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Primary School Mathematics Teachers' Beliefs About Teaching in Synchronous Virtual Classrooms: A Mixed Method Study

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Abstract: This study was conducted following the initial stage of the transition to distance education necessitated by the onset of the COVID-19 pandemic and meeting the various challenges that came with it. At this point, countries and teachers have gained experience in preparing and delivering online education. Therefore, the study aimed to identify the beliefs of primary school mathematics teachers about teaching in synchronous virtual classrooms. It adopted a mixed methods approach, following a convergent parallel design. The overall study sample comprised 410 male and female teachers. A questionnaire was used to collect quantitative data across three dimensions (teaching efficiency, employing the philosophy of active learning, mathematical achievement). There were 31 items (verified for validity and reliability) comprising statements measured using a five-point Likert scale, together with open-ended options for further elaboration. In total, 130 teachers completed the questionnaire. Interviews were conducted with 10 teachers to collect qualitative data. The results show means in the range 3–5.75 for agreement with statements concerning the beliefs of mathematics teachers about teaching in virtual classrooms in the following order of importance: teaching competence; mathematical achievement; employing the philosophy of active learning. The study also found no statistically significant differences attributable to the variables of gender, qualification, or teaching experience, and also that many factors are considered to affect teaching in synchronous virtual classrooms related to the teacher, the family, and the student.

Keywords: *Active learning, beliefs, mathematical achievement, primary school mathematics teachers, synchronous virtual classrooms, teaching competence.*

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Introduction

When the COVID-19 pandemic swept the world, it caused confusion in all countries and all sectors, including education. In the face of this, countries have made great and varied efforts to maintain the provision of education and assure its quality, as well as working to address educational loss due to the continuation of the pandemic and distance education.

One of the key factors that can contribute to confronting challenges in the field of education is teachers' knowledge (Shulman, 1986). In view of the current developments and changes in education, technical knowledge has become an important part of educational systems in the 21st century. It is a component of the technological pedagogical content knowledge (TPACK) model (see Figure 1), which also includes educational knowledge and specialized knowledge. In the field of mathematics, various applications can be employed to enhance teaching in virtual classes, improving teaching methods and strategies and raising the level of achievement of students in general and those in the primary stage in particular (Ababa et al., 2021; Hardman, 2019; Mishra & Koehler, 2006).

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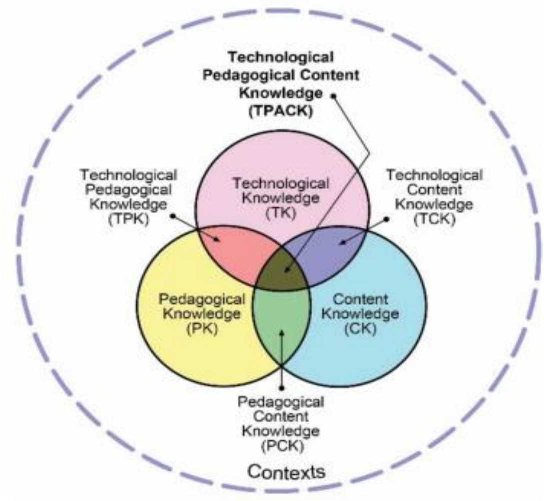

Figure 1. Teacher Knowledge Model (Technological Knowledge, Content Knowledge, Specialized Knowledge)

According to the National Council of Teachers of Mathematics (NCTM, 2000), use of technology is one of the principles in the teaching and learning of mathematics. Many factors affect the integration of technology in mathematics teaching and learning, including awareness of technology, self-confidence, planning for teaching, technical materials, and student willingness (Ince-Muslu & Erduran, 2021). In relation to distance education, the Leadership in Mathematics Education (NCSM) and the NCTM (2020) stressed the importance of effective teaching and improving student learning at the time of the COVID-19 pandemic, and focusing on the decisions that must be taken to attain high-quality mathematics education, considering the needs of both the teacher and the learner.

In this context, it is important to employ effective teaching practices, i.e., establishing mathematics goals to focus learning, implementing tasks that promote reasoning and problem solving, using and connecting mathematical representations, facilitating meaningful mathematical discourse, posing purposeful questions, building procedural fluency from conceptual understanding, supporting productive struggle in learning mathematics, and eliciting and using evidence of student thinking (NCTM, 2014). In this vein, Khalil's (2021) study emphasized the importance of enhancing teaching practices in synchronous virtual mathematics classes, providing mathematical knowledge based on operational standards (communicating, connecting, and reasoning), and attending to mathematical tasks and teaching procedures in a way that approximates teaching in face-to-face education.

To ensure that teaching is effective according to constructivist theory, it is important to apply the philosophy of active learning. This philosophy is based on several foundations, the most notable being the use of diverse learning sources, the application of strategies centred on learners, their interests and abilities, and providing the opportunity for students to communicate with each other and with the teacher (Ali, 2011). In view of the nature of the synchronous virtual classroom, the active learning perspective in the primary stage requires the teacher's knowledge of the students' nature, motivating them to participate, providing sufficient opportunities to analyse different mathematical situations to reach convincing mathematical conclusions, and directing them to do home activities that show the value of mathematics in daily life. In addition, virtual manipulatives can be used in virtual laboratories to deepen mathematical understanding and form a positive attitude towards mathematics and learning of the subject.

It is also important to focus on the mathematics that must be taught and learned, and teachers must develop their competence in using and posing appropriate problems that contribute to enhancing mathematical thinking among their students within the synchronous virtual classroom (Garcia- Moya et al., 2020; Rodríguez-Muñiz et al., 2021; Santos-Trigo et al., 2019). In the context of the COVID-19 pandemic, education moved to the home, and family partnership has become an influential factor in the educational process and a strong partner in its success, playing multiple roles such as encouraging children to learn and undertake homework (Assefa & Sintayehu, 2019; Gonida & Cortina, 2014; Tesfamicael & Ayalew, 2021). In terms of mathematics, moving to the virtual classroom is a good opportunity to demonstrate the importance of the subject and teach it to families, enhancing their roles in encouraging their children to learn mathematics and fostering a positive parental partnership with the school.

