Information and Communication Technology (ICT) Skills and the Teaching of Mathematics in Selected South African Schools

Kemi Olajumoke Adu[1,*]

[1]Walter Sisulu University, South Africa

*Correspondence: Walter Sisulu University, South Africa

Received: August 6, 2024 Accepted: September 12, 2024 Online Published: July 4, 2025

doi:10.5430/jct.v14n3p108 URL: https://doi.org/10.5430/jct.v14n3p108

Abstract

This paper explores the use of ICT skills to promote the teaching of Mathematics in South African selected secondary schools. The paper deployed a qualitative research approach with a phenomenological case study design. The lived experiences of eight purposively selected teachers from four public schools in Buffalo Metropolitan City, East London, South Africa were recorded using semi-structured, in-depth interviews. The recorded data was coded, transcribed and subjected to thematic analysis. The findings revealed that there is a need for on-the-job training in the form of continuing professional teacher development (CPTD) to update their ICT skills. Such training can be workshops, seminars, short courses and symposiums. Also, teachers should be intentional in demonstrating true professionalism; they should innovatively engage ICT to help learners make accurate decisions, solve their problems and enhance different skills and there is a need for emotional and psychological support for the teachers. The paper concludes and recommends that introducing ICT tools in the Curriculum and Assessment Policy Statements (CAPS) document is not sufficient on its own without the monitoring of the subject heads to make sure teachers adhere to the use. The school management should make sure that these tools are available or improvised to make the learning environment conducive to the use of ICT tools.

Keywords: Information and Communication Technology (ICT), Continuing Professional Teacher Development (CPTD), Curriculum and Assessment Policy Statements (CAPS), pedagogies, teaching, learning environment

1. Introduction

The technological and socio-economic development of any country requires knowledge of Mathematics (Adu & Duku, 2021). Mathematics is a science subject that is taught across all levels of education, including the primary education phase where the foundation is laid. Therefore, the primary school level is very essential in the education system of any nation. (Adu & Duku, 2021). In general, mathematics is the application of reasoning to practical problems. It can also be compared to a problem-solving tool used in fields like geography and science. At different education levels, teachers have access to a variety of instructional materials that are suitable for the student's level and can help facilitate effective teaching and learning. These resources are essential since they make studying and teaching easier at all instructional levels (Adu & Duku, 2021).

Apart from ICT resources, textbooks, graphs, charts, workbooks, and illustrations are a few examples of instructional materials that are crucial to mathematics education. According to Lipik (2015:6), these resources should spark students' interest in Mathematics, encourage the active study of the subject, foster their creative potential through the acquisition of foundational knowledge, enhance their ability to think mathematically when attempting to grasp the meaning of Mathematics and increase their awareness of how to apply Mathematics in everyday situations. (Selection of relevant curricular resources will eventually lead to the efficient use of pedagogy and assist in discharging the subject matter to learners.) Instructional materials are a vital element of teachers' everyday activities.

With the availability of ICT, teachers are essential to effectively use the resources to enhance teaching and learning to get the intended learning outcome. Teachers must translate the use and implementation of the instructional content (textbooks and other written materials) throughout their teaching career (Adu, 2018). Teachers offer methods and strategies that use text and diagrammatic representations to frame classroom activities (Adu, 2018). Under the supervision of the teacher, students can utilise the instructional materials, which include the textbook, worksheet,

charts, graphs, calculator, marker, and postcard. ICT resources are the most extensively used for lesson delivery since they are directly related to the teaching and learning of any subject (Adu, 2018).

Curriculum materials for mathematics are, in general, the essential resources for learning Mathematics content and making mathematical instructional decisions. These tools, which include computer software, textbooks, geoboards, and other materials, greatly improve students' performance in mathematics at all educational levels (Adu, Duku, & Adu, 2016). It is expected of teachers to be conversant with and flexible with these essential resources to support everyday activities and classroom instruction. According to Adu (2018), the ICT resource application serves as a source of problem-solving in Mathematics.

The COVID-19 epidemic has demonstrated that a lack of understanding about how to employ these resources can prevent a country's organs from operating. As a result, the focus has turned to educational institutions as change agents. As such, teacher educators have a responsibility to educate preservice teachers for the modern classroom, where students can be ready to function in a digital environment. According to several studies, lecturers lack ICT proficiency, which leaves graduates from their training programs ill-prepared to use ICT in the classroom—a relatively new instrument for the teaching profession (Dewa & Ndlovu, 2022).

