AJOTE
African Journal of Teacher Education
ISSN 1916-7822. A Journal of Spread Corporation

Volume 11. No. 1 2022 Pages 121-142

Mathematics Teachers' Use of WhatsApp Groups as a Platform for Continuous Professional Development in Tanzania

Jimmy Ezekiel Kihwele & Fred Mgata
Mzumbe University, the Republic of Tanzania

Abstract

Updating mathematics teachers' pedagogical skills and content knowledge is inevitable as the trend of students' performance in Tanzania is alarming. Currently, social media have been one of the strategies for elevating mathematics teachers' professional competencies through online learning communities. The study aimed at examining how mathematics teachers use Informal WhatsApp Groups (IWGs) as one of the social media for Continued Professional Development (CPD). Key study questions are what are the perceptions of mathematics teachers on the benefits of IWGs in CPD? How do mathematics teachers use IWGs for CPD-related activities? What are the challenges they encounter? And what Mathematics teachers recommend for better use of IWGs for CPD? Two IWGs were involved with a total of 54 mathematics teachers who are currently teaching in secondary schools. The open-ended questionnaire was shared in the IWGs, and members accepted to fill it. Ten members including those who have been in the IWGs for a longer period, those who frequently posted or asked questions, and group leaders were invited for interviews. The findings show that the IWGs have contributed to teachers developing their pedagogical skills and content knowledge through sharing experience, and materials and demonstrating teaching practices in video clips. The challenges include the problem of internet accessibility, inactiveness of members, and lack of effective criteria for evaluating the validity and reliability of information shared. The recommendation is for the authorities to set supportive policies and practices that will create enabling environments for mathematics teachers on CPD.

Introduction

Many secondary school students in Tanzania struggle to understand mathematics (Mazana *et al.*, 2020). Studies have investigated the factors associated with students' struggle to understand mathematics in Tanzanian secondary schools (Mazana *et al.*, 2020; United Republic of Tanzania [URT], 2019; Masele & Tweve, 2018). Mathematics teachers' weak pedagogical abilities and content knowledge are some of the mentioned factors. Thus, continuous professional development (CPD) practices in teaching are essential in elevating teachers' pedagogical skills and content knowledge to keep them updated and in sync with the changing

times (Popova *et al*., 2018). CPD includes workshops, seminars, peer observation, peer coaching, classroom action research and informal discussions or conversations conducted face-to-face or online (Priajana, 2017).

Online learning communities play a vital role in understanding the avenues of motivating and igniting interest in studying mathematics for both teachers and students. This paper discusses teachers' using WhatsApp, one of the online learning platforms to foster professional development. WhatsApp platform is flexible in reaching many teachers who could otherwise not access other forms of CPD training. WhatsApp platforms can engage teachers in constructive interactions to boost their pedagogical capabilities and content knowledge. WhatsApp group platforms offer mathematics teachers an opportunity for CPD to learn and elevate their teaching skills (Kopung, 2016; Moodley, 2019; Motteram *et al*., 2020). According to Moodley (2019), WhatsApp promotes peer collaborative mathematics learning, ubiquitous mathematics learning, synchronous and asynchronous mathematics learning and anonymous mathematics learning.

CPD allows teachers to align their contextual experience with learners' needs and interests by integrating multiple teaching methods (Aras, 2020). Contextual experience refers to the accumulated teaching experience of teachers in a particular learning setting that helps them better manage students' learning processes in their classrooms. Furthermore, CPD contributes to informing and orientating teachers on practical uses of learning resources, teaching aids, and active engagement of learners in the process of learning and considering the learning abilities of learners (Lessing & De Witt, 2007; Opfer & Pedder, 2010). Mathematics teachers must engage in CPD practices to elevate their pedagogical skills, content knowledge and professionalism for teaching that can improve learners' performance.

Studies have reported that instructional approaches, learning materials, motivation and teachers and students' attitudes significantly influence the teaching and learning of mathematics (Mazana *et al*., 2020; Mutodi & Ngirande, 2014; Mbugua *et al*., 2012). In Tanzania, both teachers and students perceive mathematics negatively, which affects their learning attitude, hence their inability to demonstrate the acquired mathematics competencies (Masele & Tweve, 2018; Setapa *et al*., 2016). Using online learning platforms such as WhatsApp helps foster teachers' attitude to the subject, thus; influencing how teachers teach mathematics and how students learn and perform (Amir *et al*., 2016; Mutodi & Ngirande, 2014). According to Mestry *et al*. (2009), teachers improve their pedagogical skills and content knowledge through engaging in various CPD activities. These CPD activities include using WhatsApp platforms

to foster quality teaching and learning. In this era of technological sophistication, most of the CPD opportunities are implemented virtually via online platforms such as WhatsApp (Moodley, 2019; Raja & Nagasubramani, 2018). Through WhatsApp, technology has enhanced online learning communities to support CPD amongst teachers (Duncan-Howell, 2010). Teachers have adopted WhatsApp to support intra-school and inter-school CPD, with the results showing that they have improved their teaching skills and content knowledge (Mughal *et al.*, 2020; Bruguera *et al*., 2019).

Universities and colleges ought to train and supply competent and adequate number of mathematics teachers who are capable of igniting interest and motivation for learners to study mathematics. In Tanzania, the Bachelor of Education in Mathematics requires a principal pass in advanced secondary and ordinary secondary level examinations. However, because many secondary school students perform dismally in mathematics, only a few qualify for university's mathematics programmes, and fewer still decide to become mathematics teachers. To promote interest and exemplary performance in mathematics, teachers need to elevate their content knowledge and pedagogical competencies using various initiatives. Opportunities to advance mathematics teachers' pedagogical skills and subject content knowledge include those afforded by technology-based platforms such as WhatsApp-based informal groups for interaction and sharing ideas, experiences, and best teaching practices.

