. I learned that learners learn with technology not from technology. Technology should never replace the teacher, but it should add on to an effective learning experience. (20W3)*

References

Black, S., Spreen, C., Vally, S. (2020). Education, COVID-19 and care: Social inequality and social relations of value in South Africa and the United States. *South African Review of Education, 26*, 40–61.

Bowden, J. & Green, P. (Eds.) (2005). Doing developmental phenomenography. Melbourne: RMIT University Press.

Borba, M. C., Askar, P., Engelbrecht, J., Gadanidis, G., Llinares, S., & Sánchez-Aguilar, M. (2016). Blended learning, e-learning and mobile learning in mathematics education. *ZDM – Mathematics Education, 48*, 589–610.

Brown, J.P. (2017). Teachers' perspectives of changes in their practice during a technology in mathematics education research project. *Teaching and Teacher Education, 64*, 52–65.

Chirinda, B., Ndlovu, M., & Spangenberg, E. (2021). Teaching mathematics during the COVID-19 lockdown in a context of historical disadvantage. *Education Sciences, 11*(177). https://doi.org/10.3390/educsci11040177

Czerniewicz, L. (2020). *University shutdowns—What we learnt from 'going online'.* https://www.universityworldnews.com/post.php?story=20200325160338881

Davies, L., & Bentrovato, D. (2011). Understanding education's role in fragility: Synthesis of four situational analyses of education and fragility: Afghanistan, Bosnia and Herzegovina, Cambodia, Liberia; IIEP Research Papers; UNESCO-IIEP: Paris, France.

Drew, C. (2019). Re-examining cognitive tools: New developments, new perspectives, and new opportunities for educational technology research. *Australasian Journal of Educational Technology, 35*(2). https://doi.org/10.14742/ajet.5389

Drijvers, P. (2020). Moving forward in the midst of a pandemic: international lessons for Math teachers. Presentation at the National Academies of Sciences, Engineering, and Medicine. https://www.nationalacademies.org/event/07-09-2020/math-distance-distance-mathematics-teaching-during-covid-19-lockdown.

Engelbrecht, J., Llinares, S., & Borba, M. C. (2020a). Transformation of the mathematics classroom with the internet. *ZDM – Mathematics Education*, 52(5), 1-17.

Engelbrecht, J., Borba, M. C., Llinares, S., & Kaiser, G. (2020b). Will 2020 be remembered as the year in which education was changed? *ZDM – Mathematics Education, 52*(5), 821–824. DOI: 10.1007/s11858-020-01185-3

Flack, C. B., Walker, L., Bickerstaff, A., Earle, H., & Margetts, C. (2020). Educator perspectives on the impact of COVID-19 on teaching and learning in Australia and New Zealand. Melbourne, Australia: Pivot Professional Learning.

Hammersley, M. (2019). Induction. In P. Atkinson, S. Delamont, A. Cernat, J.W. Sakshaug, & R.A. Williams (Eds.), *SAGE research methods foundations.* https://dx.doi.org/10.4135/9781526421036757475

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remoteteaching-and-online-learning

Hoyles, C. (2018). Transforming the mathematical practices of learners and teachers through digital technology. *Research in Mathematics Education 20*(6), 1–20. DOI:10.1080/14794802.2018.1484799

Kalogeropoulos, P., Roche, A., Russo, J., Vats, S., & Russo, T. (2021). Learning mathematics from home during COVID-19: Insights from two inquiry-focussed primary schools. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(5), 1–16.

Kennedy, B. (2018). Deduction, induction, and abduction. In Flick, U. (Ed.) *The sage handbook of qualitative data collection* (pp. 49–64). SAGE Publications Ltd. https://dx.doi.org/10.4135/9781526416070

Khirwadkar, A., Khan, S. I. Mgombelo, J., Obradović-Ratković, S., & Forbes, W. A. (2020). Reimagining mathematics education during the COVID-19 pandemic. *Brock Education Journal 29* (2), 42–46. https://journals.library.brocku.ca/brocked

Marpa, E. P. (2021). Technology in the teaching of mathematics: An analysis of teachers' attitudes during the COVID-19 pandemic. *International Journal on Studies in Education (IJonSE), 3*(2), 92–102.

Mulenga, E. M., & Marbán, J. M. (2020). Is COVID-19 the gateway for digital learning in Mathematics Education? *Contemporary Educational Technology, 12*(2), ep269.

Naciri, A., Baba, M. A., Achbani, A., & Kharbach, A. (2020). Mobile learning in higher education: Unavoidable alternative during COVID-19. *Aquademia, 4*(1), ep20016.