Teachers and even preservice teachers can acquire the necessary cognitive and pedagogic abilities for their future teaching contexts when they employ ICTs in their classrooms in a relevant way (Dewa & Ndlovu, 2022). Delivery of Mathematics curricula detached from its contextual usage (i.e., classroom teaching) in this day and age would inevitably result in a deficit in the knowledge base that graduates require to be employable in today's classrooms. Lack of pedagogical training among teachers causes inadequate ICT competency, confidence, and skills, which in turn creates internal hurdles including unfavourable attitudes towards the use of digital technologies. Teachers may possess appropriate educational software, but it will be challenging for teachers to use ICTs for learning later on if they have limited access to ICTs due to restrictive curriculum barriers and rigid structures of traditional education systems (Zaldívar-Colado et al., 2017; Dewa & Ndlovu, 2022). Thus, the study investigates how information and communication technology (ICT) proficiency affects mathematics instruction in South African schools.

2. Research Questions

1) What can be done to improve Mathematics teachers' use of ICT in the teaching and learning of Mathematics in South Africa?
2) What is the significance of Improving Mathematics Teachers' Use of ICT?
3) How can the Mathematics policy document (CAPS) be amended to guide teachers toward a successful ICT integration in South Africa?

3. Theoretical Framework: Activity Theory

Activity theory, originating from the work of Soviet psychologists Lev Vygotsky, Alexei Leontiev, and Sergei Rubinstein, is a framework for understanding human practices, including teaching and learning. In Mathematics Education, activity theory provides a lens to analyze and improve the teaching and learning processes by focusing on the interactions between individuals and their socio-cultural environment.

3.1 Key Components of Activity Theory in Mathematics Teaching and Learning

The individual or group engaged in the activity. In Mathematics Education, the subjects are typically the students and the teachers, and the goal or motive of the activity is for students, this might be learning a particular mathematical concept or solving a problem, for teachers, it might be effectively teaching a concept or facilitating understanding and the instruments used to achieve the object. In Mathematics education, these can be physical tools like calculators, rulers, and computers, or cognitive tools like mathematical symbols, language, and software (Cole & Engeström, 1993).

In the social context, the activity takes place to include classmates, teachers, school administrators, and even parents. The community influences and is influenced by the activity.

The norms, conventions, and regulations governing the activity. In a classroom setting, this includes the curriculum standards, classroom management strategies, and assessment methods.

The roles and responsibilities within the activity. This refers to how tasks are divided among students, teachers, and other participants in the educational process (Engeström, 1999).

3.2 Applying Activity Theory to Mathematics Teaching and Learning

Activity theory aids the understanding of classroom dynamics by examining how students interact with each other, the teacher, and the tools available. It considers the cultural and social context in which these interactions take place. By focusing on the object (learning goals), teachers can design instructional strategies that effectively use available tools and artefacts. For example, integrating technology like dynamic geometry software to enhance understanding of geometric concepts. Activity theory can be used to identify and address challenges in Mathematics education. For instance, if students are struggling with a particular concept, the theory suggests looking at the tools being used, the rules governing the learning process, and the division of labour to find potential areas for improvement (Rizzo, 2003).

The theory emphasizes the role of the community and collaborative efforts in the learning process. Teachers can foster group activities and peer-to-peer learning to enhance understanding and problem-solving skills. Activity theory acknowledges that learning is influenced by socio-cultural factors. Teachers can adapt their teaching methods to better suit the cultural and social backgrounds of their students, making Mathematics more relevant and accessible. A teacher using activity theory might set up a classroom activity where students work in groups to solve a complex mathematical problem. Each group (community) uses tools such as graphing calculators and online resources. The teacher provides guidance (division of labour) and ensures that the activity aligns with curriculum standards (rules). The goal (object) is for students to collaboratively develop a deeper understanding of the mathematical concepts involved (McCulloch et al., 2018). Throughout the activity, the teacher observes how students interact with each other and the tools, providing support where necessary. After the activity, the teacher can reflect on what worked well and what didn't, considering the interplay of all components of the activity system (Dewa, 2019).