Several studies done by Mazana *et al*. (2020), Bütüner (2017) Masele and Tweve (2018) as well as Ochieng *et al*. (2016) on East Africa, have revealed that many mathematics teachers lack adequate pedagogical skills and mathematics content knowledge, which result in poor teaching of the subject in schools. Mazana *et al*. described the flawed methodology that teachers in their research area use in teaching mathematics:

> Teachers describe poor teaching methodology as a cause of student failure in mathematics. Their answers revolved around poorly trained teachers with insufficient pedagogical skills, teachers lacking content knowledge, incompetency, lacking child psychology knowledge and relying on a teacher-centred approach to deliver instructions (2020**:**9)

The ineffective teaching methods that teachers use in some Tanzanian schools have negatively affected students' learning and performance in Mathematics. According to the URT (2019), in Tanzania, academic performance in mathematics at the primary school level in 2018 dropped by 3.51% compared to 2017, mainly due to teachers' lack of pedagogical skills coupled with limited content knowledge. It is impossible to address these pedagogical skills

and content knowledge challenges without engaging teachers in various CPD programmes. These CPD programmes, such as using online learning communities through WhatsApp, are central to mentoring mathematics teachers to improve their teaching skills and content knowledge.

Raluca and Romulus (2015) define informal groups as those whose collective experiences and interactions help to improve relationships and their skills beyond work matters that school management sets. In this study, WhatsApp groups refer to 16 - 38 mathematics teachers who have voluntarily joined a WhatsApp group for socialisation and interaction on teaching and learning mathematics and general issues about their wellbeing. These mathematics teachers set their own rules and regulations governing group cohesion. They have leaders who manage group activities and ensure adherence to the rules and regulations that members, primarily as administrators, set.

In Tanzania, 398 mathematics teachers (200 from primary schools and 198 from secondary schools) from poor performing areas received CPD training in the 2018-2019 period to update their knowledge and enhance their teaching skills (URT, 2019). In these CPD training, teachers learned various methods and strategies for teaching mathematics with subsequent targets to improve students' performance in mathematics. Yet, the number of teachers who received CPD training is relatively small compared to the total number of teachers in areas with poor mathematics performance. This observation implies that many mathematics teachers rarely received or participated in CPD training programmes to boost their content knowledge and pedagogical skills (Kafyulilo *et al*., 2015).

Although different students have different learning abilities and learning styles, Law (2013) claims that changes in teaching techniques and styles are necessary to accommodate the learners' varying abilities. Law further contends that teaching techniques and styles can be acquired when teachers reinvent their teaching practices in the classroom. They cannot be taught and imported to class. In this regard, teachers' collaboration helps to improve their classroom pedagogical skills and content knowledge (Arends *et al*., 2017). Improved teachers' pedagogical skills in turn will significantly and positively impact students' academic performances (Mutodi & Ngirande 2014).

Thus, integrating virtual platforms like WhatsApp into teacher professional development practices could provide an opportunity for teachers to interact and elevate their pedagogical skills and content knowledge. Studies conducted in the Philippines (Abirin & Obra

Jr, 2018) and Saudi Arabia (Albalawi, 2017) revealed that teachers informally used WhatsApp for interaction and learning as a CPD platform in different contexts. Several studies have investigated how WhatsApp has been integrated into teacher CPD to improve mathematics teaching and learning at different levels. Motteram *et al*. (2020) studied how the WhatsApp platform supported the CPD of English teachers in Jordan. They found that WhatsApp enabled teachers to share helpful information and materials, which helped improve pedagogical skills and content knowledge. However, there were challenges of access, equity, participation and sustainability**.** The study conducted by Moodley (2019) focused on understanding how WhatsApp helped create virtual learning environments for teachers. It established that the effective use of WhatsApp depends on teachers' awareness of the context and willingness of members to accept varying opinions and views.

The study by Cansoy (2017) on teachers' use of WhatsApp for CPD in Turkey found four key areas of collaboration that were of benefit to group members, all helping the teachers to transform their teaching skills. The four key areas were: i) *field knowledge*: where teachers share documents and discuss subject matters; ii) *pedagogical content knowledge*: in which teachers share experiences of the best methods of managing students, managing learning process by choosing effective instructional methods and how to use them better and methods of assessing learning achievement; iii) *sharing in-school teaching practices*: This involves teachers' sharing pictures and videos demonstrating classroom experience with other teachers from other schools for learning purposes; and iv) *emotional support among teachers*: in which teachers encourage each other, share advice for improvement and acknowledge their achievements.

La Hanisi *et al.* (2018) investigated teachers' use of WhatsApp in collaborative learning to elevate teaching skills for better facilitation of learning in Indonesia. Likewise, in South Africa, Naidoo and Kopung (2016) investigated how pre-service teachers use WhatsApp to enhance their pedagogical skills. Their study found that such WhatsApp groups foster constructivist learning environments for teachers in mathematics. In this constructivist environment, pre-service teachers improve their mathematics teaching methods. Drawing on experience they acquired from WhatsApp group platforms, teachers employ various methods and techniques of teaching to engage learners, in classroom settings. The findings from these studies show that apart from WhatsApp being a platform for communication and socialisation, it also enhances the mode of asking questions and provides a channel for students to find

solutions to problems and share new ideas. In this regard, WhatsApp can give an alternative for supporting and sustaining CPD in an easy, fun, convenient and quick way.