Teachers' beliefs have an important role in teaching and learning processes in general, as they represent a mediator between what is going on in the teacher's mind and reality. The various dimensions of beliefs (cognitive, behavioural, and emotional) are formed and affected by several factors, including knowledge, experience, goals, and context, and they differ from one teacher to another (León-Mantero et al., 2020; Rott, 2021; Yang et al., 2020). Alhunaini et al. (2022) identified many studies that have examined the beliefs of mathematics teachers and found a reciprocal relationship between them and their practices in the classroom environment. Therefore, it is important to attend to these beliefs, study them at all stages, especially at the primary stage, and work to foster those conducive to learning (Leon-Mantero et al., 2020; Tamba et al., 2021).

In mathematics education, Shoaib and Akhter (2020) have defined mathematical beliefs as perceptions about the nature, teaching, and learning of mathematics. At-Tarawneh and Khasawneh (2018) define them as an interrelated system of ideas, opinions, and perceptions that the teacher holds towards the nature of mathematics and its teaching and learning, which can be measured quantitatively and qualitatively. Mathematics teachers' beliefs differ in terms of what they consider to be the nature of mathematics and its teaching (Yang et al., 2020). Shoaib and Akhter (2020) refer to several variables that affect the beliefs of mathematics teachers: gender, qualification, and experience. In addition, Khalil and Al-Maliki (2017) consider that several variables affect the beliefs of mathematics teachers about their teaching competence, including training programs and specialized knowledge. It is therefore important to work on and address mathematics teachers' beliefs during their studies in college and to provide training sessions on developing their beliefs about the nature, teaching and learning of mathematics through application in real classrooms (Safrudiannur et al., 2021).

Understanding mathematics teachers' beliefs about what mathematics is and how to learn it contributes to teachers' success in providing learning opportunities for their students (Jakimovik, 2018). Mathematics teachers' beliefs about their teaching competence affect their teaching practices and the interaction and achievement of their students (Alotaibi et al., 2021; Boz, 2008). They are also reflected in the selection of appropriate mathematical tasks, which is one of the dimensions of achieving fairness in mathematics teaching, in addition to its impact on improving teaching practices and choosing appropriate teaching strategies (Laurens et al., 2018; Tesfamicael & Ayalew, 2021). Therefore, it is important to take care in the design, selection, and implementation of mathematical activities and tasks to achieve the goals of teaching and learning. Moreover, linking tasks to society and life situations is positively reflected in students' interaction, increasing their interest in mathematics, and developing their skills and attitudes towards it. It also helps in understanding mathematical concepts, solving problems, and developing mathematical achievement (Gonida & Cortina, 2014; Turkkan & Karakus, 2018).

The study of beliefs in general and those of mathematics teachers in particular needs more attention, diversity, and development in tools and methodologies, as well as using previous studies to benefit in attaining reliable results (Rott, 2021; Safrudiannur & Rott, 2020; Xie & Cai, 2021).

In the current period, following the initial state of the onset of the pandemic, which forced countries to teach remotely in surprising circumstances, it is to be hoped that preparation has improved, the experience of teaching in the synchronous virtual classroom has increased, and it has become possible to implement effective teaching from the perspective of constructivist theory within the synchronous virtual classroom just as it was possible in face-to-face education. Therefore, this study was concerned with the beliefs of mathematics teachers in this period and it employed various tools and methodologies to attain valid results.

Conceptual Framework

Understanding primary school mathematics teachers' beliefs about the nature of mathematics, the teaching and learning methods they employ, and their motivation and manner of self-organization can influence the provision of student learning opportunities, teaching methods, and assessment (Jakimovik, 2018; Tamba et al., 2021). Research on beliefs in general and the beliefs of mathematics teachers, in particular, faces a great challenge in this regard and it is necessary to diversify data collection tools (quantitative and qualitative) and work to develop them continuously (At-Tarawneh & Khasawneh, 2018; Rott, 2021). Saadati et al. (2021) argued the importance of continuing to study the beliefs of mathematics teachers in the context of the COVID-19 pandemic after an interval of time following the onset of the pandemic.

There are many variables related to the beliefs of mathematics teachers. Alotaibi et al. (2021) employed several, including experience, qualifications, and gender. Considering the circumstances and challenges imposed by the COVID-19 pandemic, countries have moved to distance education, which entails a reliance on technology and teachers' technological knowledge (García-Moya et al., 2020; Hardman, 2019). Both the NCTM (2000) and NCSM & NCTM (2020), and also Khalil (2021) emphasized the importance of teaching mathematics using effective teaching practices applicable in different circumstances. Thurm and Barzel (2022) stress that teachers' beliefs about their self-efficacy and the use of technology are critical in teaching mathematics using technology. Therefore, this study was conducted to identify primary school mathematics teachers' beliefs about teaching in synchronous virtual classrooms from the constructivist perspective during the COVID-19 pandemic in light of three interrelated criteria (teaching competence, active learning, mathematical achievement), and then to identify any potential differences in relation to gender, qualifications, and teaching experience.

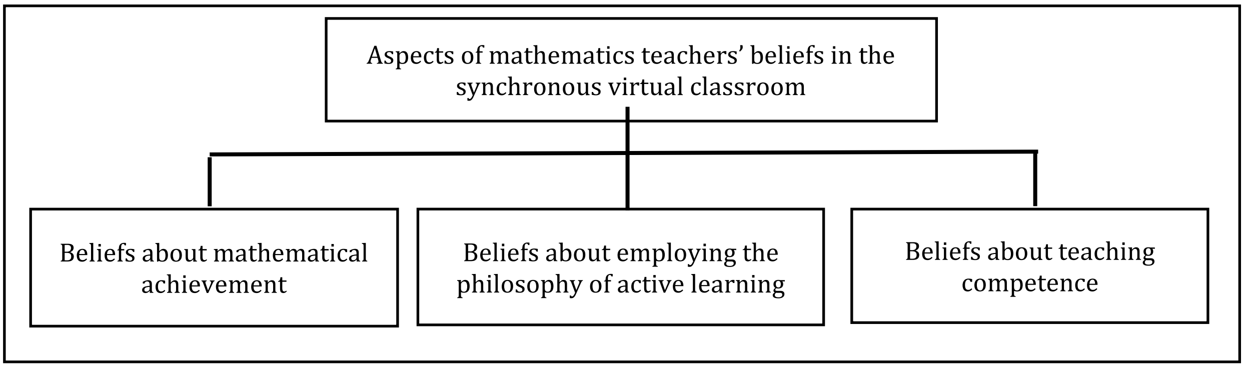

Figure 2. Aspects of Mathematics Teachers' Beliefs in the Synchronous Virtual Classroom

Study Questions

The study used the mixed methods approach (convergent parallel design) and sought to answer the following questions quantitatively and qualitatively:

1. What are primary school mathematics teachers' beliefs about teaching in synchronous virtual classrooms in relation to the dimensions of teaching competence, employment of active learning, and mathematical achievement?
2. How do primary school mathematics teachers describe their beliefs about teaching in synchronous virtual classrooms in relation to the dimensions of teaching competence, employment of active learning, and mathematical achievement?