4. Literature Review

This paper is positioned within the existing body of knowledge by reviewing literature on the following related themes.

4.1 Improving Mathematics Teachers' Use of ICT in the Teaching and Learning of Mathematics in South Africa

The discussion in the section aims to present strategies to enhance Mathematics teachers' use of ICT in South Africa and to discuss some of the factors that influence the strategies proposed. The strategies are based on lessons learned from an international and a local investigation. During these investigations, activities of teachers involved in an in-service training course on the integration of ICT in Mathematics teaching were documented in Belgium and South Africa. These activities enable the researchers to discuss the degree of success of integrating ICT in Mathematics education with the teachers on the course (Zaldívar-Colado et al., 2017; Dewa & Ndlovu, 2022). The teachers identified several factors that either inhibited or enhanced their use of ICT in their teaching of Mathematics, a finding that corresponds with the argument of other researchers that for ICT to be successfully implemented in education, teachers need to be flexible, open and motivated to adapt to and adopt new practices and methodologies. After categorizing, selecting and analysing the strategies teachers mentioned and presented during the investigations, an inventory of strategies to enhance Mathematics teachers' use of ICT was compiled. The strategies were discussed and tested on the field with a new group of Mathematics teachers. Their reflections and experiences on the strategies and a literature study provided additional insight into the results.

The Western Cape Education Department has prioritised the development and enhancement of Mathematics teachers' use of ICT in the teaching and learning of Mathematics. The department has taken a fourfold strategy to address this problem, namely: conducting annual ICT workshops for Mathematics and Physical Science teachers, offering a range of support materials such as useful websites and class lessons, providing tips for presenting mathematical material on Polaris boards, giving advice on purchasing ICT hardware and software, and providing tests and exams with model answers (Hardman et al., 2018; Dewa & Ndlovu, 2022). It is the authors' opinion that using these hardware products for the presentation of dynamic mathematical material has the potential to enhance the practice of teaching and learning for Mathematics teachers and the effectiveness of their development in using ICT products.

In a recent study, the authors established that the government had infused a great deal of money into supplying ICT hardware such as PCs, multimedia devices like Polaris boards, and software to both primary and secondary schools in the Western Cape Province and throughout South Africa. It was found that teachers, in practising their profession, used ICT in ways that it was not intended to be used, resulting in the underutilization of ICT's effectiveness. The authors believe that the use of ICT in education may not be fully utilized if educators are not adequately prepared or trained to use specific hardware and software products (Tondeur et al., 2017; Dewa & Ndlovu, 2022).

4.2 Significance of Improving Mathematics Teachers' Use of ICT in South African Schools

Teachers play a pivotal role in the enhancement of a nation's Mathematics education. A growing number of countries, including South Africa, recognize the importance of information and communications technology (ICT) and its enhancement of education. Few universities in South Africa provide pre-service Mathematics teachers with extensive training in the use of technology in Mathematics education. Technology (e.g., dynamic geometry software) allows for the visualization of in-depth representations of abstract mathematical ideas and the ultimate power of student-centred Mathematics. Most teachers enter the pre-service teacher program with years of low-level use of ICT that may have contributed to an aversive relationship between themselves, current Mathematics teachers, educational technologists, and ICT. This aversion would also darken the learners' perspectives of ICT (Franca et al., 2020; Dewa & Ndlovu, 2022).

In South Africa, teachers are encouraged, even expected, to work with ICT simply because natural and logical reasons support this position. The South African curriculum is currently being revised to accommodate the use of ICT in teaching and learning. It is accepted that the use of available tools in Mathematics, which are technology-rich, not only allows learners to focus on more profound mathematical ideas but also impacts the manner learning is situated. In particular, the results indicated the intense lasting nature of the post-training concerning the need to continue to support and develop the competencies, grow collaborators, affirm the effective use of technology, release professional community, and grow and maintain data-based decision-makers. Participants are defined as secondary school Mathematics teachers with strategy and theoretical implications (Tondeur et al., 2017; Dewa & Ndlovu, 2022).