Statement of the Problem

Several studies in East Africa show that teachers' pedagogical competencies are generally low, negatively impacting students' learning and performance (Mazana *et al*. 2020; Masele & Tweve 2018). The CPD training has been inadequate, and the few teachers who have benefited from them have failed to sustain the learning that addresses learners' changing needs and interests. Hence, the objective of this study was to explore how mathematics teachers use WhatsApp groups as a platform for continuous professional development in Tanzania. The following are the specific research questions that intended to answer the main research objective:

i. What are mathematics teachers' perceptions of the benefits of WhatsApp groups in teachers' CPD in the Tanzanian context?
ii. How do mathematics teachers use WhatsApp groups for CPD-related activities?
iii. What challenges do mathematics teachers encounter in using WhatsApp during CPD?
iv. What do mathematics teachers recommend for better use of WhatsApp groups for CPD?

Methodology

Study design

The study is purely qualitative, and it adopted a netnography design to understand the online interaction pattern of mathematics teachers in WhatsApp groups for CPD in this digital era. Netnography originates from ethnographic methods, which allow a researcher to immerse in a social environment for an extended period and engage in conversation while observing members' behaviours (Brayman, 2012). The increase in internet accessibility has enabled people to form online communities that allow them to interact regularly (Morais *et al*., 2020). On the other hand, the emergence of such online communities has made it difficult for ethnographers to study their interaction patterns and behaviours, hence the rise of netnography as a method for studying and analysing such online communities with their interactions. Essentially, netnography focuses on studying people's online interaction behaviours when

people are not in the exact location geographically but are rather technologically connected. The advantage of the netnography method is that it does not influence the monitoring of communication and interaction among the members (key informants) to gain experience-based insights into their usage behaviour (Costello *et al*., 2017). In the same vein, Addeo *et al*. (2020) add that netnography can make a researcher invisible to the people under observation and allow for automatic data recording, studying trends over time and in real-time.

Participants

The study recruited Two WhatsApp groups comprising 54 mathematics teachers (Group 1 with 38 members and Group 2 with 16 members) who had completed their Bachelor of Education in Economics and Mathematics in or before 2018 and were currently teaching in different secondary schools in the country. The study employed a convenient sampling technique to determine WhatsApp groups for the study. The study also used the purposive sampling technique to identify interviewees who met the pre-set criteria to provide the required information. The groups took part in the study because the pre-service degree programme was pure mathematics, preparing them to teach mathematics in secondary schools. The variation in the number of members within the groups emanated from the influence of the group administrators and various reasons in attracting people to join it or leave it. The groups have been operating for more than four years. Participants gave their consent to participate in the study voluntarily. These WhatsApp group members allowed the researchers into the WhatsApp groups where the researcher stayed as members for six months, observing the interaction pattern. After the observation, 16 members were purposively selected as key informants (10 and 6 from Group 1 and 2 respectively) and participated in interviews. The selected members were those who stayed in the group longest. Additionally, they were also members who have been active in the group by frequently posting, and leading the questioning and answering compared to the rest of the members. The selected members participated in a semi-structured in-depth interview of about 40 minutes.

Data collection method

Group administrators, de facto leaders of WhatsApp groups, invited the researcher to observe teachers' interactions within the WhatsApp groups for six months. The researcher conducted non-participatory observations alongside the administration of open-ended questionnaires and telephone interviews for collecting data. All 54 members agreed to fill out the open-ended questionnaire shared in the group.

Data analysis

Data analysis involved content and thematic analysis. The presentation provided detailed descriptions supported by verbatim quotations from the data and images obtained from observation of the group. The coding method helped identify the emerging patterns from the data collected to form themes that answered the research questions. The analysis process involved transcribing the recorded audio files into texts which were then coded after rounds of reading them for deeper understanding. The codes were then categorised to form the thematic patterns answering the research questions.

Ethical issues

The researcher shared specific research questions that needed answers and informed participants what the research's purpose was. Consent was obtained from the respondents before joining the WhatsApp groups and for accepting to participate in interviews. All the respondents agreed to participate in the research. The information gathered and observed in WhatsApp groups was treated confidentially and solely for learning purposes.

Findings

The study sought to answer the main research objective that explored how mathematics teachers use WhatsApp groups for continuous professional development (CPD). The study found that teachers generally have a positive perception of the use of WhatsApp groups because the platform helps them improve teaching skills and knowledge of mathematics content regardless of the costs associated with the internet. Moreover, teachers use WhatsApp groups to share resources, learn new knowledge, ask questions and demonstrate their skills and knowledge through discussions geared to improving their classroom teaching practices. On the other hand, they encountered a main challenge of the lack of a fixed schedule for specific learning activities. Also, they lacked uniform time to discuss posted topics in the forum. The lack of an agreed activity time results in a single issue taking several days without a response from the members. The researchers' last question gathered the views and suggestions of the teachers who proposed upscaling WhatsApp to benefit more teachers. The following paragraphs present these findings in detail.

Perceptions of Mathematics teachers on the benefits of WhatsApp on CPD

The first question sought to understand mathematics teachers' perceptions of the WhatsApp benefits in teaching and learning mathematics. The responses show that teachers have positive

perceptions of the tool mainly because WhatsApp exposed them to new ideas and approaches and allowed them to share innovative ideas and skills. The WGs further provide an opportunity for teachers to collaborate in solving issues related to mathematics problems and discuss the emerging issues related to their area of teaching, as illustrated in Table 1:

Table 1: Mathematics teachers' perceptions on the benefits of WhatsApp for CPD

No	Theme	Excerpts from transcripts	Implications
1	Getting exposed to new innovative ideas and approaches	✓ *Getting information on the best teaching practices* ✓ *Benefiting from different ideas posted* ✓ *Exposure to new ideas and practices* ✓ *Sharing answers to some complicated concepts* ✓ *Also, this is a place where I learn different simple approaches and strategies of teaching some mathematics topics.* ✓ *Asking different challenging questions* ✓ *The group enables us to know more things concerned with the mathematics teaching and learning process*	Online interactions promote critical thinking that results in innovative ideas and new teaching strategies
2	Sharing new creative ideas and materials	✓ *Sharing ideas with group members,* ✓ *Sharing mathematical concepts and meaning* ✓ *With WhatsApp, it becomes possible and straightforward to share different ideas and to understand various concepts concerning the subject* ✓ *I get additional materials, like past papers or images from books* ✓ *Sharing experience of teaching from other teachers through video.* ✓ *Getting notes and a better-organised scheme of works and lesson plans*	Online interaction through WhatsApp helps teachers benchmark, adopt and adapt innovative ideas. The WhatsApp platform allows them to experiment with the best methods and strategies in assisting the learning process
3	Solving challenging mathematical problems	✓ *Solving different mathematics problems with members,*	The online interaction elevate teachers' skills on alternative paths of understanding and