The results of studies that have dealt with differences in the beliefs of mathematics teachers have varied according to the variables used in the research. This study proposed the following hypothesis: There are no statistically significant differences at a level of significance of $\alpha \leq .05$ in the beliefs of mathematics teachers that can be attributed to the variables of gender, qualifications, or teaching experience.

Methodology

Research Design

Given the importance of studying beliefs and the challenges that accompany such research, this study used mixed methods, defined by Creswell (2014) as the combination of qualitative and quantitative data in one study, to obtain valid results. The convergent parallel design was used, which entails collecting quantitative and qualitative data to address the same question without one affecting the other. The figure shows the steps undertaken to collect, compare, and link the quantitative and qualitative data, and interpret the results.

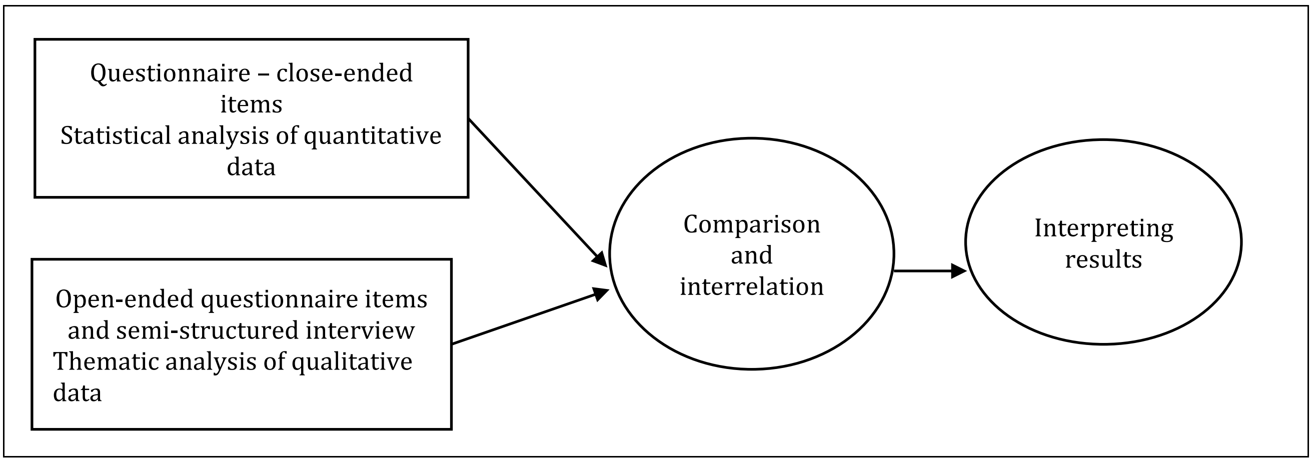

Figure 3. Steps for Collecting and Analysing Quantitative and Qualitative Data Using the Convergent Parallel Design

Data Collection

Following the mixed methods convergent parallel design, data were collected using two tools, one quantitative and the other qualitative.

First, a questionnaire was designed to examine the mathematics teachers' beliefs about teaching mathematics in the synchronous virtual classroom in relation to three dimensions: teaching competence (12 items); employing active learning in the synchronous virtual classroom (9 items); academic achievement (10 items). To construct a scale related to reality and consistent with aspirations for convergence with the level of teaching in face-to-face education, the following steps were taken:

- Reviewing the literature and previous studies that dealt with the subject of mathematics teachers' beliefs, whether before the COVID-19 pandemic, at the beginning of the pandemic, or after an interval of time, including: Boz (2008); Jakimovik (2018); García-Moya et al. (2020); Rott (2021).
- Holding discussions with a group of mathematics teachers and mathematics education experts about the beliefs shared among them when teaching in synchronous virtual classrooms.
- Presenting the items of the scale to experts in the field of mathematics education and the field of measurement and evaluation.

Each item was formulated as a statement, with positive statements corresponds to a five-point Likert scale (strongly agree = 5), (agree = 4), (neutral = 3), (disagree = 2), (strongly disagree = 1), and negative items being reverse coded. Table 1 shows the distribution of scores for the judgement criteria.

Table 1. Distribution of Scores for Item Judgement

No.	Range	Judgement
1	(1–1.80)	Strongly disagree
2	(1.81–2.40)	Disagree
3	(2.41–3.20)	Neutral
4	(3.21–4.20)	Agree
5	(4.21–5.00)	Strongly agree

An example of a positive item is "I believe that I can present mathematical procedures (algorithms) in a sequential and logical manner that contributes to developing students' procedural fluency". Examples of negative items are "I think it is difficult to follow students when they are performing activities effectively", "I think it is difficult to use virtual manipulatives when teaching mathematics" and "I think it is not necessary to relate subjects to real-life situations".

To assure validity, the scale was presented to a group of mathematics teachers, mathematics education experts, and experts in measurement and evaluation to express their views about the tool in terms of the importance of the dimensions and items, their relationship to the reality of mathematics teaching in synchronous virtual classrooms, their clarity for the study sample, and the wording of positive and negative items. The items were modified in light of their feedback. Reliability was calculated using Cronbach's alpha coefficient for the sub-dimensions and for the tool as a whole. The results are shown in Table 2.

Table 2. Reliability Coefficients for the Scale Dimensions and the Scale as a Whole

Dimensions	Number of items	α
Teaching competence	12	.730
Employment of active learning	9	.700
Academic achievement	10	.753
Performance as a whole	31	.808

As can be seen in Table 2, the coefficients for the individual dimensions range in value from .700 to .753., while the coefficient for the tool overall is .808, representing acceptable internal consistency.