The integration of Information and Communication Technology (ICT) in teaching Mathematics in South African secondary schools has significant implications and potential benefits for enhanced learning experience through the use of ICT tools such as interactive software, educational apps, and online resources to make learning Mathematics more engaging and interactive. These tools can visualize complex mathematical concepts, making them easier for students to understand. Also, the use of videos, animations, and simulations can demonstrate Mathematical principles in dynamic ways that traditional teaching methods cannot. ICT can provide personalized learning experiences through adaptive learning software, which adjusts the difficulty of tasks based on the learner's performance. Learners can learn at their own pace, revisiting challenging concepts and accelerating through topics they grasp quickly (Tondeur et al., 2017; Dewa & Ndlovu, 2022).

ICT usage in South African schools enables remote learning opportunities, allowing students in rural or under-resourced areas to access quality education materials and instruction. ICT tools facilitate collaboration among students through online platforms where they can work on group projects, share ideas, and solve problems together. Teachers can use email, instant messaging, and virtual classrooms to communicate more effectively with learners and provide timely feedback. ICT provides opportunities for teachers to engage in professional development through online courses, webinars, and educational communities and create more dynamic and effective lesson plans, utilize assessment tools, and track student progress more efficiently. However, while the benefits of using ICT to teach Mathematics are substantial, there are also challenges and considerations to address such as lack of infrastructure, adequate training, costs and inequality. The use of ICT in teaching Mathematics in South African secondary schools holds great promise for improving educational outcomes, fostering engagement, and preparing students for a digital future (Franca et al., 2020; Dewa & Ndlovu, 2022). Improving Mathematics teachers' use of Information and Communication Technology (ICT) in the teaching and learning of Mathematics in South Africa involves the following.

Professional Development and Training: This includes Continuous Professional Development (CPD) Programs like workshops and seminars and regular, hands-on workshops to train teachers in using various ICT tools and software relevant to Mathematics education. Online Courses and Webinars are accessible online training programs that allow teachers to learn at their own pace. Mentorship and peer support programmes involve the use of pair less experienced teachers with mentors who are proficient in using ICT in the classroom. Professional Learning Communities (PLCs) establish communities where teachers can share experiences, resources, and best practices. Access to technology equipment provides schools with necessary hardware such as computers, tablets, projectors, and interactive whiteboards and ensures the availability of educational software and online platforms for Mathematics teaching (Hardman et al., 2018; Dewa & Ndlovu, 2022).

Improving Mathematics teachers' use of ICT in the teaching and learning of Mathematics: This also includes having reliable internet and technical support to ensure that schools have reliable and fast internet connections with technical support to assist teachers with ICT-related issues promptly. ICT should be integrated into the contents of the curriculum and used for digital lesson Plans. The use of interactive simulations, educational games, and virtual labs

to make Mathematics concepts more engaging is encouraging (Zaldívar-Colado et al., 2017; Dewa & Ndlovu, 2022).

Teachers' use of ICT in digital assessment, implementation of online quizzes and assessments, and providing instant feedback: The use of data from digital tools to analyze students' performance and identify areas needing improvement is essential in the 21st century. Government and institutional support to enhance the teacher's use of ICT through the implementation of national and school-level policies that promote the integration of ICT in education. Private and government collaboration in terms of funding is essential in supporting school ICT initiatives (Franca et al., 2020; Dewa & Ndlovu, 2022).

Leadership training for school principals and administrators: Such training should address the benefits of ICT and how to support teachers in its use. Experimental projects and the implementation of pilot projects to test new ICT tools and teaching methods to collect feedback from these projects to refine and scale successful initiatives. Recognition and reward of teachers who effectively integrate ICT into their teaching through the awards of incentives for continuous professional development and innovation in teaching practices. Creating networks for teachers to collaborate, share resources, and support each other. Partnerships with technology companies and educational organizations to provide resources and training (Tondeur et al., 2017; Dewa & Ndlovu, 2022).

4.3 Mathematics Curriculum and Assessment Policy Statement (CAPS) in South Africa

South Africa, for years, being a high technology unequal society, has missed on linking its scarce educational resources, mainly human resources, with global network knowledge. Moreover, the ownership of scarce 21st-century educational resources is not equal. The Mathematics CAPS might not succeed in delivering all its prerequisites, for it requires more specialized and qualified teachers to not just solely support the administrative functioning of the actual ICT tools in the classroom, but also the mathematical problems phrased in written form and analysed, multi-problem-solving, lessons and examination questions should take the current in-house and out-of-house ICT experiences of teachers into consideration. The questions to be asked are: Do your written exams and classroom activities and discussions create mathematically sound citizens in South Africa.? Do they create a mathematically bright future South Africa leader in the public and private labour market? (Adu & Zondo, 2024).