4	Discussing and debating	✓ *Solve other questions and share images* ✓ *By exchanging ideas with others* ✓ *Also, by motivating and encouraging ourselves to improve*	solving Mathematical problems that are challenging to them Teachers learn varying perspectives, beliefs and attitudes through online interactions and learn to accept the differences in teaching.

Exposure of mathematics teachers to innovations

WhatsApp groups have benefited Tanzanian mathematics teachers in diverse ways. The findings obtained from interviews with teachers show that belonging to these WGs exposed mathematics teachers to new and innovative ideas and approaches that helped them bolster their understanding and practices. This exposure enabled teachers to improve their knowledge of some mathematical concepts, teaching strategies and better ways of planning and executing lesson plans. Teachers shared mathematical concepts that some some perceived to be difficult in a simplified way that helped develop self-confidence and identity. In some contexts, links or short video clips were shared demonstrating how other mathematics teachers manage both lessons and students in the learning process. Mathematics teachers also get an opportunity to ask questions and get answers from different teachers in the forum regarding different issues related to mathematics. Thus, they obtained useful information to elevate their understanding of various mathematical concepts and approaches to teaching mathematics and create supportive learning environments.

WhatsApp groups have enabled Mathematics teachers in Tanzania to share ideas, materials, and personal experience, to help other teachers improve their teaching and learning situation. The interaction of the groups reveals that teachers share images of how certain formulae are derived or applied in solving mathematical problems. Other teachers share tests or past examination question papers and their solutions. Such papers are helpful for individual teachers when benchmarking their pedagogical skills, particularly in setting examination questions at their specific level. They use such questions to determine how the learners performed when given examinations set by other teachers other than from their respective teachers. In this regard, observation from the two WhatsApp groups shows that some teachers share their challenges in teaching mathematics, such as low learner motivation and interest and inadequacy of learning materials while at the same time providing the initiatives they take to address these challenges.

Shared solutions to challenging mathematical problems

Mathematics teachers collaborated to solve complex content, or methodological content challenges faced by some of their member teachers. Some teachers struggle with some mathematics topics and require such groups to orientate them on better solutions. These initiatives have helped them to elevate their confidence, and their lesson and learners' management skills and content knowledge.

WhatsApp groups have been severally engaging mathematics teachers in debates on the effectiveness and efficiency of some approaches and methods of instructing mathematics. According to teachers, class level or location limits some teaching methods, whether rural or urban. Based on the debates and discussions stemming from the WhatsApp groups studied, it is apparent that the teachers are assisted in being able to make justifiable choices of approaches and methods that reflect their working environment.

Using WhatsApp for mathematics teachers' continuous professional development

The second research question was how mathematics teachers use WhatsApp for continued professional learning. The findings were obtained based on direct observation in groups and interviews with teachers. Figure 1 paints a composite picture of how teachers use WhatsApp for interactive learning and sharing:

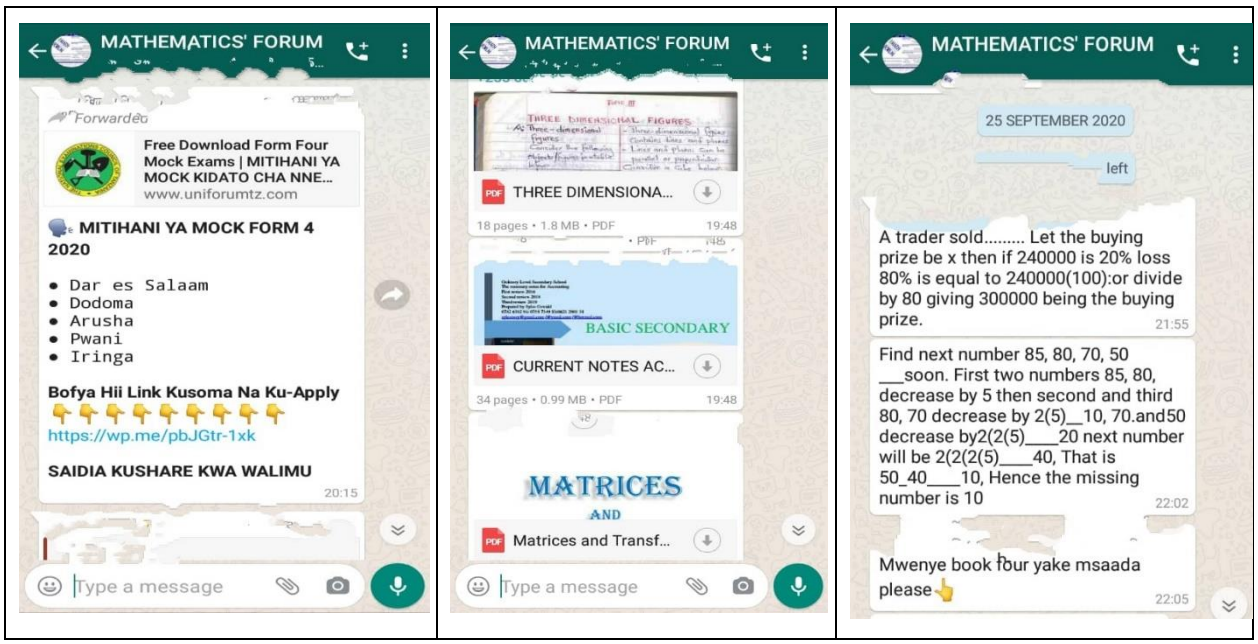

Figure 1: Screenshots of chatting obtained from the WhatsApp groups

WhatsApp as a platform for sharing online learning resources

WhatsApp allows teachers to share online learning resources such as links to useful websites and document files. WhatsApp enables teachers to share e-books in Word Document or Portable Document Format (PDF) files, and past exam papers gleaned from different schools. Mathematics teachers share links from various sites that contain subject content, past papers and new mathematics questions. Some teachers have their blogposts where they post notes on various topics. Teachers also share audio or voice notes that elaborate or explain concept(s) under discussion in the forum. WhatsApp allows sharing video clips that teachers have recorded from their classroom practices. They share mathematics syllabi and schemes of work of different levels of education. Teachers also help each other use the syllabus to prepare schemes of work, logbooks and lesson plans that can enhance students' understanding of different mathematics topics.

WhatsApp as a platform for sharing lesson management and presentation techniques

Teachers help each other apply the best techniques to manage curriculum contents and to design specific schemes of work. The management of curriculum content involves re-arranging the topics from the known to the unknown in a logical structure that helps learners understand the concepts taught and link them to real-life situations. In this regard, teacher C provided his experience on how discussions in WhatsApp groups help guide teachers on which topics to cover first and how to arrange for remedial classes to finish uncovered topics:

> During the end of the year, I was teaching Form three students who were about to sit for Form Four final examinations in the coming year. I had not covered three topics [circles, earth as a sphere and accounting]. I had to seek professional advice from experienced teachers in the group. Their experience helped me teach the topic of Accounts before moving to the topics designed for Form Four and made circles and earth as a sphere last topics after teaching all other Form four topics. I shared it with my students, and we came up with the common decision appropriate for the sake of their good performance in their exams. They did well and were among the top performers in the country's national exam (Teacher C, 2020).

Teachers practice their presentation and communication skills using WhatsApp groups, enhancing their CPD. These are carried out through writing and posting or recording a voice note explaining certain concepts, ideas or mathematical problems that fellow teachers had asked help on. Teachers in the forum help each other find solutions to different mathematics problems, including answering questions, getting new questions for learners, accessing books and past papers from different schools, including Mock exams conducted in different regions of Tanzania.

Teaching strategies and aids are also shared and demonstrated in WhatsApp groups. Sharing different problems in the forum allows teachers to advise each other on how best to teach particular mathematics topics, enhancing their professionalism. Teachers share their experiences of teaching different mathematics topics and challenge each other as they address the issues raised, ultimately improving their teaching practices to increase students' mathematics performance.

Challenges to using WhatsApp groups

The third question asked the respondents about the challenges besetting teachers' effective use of WhatsApp for continuous professional development. Their responses show that teachers face various challenges using the WhatsApp groups for CPD. According to them, four challenges emerged from their responses. The correctness of information published in the forum, the inactivity of some members, lack promptitude of feedback from the members, and problems with internet connectivity.

Table 2: Reported challenges that mathematics teachers face when using WhatsApp

No	Theme	Extracts from transcripts	Implications
1	Question of validity, reliability and accessibility of information	✓ *Sometimes we get the wrong information* ✓ *Failing to get some useful information*	Mathematics teachers face the challenge of understanding whether the shared information is correct based on curriculum standards and reflects the requirements of the national examination council when it comes to students' assessment
2	Challenge of reliable internet connection	✓ *I faced challenges like network limitations and costs of buying bundles* ✓ *Insufficient network and lack of money for purchasing data bundles* ✓ *Internet bundles for downloading materials are expensive*	Some mathematics teachers reside in areas with weak internet connections while others hardly manage to purchase data for the internet, making them unable to participate in live discussions
3	Members' inactivity and delayed feedback	✓ *Members are less serious and sometimes post irrelevant issues* ✓ *Less response of the group, sometimes they reply too late* ✓ *People sending information other than Mathematics-based content* ✓ *The challenge is sometimes you can send a question, but the members are not active (mostly they are offline), so sometimes it takes time to get feedback on what you had inquired* ✓ *Poor cooperation among members and poor response of group member* ✓ *Sometimes you may find that you need some help, but the member is not online*	Limited access to internet connection deprives mathematics teachers of a chance to actively and timely participate in online interactive learning.

- ✓ *Not getting in touch with the group for a long time*

With the above-noted challenges the forum members faced, they proposed initiating strategies regarding the validity and reliability of shared information. They believed that accessed information needs to be correct to be helpful to learners and must be relevant to the content as prescribed in the subject syllabus. In some cases, teachers reported that when debates were rather hot, they wanted to access online sources to verify the topic in the forum. Sometimes, they could not get sufficient information on the matter. Thus, teachers should have the skills to establish the validity and reliability of data from a vast array of online sources. These skills can also help them filter the correct information rather than grab whatever some teachers post in WhatsApp groups.

Internet connectivity and accessibility difficulties pose a challenge for many mathematics teachers. The findings reveal that teachers in different locations experience varying internet speeds. Some access the forum with slow internet speed makes it difficult to even open some shared files and videos. Second, the cost of buying data remains high, making it impractical to have frequent access to data. In this regard, one teacher narrated that he sometimes was unable due to cost to access the forum for up to two to three weeks. Occasional participation in the groups implies that teachers missed many discussions on various topics that were ongoing during their absence, and they find members have moved on to discussing a different issue or topic foreclosing their ability to ask questions about those earlier topics.