The scale also included open-ended questions to survey teachers' perspectives in their own words in each section; such questions supported the individual interviews and were used when analysing the qualitative data, and when linking and discussing the results. They were as follows:

Dear teacher, teaching in the virtual classroom requires many skills and a lot of experience for any teacher and mathematics teachers in particular due to the nature of the subject and the stage of learning. How would you rate your competence in teaching mathematics in the synchronous virtual classroom? Why? Teachers usually have beliefs (positive or negative) related to their practices and competence in teaching mathematics in synchronous virtual classrooms. What are the most prominent ones from your point of view? (This is an open-ended question and answering it is optional; it is understood that your answer is important and will enrich the study.)

Dear teacher, through your teaching experience in the field of mathematics education in synchronous virtual classrooms, do you think it is possible to employ the philosophy of active learning when teaching mathematics in synchronous virtual classrooms? Why? Please indicate reasons and beliefs about the student, teacher, and family, and what you see as related to achievement. (This is an open-ended question and answering it is optional; it is understood that your answer is important and will enrich the study.)

Dear teacher, through your teaching experience during the recent period, how would you evaluate the level of your students' mathematical achievement? Why? What factors do you think affect mathematical achievement in the synchronous virtual class? (This is an open-ended question and answering it is optional; it is understood that your answer is important and will enrich the study.)

Semi-structured interviews were also conducted with a sample of the mathematics teachers who agreed to take part. The aim was to survey their positive and negative beliefs in relation to the pre-determined dimensions of the study: teaching competence, employment of active learning, and mathematical achievement. In judging the validity and reliability of qualitative tools used for data collection, the criteria of credibility and dependability are used. This study applied the criteria proposed by Høstrup et al. (2011) and Johnson et al. (2020), namely using diverse data collection tools, asking closed and open-ended questions within the questionnaire and conducting interviews. The purpose of the study, the reasons for the choice of methodology, and the integration of data from the different tools were described in full.

The study sample, the mechanism for their selection, and the reasons behind this were clarified. The reasons for using the various tools, citing the opinions of the participants, and finally analysing the results and merging them were set out in full. Table 3 sets out the demographic characteristics of the study sample for the questionnaire.

Table 3. Demographic Characteristics of the Questionnaire Respondents

Variable	Category	N	Percentage
Gender	Male	168	41
	Female	242	59
Qualification	Bachelor's degree	372	90.7
	Master's degree and above	38	9.3
Teaching experience	1–5 years	28	6.8
	6–10 years	100	24.4
	> 10 years	282	68.8

Due to the conditions under which the study was conducted, the multiplicity of participants and their different circumstances, open-ended questions were added at the end of each section of the questionnaire. The participants were free to respond if they wished and 130 did so.

The responses were reviewed with respect to the various study dimensions and those relevant were incorporated. In addition, semi-structured interviews were conducted with 10 mathematics teachers by phone, addressing their beliefs related to the dimensions of the study. The duration of the interviews ranged from 15 to 25 minutes.

Data Analysis

Consistent with the mixed methods design, the quantitative data were analysed using the arithmetic mean (*M*), standard deviation (*SD*), *t*-test for two independent samples, and one-way ANOVA. The data collected based on a random sample were tested for the normality of distribution as shown in Table 4. Moreover, as previously noted, Cronbach's alpha was used to verify the reliability of the scale before application.

Table 4. Results of Kolmogorov-Smirnov Test of the Normality of Data Distribution

Variable	D	Df	Sig.
Gender			
Male	.065	168	.081
Female	.053	242	.092
Qualification			
Bachelor's degree	.042	372	.155
Master's degree or above	.135	38	.077
Teaching experience			
1–5 years	.110	28	.200
6–10 years	.078	100	.136
> 10 years	.043	282	.200

It is clear from Table 4 that the data were normally distributed for all variables (sex, qualification, teaching experience). Therefore, the assumption of normality was met, fulfilling the conditions for using the *t*-test and one-way ANOVA.

The qualitative data were analysed using thematic analysis, which allows the researcher to identify topics and present them in a systematic way by focusing on the data and identifying the common meanings extracted from the data (Braun & Clarke, 2006). The steps were as follows:

- Familiarization with the data: reading, surveying, and contemplating the data collected in preparation for preliminary coding of responses.
- Assigning preliminary codes: writing preliminary codes using descriptive coding (summarizing the statement or sentence in simple words), comparing statements, and associating similar codes.
- Searching for patterns of themes: sorting the preliminary codes and determining similarities and correspondences to derive suitable themes covering all the codes.
- Reviewing the themes: going through the themes many times to verify that they represented the codes and provided an integrated picture of the preliminary and similar codes. A second reviewer assisted to ensure that the themes were appropriate, merge close themes, and come to an appropriate visualization.
- Defining and naming themes: determining the themes and the data subsumed under them, and verifying the extent to which the themes were consistent with the data.
- Producing the report: writing up the report, including the various themes, and stating the concept of each theme and its components, as well as providing evidence and quotations from the statements of participants, and using simple statistics to support the results.

Results

This section first reports the quantitative results from analysis of the questionnaire data for each of the three dimensions, then the qualitative results.

Quantitative Results

Table 5 presents the results concerning the mathematics teachers' beliefs concerning their teaching competence in synchronous virtual classrooms.