Amending the Mathematics policy document (CAPS) to guide teachers towards successful ICT integration in South Africa can be done through several strategic modifications. These may include the following.

Clear articulation of the vision and objectives of integrating ICT in Mathematics Education: Doing this may involve emphasising the benefits for both teaching and learning processes and defining specific learning outcomes that include the use of ICT tools and resources. This can involve skills like using graphing software, engaging with online simulations, and utilising educational apps. Introduction of modules that guide teachers on how to integrate ICT into specific Mathematics topics. For example, using spreadsheets for statistical analysis or dynamic geometry software for exploring geometric concepts. Recommendation of pedagogical approaches that effectively integrate ICT. This can include blended learning, flipped classroom models, and inquiry-based learning supported by digital tools and the provision of detailed examples and case studies of successful ICT integration in Mathematics teaching. Highlight different tools and methods used in these examples (Adu & Zondo, 2024).

Incorporation of guidelines on how to use ICT for assessments, such as online quizzes, digital projects, and interactive exercises: This strategy may include rubrics and examples of how these assessments can be aligned with learning outcomes and emphasize the use of ICT for both formative and summative assessments, ensuring continuous feedback and improvement. There is a need for a mandatory regular professional development program focused on ICT in education. It will also require outlining the types and frequency of these programs in the policy document. Teachers should be encouraged with a culture of continuous learning and professional growth through online courses, webinars, and participation in professional learning communities (Dewa & Ndlovu, 2022). Inside the curriculum contents, there should be a list of recommended ICT tools, platforms, and resources that align with the Mathematics curriculum. The curriculum should also provide guidelines on how to access and effectively use these resources through Open Educational Resources (OER) that provide links to quality digital content that teachers can freely use and adapt (Adu et al., 2022). There should be ICT infrastructure standards that schools should meet to support effective teaching and learning. This can include internet bandwidth, hardware specifications, and software requirements. It should encourage collaboration among teachers through online platforms where they can share resources, ideas, and experiences related to ICT integration and foster communities of practice within and across schools to support the exchange of knowledge and best practices.

Development of mechanisms for monitoring the implementation of ICT integration in schools. This strategy will include indicators and metrics to measure success to establish a feedback loop where teachers can provide input on

the effectiveness of ICT integration strategies and suggest improvements (Ojo & Adu, 2018). South African government should address the issue of equity and inclusion which include strategies to ensure all schools, especially those in under-resourced areas, have access to the necessary ICT infrastructure and resources. Provide guidelines for equitable distribution of resources (Dewa & Ndlovu, 2022).

5. Methods

5.1 Research Approach

This paper used a qualitative research approach intended to explore information and communication technology (ICT) skills and the teaching of Mathematics in South African selected schools. This approach is suitable as the paper looks at the in-depth ICT knowledge skills from a very small sample (Adu & Zondo, 2024; Adu, 2023).

5.2 Research Design

For this work, a phenomenological case study design was chosen because it allows for a thorough comprehension of occurrences using semi-structured, in-depth interviews that record the participants' lived experiences. This would enable people to comprehend how the resources at their disposal support the teaching of life sciences (Kazeni, & Mkhwanazi, 2021; Adu & Olowu, 2022).

5.3 Sampling and Instrumentation

For this study, eight teachers (P1-P8) from four public schools in Buffalo Metropolitan City, East London, South Africa, were selected using purposeful selection techniques. These schools are in the city. The respondents were questioned in a semi-structured interview manner to gather information (Adu & Zondo, 2024) the interview guide was sent to experts for content validation before administering it. However, trustworthiness is applied.

5.4 Trustworthiness

Credibility, transferability, dependability, and confirmability are all guaranteed when participants are allowed to view the research's conclusions and provide their assent (Creswell, 2014; Adu & Olowu, 2022). By using the data they had gathered, the researchers attempted to avoid any kind of data manipulation and to accurately and impartially represent the perspectives of the research participants.