Another challenge is getting delayed feedback on some questions posed in the forum. Since the group consists of members from different schools, even their schedules and teaching workloads vary, hence they lack common time for interaction in the forum. This makes it difficult for all members to respond timely to issues posted in the forum, sometimes responses coming in only after several days past posting. A few of the teachers admitted that inactivity and late responses discouraged some from using WhatsApp groups as an interactive learning platform.

Mathematics teachers' recommendations for better use of WhatsApp for CPD

The final question in the study sought to get the teachers' suggestions on the practical use of WhatsApp for teachers' learning.

Table 3: Recommendations for supportive environments for using WhatsApp forum

No	Theme	Extract from Transcripts	Implications

1	Involving school leaders, subject experts or experienced teachers in the group	✓ *To allow top leaders and lecturers or experienced teachers to be in the group to get information on matters that arise which are challenging to teachers and take them to management for getting solutions.*	The presence of experts in the group plays a crucial role in controlling the quality of learning and material shared and providing the required assistance.
2	Enhancing internet accessibility to teachers	✓ *Improvements of the network by reducing the cost* ✓ *To provide free Wi-Fi to make easy sharing of ideas because sometimes people fail to contribute their ideas due to lack of money for buying data for the internet.* ✓ *It could be better if the internet could be free for learning groups because sometimes internet accessibility is the problem.* ✓ *Make good, friendly and supportive policies for teachers*	Providing the internet at a subsidised price will motivate teachers and promote their active interaction and learning for professional development.
3	Schools should allocate time in the timetable for CPD	✓ *To have a specific time for communication to enable a member to find areas with a strong and accessible network.* ✓ *To have some discussions on specific issues on which teachers face challenges to share the experience. Also, this method helps teachers properly handle some challenges in the teaching process.* ✓ *Encouraging group members to become active.*	Mathematics teachers have huge workloads; hence, the arrangement of their lesson schedules should consider giving them free time for professional development activities where they can use the WhatsApp platform for interactive learning
4	To provide training for teachers on the best use of WhatsApp groups	✓ *Workshops are important so that each member of the group knows their responsibility in the forum* ✓ *Members should be strict in sharing concepts and techniques of solving mathematics* ✓ *By educating members and giving seminars on using the WhatsApp forum*	Training on better use of WhatsApp forums for learning have a multiplier effect on teachers where they elevate their learning avenues for professional development

This section presents recommendations based on the findings of mathematics teachers view of the benefits and challenges of using WhatsApp groups in elevating their professionalism. Teachers believe that school leaders and experts in the subject area should participate in WhatsApp groups. These experts may be teacher educators or experienced teachers in mathematics. The leaders and experts will guide and assist teachers who experience some challenges that need intervention in terms of leadership or experience in the area. Forums' lack of consensus among group members calls for an intervention from the expert's opinion and advice.

Mathematics teachers call for affordable internet services to use WhatsApp for CPD. The recommendation is raised for internet providers to treat mathematics teachers as a special group that requires internet services to support the online interaction approach for capacity

building and accessing adequate teaching and learning resources. The provision of cheap internet service requires the government to collaborate with service providers to support teachers' access to affordable internet in school settings. Cheaper internet could promote technological-based teaching and learning and likely actuate an active learning environment.

The school management should allocate free time once a week for teachers to engage in CPD activities, including through WhatsApp groups. The free time during work hours could enable teachers to interact fully for both formal and informal activities designed to elevate their skills and knowledge. Activities such as discussion, conversations, debates and reading shared materials facilitate the creation of new knowledge vital in transforming teachers' pedagogical skills and boosting their knowledge of the content. The study findings also indicate that teachers share materials and conduct long chats that require adequate preparatory time for reading and comprehending the materials before online discussions. School management should acknowledge the WhatsApp groups, recognise them, and allocate some time to learn.

Schools should conduct training and workshops to on the best ways of using WhatsApp groups to improve mathematics teachers pedagogical and content knowledge. This is especially needed because in some schools, social media remain a non-educative device, preventing the teachers' use of online platforms for interactive learning. Consequently, some teachers treat web-based platforms as simply social applications that erode teachers and learners moral and ethical standards. In this light, teachers in such schools do not believe that WhatsApp groups, for example, can be beneficial to them nor enhance their informative interaction.

Discussion

The study first sought to understand mathematics teachers' perceptions on the benefits of using the WhatsApp forum in CPD-related activities. The study revealed variations of opinions, ideas, and time for the response to topics posted in the forum. The findings indicated that teachers believe that WhatsApp groups are beneficial in elevating their teaching skills because they enable sharing of experience, teaching and learning resources, and information. This finding concurs with Moodley (2019), who found that the materials of different forms such as images, file documents, and short video clips shared virtually accord teachers an opportunity to learn from counterparts' experiences and practices (Motteram *et al*., 2020). Although some teachers encounter challenges related to internet accessibility, the use of the WhatsApp forum remains convenient for many teachers who use smartphones because they can carry them everywhere unlike is possible for office computers. The findings resonate with Cansoy's (2017)

revelation of four areas that teachers benefit from when engaging in WhatsApp groups, viz., mathematics teachers develop their profession in content, pedagogy, and leadership skills, which are critical to teaching and learning mathematics decisions.

Secondly, the study intended to determine how mathematics teachers use WhatsApp to elevate their professional competencies through CPD activities. The findings show that teachers' use of WhatsApp groups was both synchronous and asynchronous allowing them to learn at times that were convenient for them. This finding concurs with Naidoo and Kopung (2016), who found that teachers who used WhatsApp groups engaged in learning at their own pace and time. This flexible nature of the WhatsApp forum enriches the teaching context as teachers can reflect on their practices and adopt new teaching methods at convenience. Online learning communities such as WhatsApp groups will likely benefit more teachers who cannot access other CPD training, seminar, or workshop opportunities. As is clear in this study, teachers use the WhatsApp platform to learn and share experiences, ideas, views, methods, and materials. Our study reflects Khoo *et al*. (2009) view that an online learning community of teachers can help them achieve results otherwise difficult for an individual to accomplish. School management should train such mathematics teachers on the best ways to use these WhatsApp platforms. By so doing, it is likely to ensure excellence in their teaching practices in the subject.