Table 5. Mathematics Teachers' Beliefs About Their Teaching Competence in Synchronous Virtual Classrooms

No.	Statement	M	SD	Level
1	I think I will be able to find the best teaching methods that suit the nature of synchronous virtual classrooms.	4.07	.835	Agree
2	I think that I can teach all mathematics subjects on the virtual platform very efficiently.	3.97	.922	Agree
3	I think I have enough knowledge of how to teach math concepts in a way that helps students assimilate them in a synchronous virtual classroom.	4.28	.657	Strongly Agree
4	I think that I can present mathematical procedures (algorithms) in a sequential and logical manner that contributes to developing students' procedural fluency.	3.92	.810	Agree
5	I think I can balance the provision of both conceptual knowledge and procedural knowledge in synchronous virtual classrooms.	3.93	.785	Agree
6	I think it is difficult to effectively keep track of students when they are performing activities in the synchronous virtual classroom.	3.71	1.100	Agree
7	I think it is difficult to use virtual manipulatives when teaching mathematics in the synchronous virtual classroom.	3.32	1.193	Neutral
8	I think I can answer students' questions appropriately while teaching in the synchronous virtual class.	4.34	.707	Strongly Agree
9	I believe that I can use the teaching skills that I used in face-to-face teaching.	3.73	1.067	Agree
10	I think that I can teach in a unique way when the principal/educational supervisor/my specialty colleagues are present while teaching in the synchronous virtual class.	4.02	.891	Agree
11	I think that, while teaching in synchronous virtual classes, I can take into account the requirements of the international TIMSS assessment (Knowledge – Application – Reasoning).	3.60	.954	Agree
12	I think that while teaching in synchronous virtual classrooms, I can take into account the processes required in the international PISA test (Formulation – Employment – Interpretation).	3.54	.912	Agree
Overall mean		**3.87 (Agree)**		

Table 5 shows an overall mean for mathematics teachers' beliefs about their teaching competence in the synchronous virtual classrooms of 3.87 (agree), and the means for the statements are in the range 3.32–4.34. The statement "I think can answer students' questions appropriately while teaching in the synchronous virtual class" has the highest mean due to the teachers' confidence in their mathematical knowledge of the content they teach at primary school. The statement "I think it is difficult to use virtual manipulatives when teaching mathematics in the synchronous virtual classroom" has the lowest mean. This is due to the change in dealing with tangible objects and manipulatives in virtual reality, the need for training and practice to deal with mathematical applications in general and virtual manipulatives in particular, and the need for more preparation and considerable time investment. Moreover, the reduction in teaching time in virtual classes may be one of the reasons. The results of this study are in line with those of Saadati et al. (2021), who found a high level of teachers' beliefs about their teaching competence in the use of technology.

Table 6. Mathematics Teachers' Beliefs About Employing Active Learning in Synchronous Virtual Classrooms

No.	Statement	M	SD	Level
1	I think that clarity of lesson objectives for students contributes to their achievement when teaching in the synchronous virtual classroom.	4.56	.570	Strongly Agree
2	I think that giving the students the opportunity to get involved in determining the proceeding of the class in the synchronous virtual classroom contributes to having a special class.	4.26	.825	Strongly Agree
3	I think that involving students in the lesson activities in the synchronous virtual classroom leads to the loss of class time.	2.74	1.207	Neutral
4	I think that students working in groups in synchronous virtual classrooms cause chaos during class.	3.46	1.138	Agree
5	I believe that linking previous experiences with new ones helps to develop understanding.	4.61	.509	Strongly Agree
6	I think I do not need to relate course topics to real life situations when teaching in the synchronous virtual classroom.	2.08	1.039	Disagree
7	I believe that directing the students to do activities consistent with the objectives of the lesson (in their homes) achieves the objectives of the lesson.	4.29	.772	Agree
8	I think that giving students the opportunity to present their ideas and express their opinions will hinder the course of the lesson in the synchronous virtual classroom.	2.67	1.211	Neutral
9	I think the best way to illustrate math topics in synchronous virtual classrooms is to present and explain the whole lesson, without involving the students.	3.07	1.184	Neutral
Overall mean		**3.53 (Agree)**		

Table 6 shows an overall mean for mathematics teachers' beliefs about employing active learning in the synchronous virtual classrooms of 3.53 (agree) and means for the statements in the range 2.08–4.61. The statement "I believe that linking previous experiences with new ones helps to develop understanding" has the highest mean. This is due to teachers' awareness of the nature of mathematics, the interdependence of its topics, the accumulation of knowledge, the importance of previous knowledge for facilitating the new lesson and easily accepting and understanding new mathematical knowledge, and the growing interest in addressing educational loss. The statement "I think I do not need to relate course topics to real life situations when teaching in the synchronous virtual classroom" has the lowest mean (disagree). This is due to the fact that mathematics teachers in the primary school stage are aware of the importance of using different life situations to help students understand different mathematics topics and engage them in interaction with activities in everyday life.

Table 7. Mathematics Teachers' Beliefs About Mathematical Achievement in Synchronous Virtual Classrooms

No.	Statement	M	SD	Level
1	I believe that students' low achievement in mathematics in synchronous virtual classrooms is due to ineffective teaching methods used by the teacher.	3.06	1.176	Neutral
2	I think that whenever students' grades in mathematics improve, this is related to the teacher's use of more effective teaching methods that are commensurate with the nature of the synchronous virtual classroom.	3.76	1.078	Agree
3	I think that whenever a student performs better than usual in synchronous virtual classrooms, this is most likely due to the math teacher's extra effort.	3.92	3.92	Agree
4	I think that the weak mathematical background of some students in the synchronous virtual class can be overcome by taking individual differences into account.	4.13	4.13	Agree
5	I think that the family's monitoring of students' achievement has become more influential in their levels after moving to synchronous virtual classrooms.	4.62	4.62	Strongly Agree
6	I think that my students can acquire different mathematical thinking skills in synchronous virtual classrooms.	3.88	3.88	Agree

Table 7. Continued

No.	Statement	M	SD	Level
7	I think that my students can solve and infer different lesson ideas in synchronous virtual math classrooms.	3.94	3.94	Agree
8	I think it is possible to enhance students' perseverance in solving math problems in synchronous virtual classrooms.	3.93	3.93	Agree
9	I think that my students can solve math problems that take into account the requirements of international tests (TIMSS & PISA).	3.46	3.46	Agree
10	I think that teaching mathematics in synchronous virtual classrooms contributed to the formation of positive attitudes among students towards mathematics.	3.77	3.77	Agree
Overall mean		**3.85 (Agree)**		

Table 7 shows an overall mean for mathematics teachers' beliefs about the mathematical achievement of their students of 3.85 (agree). The means for the individual statements were in the range of 3.06–4.62. The statement "I think that the family's monitoring of students' achievement has become more influential in their levels after moving to synchronous virtual classrooms" has the highest mean. This is due to the significant change to virtual education in general and in the primary stage in particular. The family became a partner in promoting attendance, teaching, urging interaction within the classroom, and observing requirements and homework. The family is fully aware of what is going on in the virtual classroom and the possibility of communicating with the teacher. The statement "I believe that students' low achievement in mathematics in synchronous virtual classrooms is due to ineffective teaching methods used by the teacher" has the lowest average. This is due to the teacher's conviction of the multiplicity of variables related to mathematical achievement in the virtual learning context, including the role of the family, student interaction, technology-related problems, and multiple changes in the academic system in terms of time and class duration.