5.5 Data Analysis

Thematic analysis of the data involved familiarising oneself with the data, creating a code (P1-P8 where P1 means participant 1), looking for the theme, and transcribing the data. The research questions served as the basis for the subject (Creswell, 2014; Adu & Zondo, 2024).

6. Findings

From the data collected in line with the research questions, three themes emanated which are improving Mathematics teachers' ICT skills in the teaching of Mathematics, the significance of using ICT to teach Mathematics, and the improvements on CAPS policy documents as a guide towards a successful ICT integration. The 8 teachers were coded using P1-P8 to transcribe their views.

Theme 1: Improving Mathematics teachers' ICT skills in the teaching of Mathematics

In this theme, the following sub-themes were generated.

1.1 Training Course on the Integration of ICT in Mathematics Teaching

The respondents (100%) revealed that they need training courses, workshops and seminars to upgrade their knowledge of the integration of ICT in teaching Mathematics. Continuing professional teacher development (CPTD) should be encouraged among the teachers. Specifically, some teachers have this to say.

> *The culture of teaching using ICT should be created with a commensurate conducive environment. This will help the teachers to navigate the challenges when using ICT infrastructure because many teachers are technophobic and lack the rudimentary skills of ICT usage (P2).*
>
> *The lack of ICT facilities in my school discourages the use and the design of ICT-integrated lessons (P1).*
>
> *When the teacher has the necessary ICT tools through the partnership and collaboration of many stakeholders like the government, the Department of Basic Education (BDE), School*

> *Management Teams (SMT), and School Governing Bodies (SGBs) this will promote ICT skills in the teaching of Mathematics (P5)*
>
> *To enhance the integration of ICT in Mathematics for the improvement of curricula teaching, development of teachers' technical skills, accessibility and adaptability of modern technology, teachers must be intentional and professional (P4)*

1.2 Factors That either Inhibited or Enhanced the Use of ICT in the Teaching of Mathematics

Concerning the above sub-theme, the respondents had different opinions.

> *One of the factors that enhanced the use of ICT is the unprecedented COVID-19 pandemic which makes it impossible for face-to-face teaching, the teacher switched to virtual classrooms and ICT integration is the only solution. However, the lack of ICT skills, poor network, data usage, internet problems and low bandwidth are some hindrances (P3)*
>
> *One respondent (P8) believed that the 4th Industrial Revolution (4IR) and 21st-century classroom dynamics enhanced the use of ICT, this allows Mathematics teachers to disseminate current and real-life information to the learners and appeal to them.*
>
> *The structure of Mathematics curriculum contents that can only be delivered by technological pedagogies promotes the use of ICT skills effectively, nevertheless, lack of readiness and adaptation to change by the teachers inhibited the use (P6)*
>
> *One of the respondents (P7) reiterated that the school management did not encourage using ICT because we were not adequately prepared especially with cutting-edge theory to change our mindset and invest in our professional development. The school-initiated CPTD, holding ICT meetings can help a great deal to make us technologically inclined because constant practice will assist. The respondent suggested the supply of ICT infrastructure like desktops, laptops and tablets to enhance ICT skills.*

***Theme 2*:** The significance of using ICT to teach Mathematics in South African schools

All eight respondents indicated that using ICT to teach Mathematics increase learners' participation and removes boredom during my teaching. As teachers, they enjoy it too because they become facilitators while their learners are very active in class. ICT usage in teaching Mathematics promotes collaboration and problem-solving skills.

> *ICT usage helps learners to enhance learners' visualization and navigate complex Mathematics concepts. It promotes active learning and improves retention. Feedback is enhanced and virtual manipulatives (P3)*
>
> *Learners make informed decisions when using ICT because of the scientific analysis of data collected (P4)*
>
> *I use technological tools for assessment and tracking during my teaching. I achieve the learning outcomes (P7)*

Theme 3: The improvements on CAPS policy documents as a guide towards a successful ICT integration.

To improve the integration of ICT through CAPS policy documents, six out of eight respondents believe in the following.