National Council for Mathematics Teachers (NCTM) & Leadership in Mathematics Education (NCSM). (2020). Moving forward: Mathematics learning in the era of COVID-19. https://www.nctm.org/Research-and-Advocacy/Moving-Forward---NCSM-and-NCTM-Joint-Statement/

National Planning Commission, Department of the Presidency, Republic of South Africa (2012). National Development Plan 2030: Our future-make it work. Executive Summary. https://www.gov.za/sites/www.gov.za/files/Executive%20Summary-NDP%202030%20-%20Our%20future%20-%20make%20it%20work.pdf.%20.

Neuendorf, K.A. (2017). Defining content analysis. In *The content analysis guidebook* (pp. 1–35). Thousand Oaks, CA: SAGE Publications, Inc, https://dx.doi.org/10.4135/9781071802878

Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L., & Zoran, A. G. (2009). A qualitative framework for collecting and analyzing data in focus group research. *International journal of qualitative methods, 8*(3), 1–21.

Roschelle, J., Shechtman, N., Tatar, D., Tech, V., Hegedus, S., Hopkins, B., Empson, S., Knudsen, J & Gallagher, L.P. (2010). Integration of technology, curriculum, and professional development for advancing middle school mathematics: Three large-scale studies. *American Educational Research Journal, 47*(4), 833–878.

Schwartz-Shea, P., & Yanow, D. (2020). Interpretivism. In P. Atkinson, S. Delamont, A. Cernat, J. W. Sakshaug, & R. A. Williams (Eds.), SAGE research methods foundations. https://dx.doi.org/10.4135/9781526421036915455

Stols, G., Ferreira, R., Pelser, A., Olivier, W. A., Van der Merwe, A., De Villiers, C., & Venter, S. (2015). Perceptions and needs of South African mathematics teachers concerning their use of technology for instruction. *South African Journal of Education, 35*(4), 1–13.

Sulistyani, N., Utomo1, B., & Kristantol, Y. D. (2021). Emergency remote teaching experiences of mathematics education lectures to address COVID-19 pandemic.

Journal of Physics: Conference Series 1806, doi:10.1088/1742-6596/1806/1/012088

Tang, T., Abuhmaid, A. M., Olaimat, M., Oudat, D. M., Aldhaeebi, M., & Bamanger, E. (2020). Efficiency of flipped classroom with online-based teaching under COVID-19. *Interactive Learning Environments*, 1–12.

Tarling, I. & Ng'ambi, D. (2016). Teachers pedagogical change framework: a diagnostic tool for changing teachers' uses of emerging technologies. *British Journal of Educational Technology, 47*(3), 554–572.

Tauson, M. & Stannard, L. (2011). EdTech for learning in emergencies and displaced settings: A rigorous review and narrative synthesis. Save The Children: London, UK. https://resourcecentre.savethechildren.net/node/13238//edtech-learning.pdf

Thomas, M. O., & Lin, C. (2013). Designing tasks for use with digital technology. In C. Margolinas (Ed.), *Task design in mathematics education*. Proceedings of ICMI Study 22 (pp. 111–119).

UNESCO. (2020). Covid-19 education response. https://en.unesco.org/covid19/educationresponse/globalcoalition

Appendix—Questionnaire

1. Which subjects are you teaching and on which level are you teaching?
2. Share the hardware and software technology that you have access to for teaching and learning.
3. How did your teaching practice change (or not) initially when you were introduced to technology (prior to this year)?
4. What was the impact (if any) of the 2020 Lockdown on your general teaching practice? If you compare your practice now to that of last year this time?
5. Which specific subject topics/content/processes did you have to teach differently due to the impact of Covid-19? Please share examples?
6. If your teaching practice changed during this year, what is the impact you noticed on your learners/students?
7. What is the emotional impact of the changes in environment and educational approach on you? Did it increase/decrease strain, working hours, intensity, etc?
8. What was the impact (if any) of this year's two modules (CTM and CIT) on your teaching practice? What do you think was the reason for this (if any)?
9. If your teaching practice has changed after completing these modules, how do you think you will maintain the changes? Or will you revert back to the way you taught before?
10. Do you think that there are certain aspects that allow you to teach differently than others? If so, what are these aspects?
11. If in future you were to be in the position to not have technology available in your school—how you think your experience this year would have enabled you (or not) to teach in a different way than before you were introduced to technology?
12. Please share any feedback/advice on our approach to CTM/CIT during this year of the pandemic.