Table 8. Results of Independent Samples T-Tests for Significance of Differences in the Beliefs of Mathematics Teachers About Synchronous Virtual Classroom Learning Based on Gender and Qualifications

Variable	Category	N	M	SD	df	t	Sig.
Gender	Male	168	115.9	10.6	408	1.143	.482
	Female	242	117.2	11.3			
Qualification	Bachelor's degree	372	116.8	10.8	408	.772	.158
	Masters' degree and above	38	115.3	13.4			

Table 9. Results of One-Way ANOVA Testing the Significance of Differences in the Beliefs of Mathematics Teachers About Synchronous Virtual Classroom Learning Based on Teaching Experience

Variable	Source of variance	Sum of squares	df	Mean square	F	Sig.
Teaching experience	Inter-group	55.24	2	27.621	0.225	.799
	Intra-group	50037.6	407	122.94		
	Total	50092.9				

Tables 8 and 9 show no statistically significant differences ($\alpha \leq .05$) in the beliefs of mathematics teachers about teaching in synchronous virtual classrooms in terms of gender, qualifications, or teaching experience. This is because the transition of teaching to synchronous virtual classrooms was new for all teachers and everyone receives the same instructions and training programs in teaching mathematics. However, the results of this study differ from those of Saadati et al. (2021) and Aloufi et al. (2021), who found that females are superior to males in terms of their beliefs about teaching practices.

Qualitative Results

Both deductive and inductive approaches were conducted when analysing the responses to the open-ended questionnaire items and individual semi-structured interviews. The deductive path was related to the key dimensions in the quantitative part of the study (teaching competence, employing active learning, and mathematical achievement), while the inductive path was used to distinguish the responses in subsections.

Beliefs about teaching competence in synchronous virtual classrooms

Beliefs about teaching competence are an important factor because they are related to several aspects of teaching and learning: the level of teaching performance, student achievement, and assessment practices. The study identified both positive and negative beliefs. The former concerned the opinions teachers held about their teaching competence related to the possibility of implementing effective instruction under the conditions of distance teaching in the synchronous virtual classroom in contrast to face-to-face teaching. In terms of negative beliefs concerning teaching competence, this referred to teachers' perceptions of their inability to provide effective teaching practices in the virtual classroom in contrast to face-to-face instruction.

In terms of positive beliefs, the teachers generally viewed the virtual classroom as including many components and tools that facilitated the process of teaching mathematics topics in general, and that could ensure the process of continuing teaching and learning and achieving an acceptable level of goals. One teacher said "In general, teaching mathematics in the synchronous virtual classroom has become smooth and easy". Another reported "The platform provides multiple services that facilitate teaching and assessment".

There was an opportunity to learn how to employ applications and software in teaching mathematics, and this helped to provide mathematical knowledge appropriately and diversify teaching methods and strategies. As one teacher said, "I became better than before in using applications and mathematical software when teaching mathematics topics". This also helped enhance technology control and manage the virtual classroom efficiently. A teacher emphatically stated "I can manage my virtual classroom in a great way".

The shift to teaching in the virtual classroom provided the motivation for learning and professional self-development, as well as giving teachers the opportunity to exchange experiences. They saw an opportunity to improve verbal communication and mathematical dialogue. A participant said that "Many students' verbal communication improved". Some also believed that this experience increased their self-confidence through overcoming challenges and acquiring various technical skills. Another participant said "This experience allowed me to develop my teaching performance with self-reliance".

However, the mathematics teachers also articulated negative beliefs and opinions about their teaching competence in synchronous virtual classrooms. Some teachers made a general comparison between face-to-face teaching and distance teaching. As one teacher said, "It is not possible to teach in synchronous virtual classrooms to a performance level equivalent to face-to-face teaching". Another indicated "I cannot follow up on students and verify that they have understood". This was confirmed by another participant, who recounted "I think that the teaching performance has decreased in general due to the multiplicity of needs" and "It is difficult to convey information well when teaching at a distance".

Some teachers viewed it as difficult meet students' psychological needs, which limited the extent of diversity in teaching, the ability to retain the attention of students throughout the class, and determining the true level of students and the extent of their comprehension of the lesson. One participant said "I do not know how much students pay attention to the lesson due to the absence of body language".

Teachers also found it difficult to organize class time due to the multiplicity of circumstances and variables. Moreover, it was hard to provide teaching at a consistent level of performance and excellence. Some teachers believed that teaching competence was declining due to the various needs for development, and long-term planning was not possible leading to the provision of mathematical content in a fragmented, incoherent, and inconsistent manner. Other teachers saw the presence of the family next to the student as a challenge to good teaching and considered that appropriate strategies should be used to ensure a good fit in terms of family involvement in the student's participation.

Beliefs about employing active learning in synchronous virtual classrooms

Mathematics teachers' beliefs about employing active learning in synchronous virtual classrooms varied. Several teachers considered it possible to take account of certain foundations for active learning, while others found it difficult to apply them in the synchronous virtual classroom. The former group cited choosing software and applications that could contribute to attracting students' attention, increasing their interaction, improving their communication and mathematical dialogue, and presenting some situations from daily life or referring to them verbally. In this context, a participant pointed out that "In all cases, it is important to link mathematics lessons to students' lives". Moreover, previous experience should be emphasized before presenting new content. A participant said that "The mathematics class cannot go well without referring to previous experiences, whether in distance teaching or face-to-face teaching". It is also possible to direct distinguished students to self-learning and to use some strategies that promote the observance of the active learning philosophy in the virtual classroom, including the active learning strategy.

However, some teachers see difficulties in employing active learning and the ability to manage time and the impossibility of doing so in the primary stage in particular. Others believe that the teacher presenting the lesson and the student being the recipient is the best way to achieve an acceptable level of interest and that students' (lack of) involvement may cause other students to be distracted and class time to be lost and reduced. This was stated by a participant as follows: "I think that the best method for teaching mathematics in distance education is for the teacher to take charge of matters". Some teachers viewed it as difficult to consider active learning in all mathematics lessons. Also, active learning requires great effort in preparation. A participant noted that "Time constraints hinder the use of active learning strategies". Another observed, "Active learning in the virtual classroom requires a long time and doubled effort".