> *In the objectives of the topics inside the Mathematics CAPS documents, there should be an emphasis on the use of ICT tools and steps to be taken by teachers in integrating ICT into Mathematics (P1).*
>
> *CAPS documents should guide teachers on how to integrate ICT into specific Mathematics topics and include technological pedagogies that teachers can easily use on each topic (P6).*
>
> *Some strategies like flipped classroom models and inquiry-based learning that are supported by digital tools should be included in the CAPS policy documents of Mathematics (P4)*

Like the comments of P4 above,

> *P8 said that inside the curriculum contents, there should be a list of recommended ICT tools, platforms, and resources that align with the mathematics curriculum.*

However, two respondents said.

Even if CAPS specify tools and strategies to be used for each topic, there is a need for ICT infrastructure standards that schools should meet to support effective teaching and learning and encourage collaboration (P2)

CAPS do not provide a clear-cut way of using ICT tools effectively towards the achievement of the desired outcomes and CAPS leaves teachers in the deep end because CAPS assumes that all teachers are technologically inclined (P3).

7. Discussion of the Findings

All eight respondents revealed that they need on-the-job training in the form of Continuing professional teacher development (CPTD) this can be workshops, seminars, short courses and symposiums to update their ICT skills according to Adu and Olowu (2022), teachers need positive attitude towards CPTD to be relevant in the 21st century. It was revealed that teachers should be intentional and demonstrate true professionalism in this era because the only language or natives of teaching is ICT tools. Mathematics teachers need to face the reality of ICT and think outside the box so that their learners can make accurate decisions, solve their problems and enhance different skills.

Adu and Zondo (2024) had the same opinion about teachers being proactive, skillfully and disseminating curriculum contents with ICT pedagogies. However, according to one of the respondents, the availability of ICT tools is not as important as maintaining and using them. There is a need for cultural disposition and a change of mindset on the part of the teachers before the desired learning outcome can be met (Dewa & Ndlovu, 2022). Constant practice of the use of ICT infrastructure is very essential, the question we do ask is are teachers ready? Many teachers went on early retirement due to unreadiness and the sudden interruption of COVID-19, many teachers are discouraged because of low bandwidth, internet, and access to ICT tools like iPads, tablets, laptops and desktops (Adu et al., 2022).

The needed emotional and psychological supports were not given as reiterated by a couple of respondents, they believe, that the school management and Department of Basic Education did not provide the adequate support that the teachers needed especially during the pandemic that forced them into the virtual classroom. Moreover, they said they should have been encouraged if the CAPS document of Mathematics stipulates the ICT pedagogies, the teacher has to improvise and think outside the box which is another stress. According to Olawale et al., (2021). Teachers faced some psychosocial challenges during COVID-19, apart from their health, they are faced with some trauma, psychological imbalance and enormous stress since they were not prepared for the advent of this pandemic and lack of encouragement on the part of the school management.

8. Conclusion and Recommendations

Activity theory provides a theoretical anchor for analysing and improving Mathematics teaching and learning. By considering the interactions between the subject, object, tools, community, rules, and division of labour, educators can design more effective and culturally responsive instructional strategies that enhance student engagement and understanding in Mathematics.

Most respondents believe that they do not have any option than to use ICT resources to teach in this dispensation, many believe that they will not be relevant if they fail to integrate ICT. They said that COVID-19 exposed the level of ICT literacy and many of them went for early retirement. There are many challenges faced by the teachers that inhibit them from using ICT facilities, these include, lack of support from the school management and regular training, lack of access, poor feasibility, data problems, access to personal desktops or laptops/tablets, negative attitude, failure to adjust to new normal to mention a few. However, teachers need to be professional and come out of their comfort zone by realising that it will take the government and school leadership sometimes before they can provide all the needed ICT resources.

Introducing ICT tools in the CAPS document is not sufficient on its own without the monitoring of the subject heads to make sure teachers adhere to the use. Similarly, the school management should make sure that these tools are available or improvise them and make the learning environment conducive to the use of ICT tools. One of the respondents believed that not all teachers have the ability to set up overhead projectors and some ICT tools in the classroom, therefore this paper suggested that ICT experts/specialists should be employed to assist in each classroom. Such experts/specialists can also conduct many training for the teachers.

Mathematics is a living and dynamic subject in which the recipient must be functional and relevant in their society. Apart from the fact that some teachers believe that setting ICT equipment in the classroom is time-consuming and teachers fail to prepare for it, ICT promotes learners' participation and achievement of desired learning outcomes.