Motteram *et al*. (2020) also identified the challenge of internet connectivity in their study. The study observed first that internet connectivity tends to affect the rate of interaction among the group members. They observe that internet connectivity problems made some members silent or late in their replies to the problems shared in the group. Second, they observe that connectivity problems worsen mathematics teachers' struggle to filter the validity and reliability of the vast information and materials shared by different members. Since some materials shared in the groups did not indicate source, questions arose on whether they aligned with their school curriculum requirements. In the efforts to address this challenge, mathematics teachers encountered another challenge; accessing dependable sources to obtain the materials. Unfortunately, the variation of teachers' abilities in the same forum due to different levels of education and experience hampered the problem of filtering the quality of materials. Nevertheless, the collaboration in addressing mathematics problems benefits all teachers regardless of their education level.

Conclusion and recommendations

The study explored how mathematics teachers' use WhatsApp groups as a platform for continuous professional development in Tanzania. WhatsApp platforms have proven to play a pivotal role to mathematics teachers in different aspects. WhatsApp groups provide a platform to enhance teachers' pedagogical skills and content knowledge. These pedagogical skills and content knowledge help enhance students' learning. WhatsApp has elevated teachers' content knowledge and pedagogical skills in this context. WhatsApp groups' adoption and improved use have helped bridge the CPD gap for some teachers in Tanzania, thus bolstering their professionalism. The challenges that mathematics teachers in Tanzania face requires interventions that could maximise the utilisation of the WhatsApp platform for CPD.

Our study, in line with views of research participant Mathematics teachers, suggests some recommendations. Mathematics teachers recommended better ways of facilitating effective and efficient use of WhatsApp platforms. First, it was challenging to include university lecturers and school leaders in the same WhatsApp groups because of their differing abilities to effectively participate. Groups might need to be varied at different levels to tailor mathematics' teachers' interests appropriately (Khoo *et al*., 2009). Mathematics teachers in WhatsApp groups can compile challenging questions which need some interventions while university lecturers and school leaders could assist with solutions and suggestion to the questions or challenges posted.

The internet provision for teachers requires commitment and an agreement among three parties—teachers, the government and internet service providers in a way that facilitate affordable internet access. These determine how to help teachers and monitor their practices to ensure the use of the service for the intended learning purpose. The school management should value CPD activities and spare some time at least once per week or month to allow their teachers to participate fully. The school leaders should closely monitor the effective use of the allocated day and time for mathematics CPD activities.

The recommendations highlight that capacity building should help mathematics teachers identify, vetting, and organise the required resources and facilities to enhance their use of WhatsApp groups for CPD. Teachers must be sure of the validity and relevance of the materials to share in the forum. Future studies could focus on studying the management support essential for enabling Mathematics teachers to embrace WhatsApp and other social media platforms for CPD.

References

Abirin, S. G., & Obra Jr, M. R. (2018). Development and use of social media-based mathematics instructional module for grade 7 students of geras integrated school. *New Media and Mass Communication*, *72*, 31–59.

Addeo, F., Paoli, A. D., Esposito, M., & Bolcato, M. Y. (2020). Doing social research on online communities: The benefits of netnography. *Athens Journal of Social Sciences*, *7*(1), 9–38. https://doi.org/10.30958/ajss.7-1-1

Albalawi, A. S. (2017). Mathematics teachers' perception of using social media in their teaching in Tabuk, Saudi Arabia. *International Electronic Journal of Mathematics Education*, *12*(2), 111–131.

Amir, K., Mohamed, H. C., & Mnjokawa, C. E. (2016). Learners' attitudes and performance in science subjects in a-level in secondary schools, in Mbarara, Uganda. *Journal Of Educational Research*, *2*(5), 10–25.

Aras, S. (2020). Action research as an inquiry-based teaching practice model for teacher education programs. *Systemic Practice and Action Research*. https://doi.org/10.1007/s11213-020-09526-9

Arends, F., Winnaar, L., & Mosimege, M. (2017). Teacher classroom practices and mathematics performance in South African schools: A reflection on TIMSS 2011. *South African Journal of Education*, *37*(3), 1–11. https://doi.org/10.15700/saje.v37n3a1362

Bryman, A. (2012). Social research methods (4th Ed). Oxford: Oxford University Press.

Bruguera, C., Guitert, M., & Romeu, T. (2019). Social media and professional development: A systematic review. *Research in Learning Technology*, *27*, 1–18. https://doi.org/10.25304/rlt.v27.2286

Bütüner, S. Ö. (2017). Secondary school mathematics teachers' knowledge levels and use of history of mathematics. *Journal of Education and Training Studies*, *6*(1), 9–20. https://doi.org/10.11114/jets.v6i1.2722

Cansoy, R. (2017). Teachers' professional development: The case of WhatsApp. *Journal of Education and Learning*, *6*(4), 285–293. https://doi.org/10.5539/jel.v6n4p285

Costello, L., McDermott, M.-L., & Wallace, R. (2017). Netnography: Range of practices, misperceptions, and missed opportunities. *International Journal of Qualitative Methods*,

16, 1–12. https://doi.org/10.1177/1609406917700647

Duncan-Howell, J. (2010). Teachers making connections: Online communities as a source of professional learning. *British Journal of Educational Technology*, *41*(2), 324–340. https://doi.org/10.1111/j.1467-8535.2009.00953.x

Kafyulilo, A., Fisser, P., Pieters, J., & Voogt, J. (2015). ICT use in science and mathematics teacher education in Tanzania: Developing technological pedagogical content knowledge. *Australasian Journal of Educational Technology*, *31*(4), 381–399. https://doi.org/10.14742/ajet.1240

Khoo, E., Forret, M. & Cowie, B. (2009) Developing an online learning community: A model for enhancing lecturer and student learning experiences. *Proceedings ascilite Auckland 2009: Concise paper*, 528-532

Kopung, K. J. (2016). *Exploring the use of Whatsapp instant messaging as a platform for pre-service teachers' learning of mathematics : Unpublished dissertation, School of Science , Mathematics and Technology Education*. University of Kwazulu-Natal.