Beliefs about the mathematical achievement of students in synchronous virtual classrooms

The teachers' beliefs and opinions about their students' achievement in mathematics were based on three elements that they believed to be highly influential: (i) the teacher's role; (ii) the family's role; (iii) the students' role.

Some participants directly linked the development of students' mathematical achievement to the teacher's performance and his ability to use teaching methods and strategies and choose appropriate tasks, applications, and software that would contribute to the development of mathematical achievement. A participant said "The more the teacher diversifies teaching methods and strategies, the higher the level of achievement of his students". In contrast, some teachers considered it difficult to determine the level of student performance due to the challenges of implementing the electronic assessment. Moreover, they were of the opinion that electronic assessment could not give a true picture of students' achievement, limiting the development of various questions that could tackle different skills and levels. Assessment is restricted to daily participation. One teacher referred to this, stating: "It is not possible to determine the real level of the students"; "It is difficult for the teacher to follow up well on the level of his students in distance education" and "Mostly, students' assessment questions are at the level of knowledge and application; it is difficult to assess higher thinking skills".

In terms of the family's role, there was broad agreement about the influence of the family on students' achievement, whether positive or negative. It was believed that families' closeness to students helped them focus on the class, interact, and follow up through the required homework and tasks. Families also urged the children to complete their tasks and held frequent discussions with teachers. A participant said that "The participation of families contributed to the improvement of student's achievement". However, some teachers were of the view that the family had a negative influence on the achievement of their students as manifested in their performance in homework and interference during the class. As one participant put it, "Some families' practices cause their children to lower their level, such as doing homework on their behalf".

In terms of the students' role, a group of teachers believed that the level of mathematical achievement was mainly related to their motivation to learn and the extent of their seriousness and their readiness for the lesson. Some teachers maintained that students' remarkably low performance was either due to a lack of attention on their part or to technological problems that precluded students' from benefiting from what was taught. This was emphasized by a participant who said "Whenever students work hard, their mathematical achievement increases". Some teachers also pointed out that students' achievement can fluctuate without a clear justification: sometimes it is high and sometimes it is low. Furthermore, students' capability in terms of self-learning and their attitudes towards learning mathematics are among the salient factors that promote (hinder) achievement and enhance (diminish) their perseverance in learning mathematics. As a participant recounted, "The student's attitude towards mathematics is an important factor in improving his achievement".

Comparison and Linking of Results

The comparison and linking process was carried out in light of the criteria presented in Table 10. Making comparisons and linking the quantitative and qualitative data is an essential stage in the convergent parallel design. This study addressed three dimensions. In terms of the first, which concerned teachers' beliefs about their teaching competence, there is an agreement between the quantitative and qualitative data in several respects, including the ability to teach mathematics topics in the virtual classroom, to use appropriate teaching strategies and methods, and to appropriately provide mathematical knowledge. This is because remote teaching has now been employed for a long period, the pandemic has been accompanied by many training and self-development programmes, and teachers' knowledge of the content supports teaching and answering students' various questions and inquiries. There was also agreement about the difficulty of following up on students' progress while implementing activities in the classroom for several reasons, including the short duration of the class, and the difficulty of interpreting body language and attracting the students' attention. The interviews also revealed negative beliefs among teachers, including the impossibility of teaching well in the virtual classroom and the multiplicity of the challenges that hindered good teaching.

Table 10. Standards for Comparing and Linking Quantitative and Qualitative Data

Quantitative study	Qualitative study	Explanation
Beliefs about teaching competence	Positive beliefs	Related to the teacher's opinion of himself and the possibility of effective teaching in the synchronous virtual classroom at a level close to that of face-to-face education.
	Negative beliefs	Related to the teacher's opinion of himself and his inability to teach effectively in the synchronous virtual classroom at a level close to close to that of face-to-face education.

Table 10. Continued

Quantitative study	Qualitative study	Explanation
Beliefs about the employment of active learning	Possibility of employment in the virtual classroom	Describes the teacher's ability to consider the foundations of the active learning philosophy within the synchronous virtual classroom at a level close to that in face-to-face education.
	Impossibility of employment in the virtual classroom	Describes the challenges and obstacles that hinder the teacher from considering the foundations of the active learning philosophy within the synchronous virtual classroom at a level close to that in face-to-face education.
Beliefs about students' mathematical achievement	Relationship with the performance of the teacher	Describes the relationship between success in teaching different mathematics subjects and raising the level of students' achievement on the one hand and dependence on the teacher's performance on the other.
	Relationship with the student himself	Describes the student's roles and responsibilities in achieving in the virtual classroom.
	Relationship with the role of the family	Describes the positive or negative role of the family in student achievement.

Concerning the second dimension, employing active learning, opinions differed regarding its foundations. There was agreement on the importance of the clarity of teaching for students in the virtual classroom. However, some teachers believed that it was difficult to address many of the foundations of active learning for primary school students due to the multiplicity of distractions and the negative interference from some families during class. It is preferable for the teacher to be able to explain the lesson over a large proportion of the class time to ensure that the objectives are achieved.

Regarding the third dimension concerning beliefs about mathematical achievement, the results of the quantitative study indicated the possibility of developing students' mathematical achievement and thinking skills, but depending on the teacher, the student, and the family. The interviews revealed the difficulty of evaluating students' mathematical achievement effectively through the electronic assessment. Therefore, opinions differed about who played the most prominent role: the teacher, the family, or the student. The role of the teacher becomes salient in making an extra effort, diversifying teaching methods and strategies, and linking what is taught to previous experiences and the student's daily life. As for the family, there is agreement about the negative or positive impact because of the role it plays. The student is an important factor in mathematical achievement in terms of motivation, interest, and follow-up.