La Hanisi, A., Risdiany, R., Dwi Utami, Y., & Sulisworo, D. (2018). The use of WhatsApp in collaborative learning to improve English teaching and learning process. *International Journal of Research Studies in Educational Technology*, *7*(1), 29–35. https://doi.org/10.5861/ijrset.2018.3004

Lessing, A., & De Witt, M. (2007). The value of continuous professional development: Teachers' perceptions. *South African Journal of Education*, *27*(1), 53–67.

Masele, J. J., & Tweve, J. (2018). Efficacy of information provision strategies for promoting mathematics education in Tanzania: A case of selected secondary schools in Dar es Salaam. *University of Dar Es Salaam Library Journal*, *13*(1), 68–87.

Mazana, M. Y., Montero, C. S., & Casmir, R. O. (2020). Assessing students' performance in mathematics in Tanzania: The teacher's perspective. *International Electronic Journal of Mathematics Education*, *15*(3), 1–38. https://doi.org/10.29333/iejme/7994

Mbugua, Z. K., Kibet, K., Muthaa, G. M., & Nkonke, G. R. (2012). Factors contributing to students' poor performance in mathematics at Kenya certificate of secondary education in Kenya: A Case of Baringo County, Kenya. *American International Journal of Contemporary Research*, *2*(6), 87–91.

Mestry, R., Hendricks, I., & Bisschoff, T. (2009). Perceptions of teachers on the benefits of teacher development programmes in one province of South Africa. *South African Journal of Education*, *29*, 475–490. https://doi.org/10.15700/saje.v29n4a292

Moodley, M. (2019). Whatsapp: Creating a virtual teacher community for supporting and monitoring after a professional development programme. *South African Journal of Education*, *39*(2), 1–10. https://doi.org/10.15700/saje.v39n2a1323

Motteram, G., Dawson, S., & Al-Masri, N. (2020). WhatsApp supported language teacher development: A case study in the Zaatari refugee camp. *Education and Information Technologies*, *25*, 5731–5751. https://doi.org/10.1007/s10639-020-10233-0

Morais, G. M., Santos, V. F., & Gonçalves, C. A. (2020). Netnography: Origins, foundations, evolution and axiological and methodological developments and trends. *The Qualitative Report, 25*(2), 441–455.

Mughal, S. H., Asad, M. M., & Adams, D. (2020). Goals of the national mathematics curriculum of Pakistan: educators' perceptions and challenges toward achievement. *International Journal of Educational Management*. https://doi.org/10.1108/IJEM-04-2020-0203

Mutodi, P., & Ngirande, H. (2014). The influence of students' perceptions on mathematics performance. A case of a selected high school in South Africa. *Mediterranean Journal of Social Sciences*, *5*(3), 431–445. https://doi.org/10.5901/mjss.2014.v5n3p431

Naidoo, J., & Kopung, K. J. (2016). Exploring the use of WhatsApp in mathematics learning: A case study. *Journal of Communication*, *7*(2), 266–273. https://doi.org/10.1080/0976691x.2016.11884907

Ochieng, K. R., Kiplagat, P., & Nyongesa, S. (2016). Influence of teacher competence on mathematics performance in KCSE examinations among public schools in Nyatike subcounty, Migori county Kenya. *International Journal of Secondary Education*, *4*(5), 44–57. https://doi.org/10.11648/j.ijsedu.20160405.11

Opfer, V. D., & Pedder, D. (2010). Benefits, status and effectiveness of continuous professional development for teachers in England. *The Curriculum Journal*, *21*(4), 413–431. https://doi.org/10.1080/09585176.2010.529651

Popova, A., Evans, D. K., Breeding, M. E., & Arancibia, V. (2018). *Teacher professional development around the world: The gap between evidence and practice* (No. 8572). Africa

Region, Office of the Chief Economist.

Priajana, N. (2017). Continuing professional development activities for English teachers. *ELT Echo : The Journal of English Language Teaching in Foreign Language Context*, *2*(1), 37–48. https://doi.org/10.24235/eltecho.v2i1.1592

Raja, R., & Nagasubramani, P. C. (2018). Impact of modern technology in education. *Journal of Applied and Advanced Research*, *3*(1), S33–S35. https://doi.org/10.4324/9780203168899_chapter_10

Raluca, Z., & Romulus, V. (2015). Informal groups in global work environment: Group work or team work? *Ovidius University Annals, Economic Sciences Series*, *XV*(1), 648–653.

Setapa, M., Mustapha, W. A. H. W., Kanafiah, S. F. H. M., & Zaman, L. K. (2016). A study of students' perception toward mathematic. *Journal of Applied Environmental and Biological Sciences*, *6*(7), 28–33.

United Republic of Tanzania. (2019). Education sector performance report (2018/2019): Tanzania Mainland. In *Ministry of Education, Science and Technology* (Vol. 7). Dodoma.

Law, H. Y. (2013). Reinventing teaching in mathematics classrooms: Lesson study after a pragmatic perspective. *International Journal for Lesson and Learning Studies*, *2*(2), 101–114. https://doi.org/10.1108/20468251311323360