Discussion

In response to the recommendations of many studies (Rott, 2021; Safrudiannur & Rott, 2020; Xie & Cai, 2021), this study varied the tools and stages of data collection to encompass the complexity of the exploration of beliefs. Quantitative and qualitative data were collected in parallel, without one depending on the other, to tackle the topic from different angles and attain a comprehensive view of teachers' perspectives. The study also focused on the primary stage of education, which differs in nature from other stages in several respects. Distinct dimensions were addressed to compare teaching beliefs related to instruction under natural conditions in contrast to the peculiar conditions of the COVID-19 pandemic, namely: teaching competence, the basis for sound teaching practices when teaching mathematics in a technical environment (Thurm & Barzel, 2022); employing active learning, considered a challenge due to the difference in the classroom environment, the need for preparation, and the lack of body language; mathematics achievement, being one of the most important goals of continuing education.

The problem of educational loss has received great attention in various educational systems and international institutions. Education officials hope that the gap will narrow now that a period of time has passed since the onset of the COVID-19 pandemic and that it will be possible to avoid deficiencies at the beginning of emergency education. In general, the teachers' perceptions are positive regarding teaching competence, which agrees with the results of Saadati et al. (2021), who found that teachers realized their ability to teach mathematical knowledge (conceptual and procedural) and to perform well in mathematics classes in relation to various topic due to the availability of the necessary mathematical knowledge in terms of content and their previous experience of teaching the primary stage.

Moreover, as the study was undertaken in the second year of the COVID-19 pandemic, the teachers were better able to deal with technology in general and to teach in the virtual classroom in particular. In addition, virtual classrooms provide good teaching aids and materials for primary school mathematics topics. The content focuses on numbers and operations to a greater extent, while measurement and algebra come later on. Then, the basic engineering concepts are presented through tools available on the educational platform.

The transition to distance education created a movement in the field of professional development, whether through programmes offered continuously or through self-development, as indicated by many teachers. This is consistent with Khalil and Al-Maliki's (2017) study on the multiplicity of factors affecting the beliefs of mathematics teachers, including training programmes and specialized knowledge. However, the teachers expressed beliefs about the difficulty of following up with students during the virtual class when they were performing their activities. This was also emphasized by the qualitative results, i.e., the difficulty of achieving equilibrium between face-to-face and emergent education in all practices.

Also, there was a divergence in beliefs about employing active learning due to the change in environment, which was influenced by family culture, and teachers' beliefs about mathematics teaching, both before and during the pandemic. There was agreement on some foundations, such as defining the objectives of the lesson and linking them to previous experiences. There was disagreement on other foundations, such as allowing students to participate in the lesson. This is due to the changes that occurred and affected the course of the lesson, including reducing class time and the presence of family members next to students, having either a positive or negative impact on the students and their interaction during the class.

With regard to mathematical achievement, the disagreement regarding the factors responsible for achievement (the teacher, the family, or the student) may be due to the difficulty of accurately judging the students' level through electronic assessment. Moreover, formulating questions and diversifying their presentation and levels requires effort, prior preparation, and experience in preparing electronic tests. This is confirmed by the studies of Al-Khabti (2021) and Horn and McGugan (2020). Difficulties may also be due to teachers' consideration of the conditions of students in the primary stage. Furthermore, technical problems can affect the quality of assessment of the actual and realistic level of the student.

In general, teachers maintain that the development of mathematical achievement is possible despite multiple challenges, as there are students who interact and persevere in different types of activities. This may be due to the nature of students in the primary stage and their eagerness to compete whenever possible. The difficulty is thus limited to the accuracy of judging their performance, which is one of the most prominent differences between distance education and face-to-face education.

The study found no statistically significant differences between the teachers on any dimension related to gender, qualifications, or teaching experience, likely because all the teachers were newly experienced in emergent education and had experienced the same conditions and challenges. The capabilities that they had in the virtual classroom were equal because everyone was teaching using the same virtual platform, with the same advantages and shortcomings. Moreover, everyone received the same professional development, whether related to technology or education.

Conclusion

The study was conducted after some time had passed since the implementation of distance learning in the synchronous virtual classroom. This in turn contributed to the beliefs of mathematics teachers being relatively positive towards teaching in the synchronous virtual classroom because the educational systems and teachers had adjusted and many of the challenges that had been experienced at the beginning of the COVID-19 pandemic had been overcome.

Beliefs about teaching competence were highest because the teachers had attended training programmes and gained experience; therefore, they were prepared and had adapted to the new conditions. In contrast, teachers' beliefs concerning employing the philosophy of active learning presented the lowest mean scores. This may be due to a number of reasons, including reduced class time and the teachers' focus on completing the curriculum.

The study also found no differences in beliefs concerning teaching in synchronous virtual classrooms in terms of the variables gender, experience, and qualifications, most likely due to the fact that the pandemic meant everyone was working in a new environment and receiving the same programmes and directions. With regard to the study methodology, the diversity of methods and tools helped to develop a clearer picture of teachers' perceptions, in particular showing the reasons for their responses.

Recommendations

Future studies might observe the performance of mathematics teachers in the virtual classroom and undertake a comparison with teachers' perceptions to identify the relation between them. Moreover, the relationship between teachers' beliefs and students' achievement could also be studied. In addition, research might analyse previous studies that dealt with the beliefs of mathematics teachers at the beginning of the pandemic and their beliefs after the passage of time to identify any changes and the reasons for them.

Mathematics teachers might also conduct participatory procedural research, aiming to improve their teaching practices, raise the level of mathematics achievement among their students, and create a positive approach towards teaching and learning mathematics.

Finally, mathematics teachers should pay great attention to the clarity of teaching and involving students in meaningful mathematical dialogue, to say nothing of providing extensive opportunities for students to express their ideas, raise questions, and justify their answers.

Limitations

This study has identified the beliefs of mathematics teachers in the primary stage in relation to the introduction and continuation of distance teaching, as typical in many countries following the onset of the COVID-19 pandemic. These beliefs were addressed in terms of three dimensions: teaching competence, employing active learning, and mathematical achievement. The study encompassed teachers' experience of teaching mathematics before the pandemic, at the beginning of the pandemic, and after an interval had passed since the onset of the pandemic. These dimensions can form the basis for ensuring the continuation of instruction in line with effective teaching practices consistent with face-to-face teaching, ascertaining teachers' ability to engage in effective online teaching, and mitigating the problem of educational loss, which is an international phenomenon. The qualitative aspect of the study provided a means of triangulation, both through open-ended items in the questionnaire and semi-structured interviews with 10 teachers. This provides an example of methodological rigour for other studies.

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