The recipients (learners) must be able to use the knowledge gained from the teaching of Mathematics to make good decisions and to be relevant in their society. The use of ICT or access to it is a must in this century. The paper revealed the inordinate attitude of teachers to adapt to a change and adjust to the new normal due to mindset. By focusing on the different technological strategies, Mathematics teachers in South Africa can enhance their use of ICT, leading to improved teaching effectiveness and better learning outcomes for learners. These amendments can help create a structured and supportive environment for mathematics teachers to integrate ICT into their teaching practices effectively. CAPS should direct teachers appropriately to assist them in improving lifelong learning and meeting up with global teaching and learning, CAPS should have a link where learners can click to have access to technological pedagogies.

References

Adu, E. O., & Zondo, S. S. (2024). Enhancing teachers' digital skills in the teaching of economics in South African secondary schools. *International Journal of Educational Research Open, 6*, 100310.

Adu, E. O. (2023). Economics Teachers' Content Knowledge and Teaching Strategies Used to Teach Economics in Selected South African Schools. *Journal of Curriculum and Teaching, 12*(4), 1-8 https://doi.org/10.5430/jct.v12n4p1

Adu, K. O., Badaru, K. A., Duku, N., & Adu, E. O. (2022). Innovation and technology: A panacea to teaching and learning challenges during the COVID-19 lockdown in South Africa. *Research in Social Sciences and Technology* (RESSAT), *7*(1), 69-89.

Adu, K. O., & Duku, N. (2021). Learning styles and instructional material as a correlate of grade 6 learners' mathematics performance in Buffalo City; South Africa. *Journal of Social Science and Technology, 6*(3), 242-255.

Adu, K. O., Duku, N. S., & Adu, E. O. (2016). Educators' perception of the importance of utilizing teaching resources in grade 9 mathematics. *International Journal of Education Sciences (IJES)*, *16*(1,3), 7-13.

Adu, K. O. (2018). *The use of textbooks by teachers in teaching mathematics at selected primary schools in East London Education District*. An unpublished dissertation submitted to the faculty of education, University of Fort Hare. South Africa.

Adu, E. O., & Olowu, R. T. (2022). Teachers' perceptions of how global citizenship education promotes problem-solving skills and conflict resolution in Nigeria. *International Journal of Social Sciences & Educational Studies* (IJSSES), *9*(4), 54-67.

Cole, M., & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 1-46). Cambridge University Press.

Creswell, J. W. (2014). *A concise introduction to mixed methods research*. Sage Publications. California.

Dewa A. (2019). *Stocktaking to support information and communication technology integration into mathematics teaching in initial teacher education* [doctoral dissertation]. Johannesburg: University of the Witwatersrand, Faculty of Humanities, School of Education.

Dewa A., & Ndlovu N. S. (2022). Use of information and communication technologies in mathematics education lecturers: Implications for preservice teachers. *J transdiscipl res S Afr., 18*(1), a1165.

Engeström Y. (1999). Activity theory and individual and social transformation. In: Engeström Y, Miettinen R, Punamaki RL, (Eds.), *Perspectives on activity theory*. Cambridge: Cambridge University Press, Pp 19–38.

França R. P., Iano Y., Monteiro A. C., & Arthur R. (2020). Improvement of the transmission of information for ICT techniques through CBEDE methodology. In: Ghavifer S, Athirah W, Rosdy W, (Eds.), *Utilizing educational data mining techniques for improved learning: Emerging research and opportunities*. Hershey PA: IGI Global, Pp 13-34.

Hardman J., Dlamini R., & Dumas C. (2018). *Teaching with information and communication technology (ICT)*. Cape Town: Oxford University Press

Kazeni, M., & Mkhwanazi, N. (2021). *Life sciences teachers' understanding, perceptions and adoption of inquiry-based science education in selected South African high schools*. An unpublished thesis submitted at the University of the Witwatersrand South Africa.

Lipik, M. (2015). Analysing the use of textbooks in mathematics education: The case of Estonia. *ACTA PAEDAGOGICA VILNENSIA, 35.*

McCulloch A. W., Hollebrands K., Lee H., Harrison T., & Mutlu A. (2018). Factors that influence secondary mathematics teachers' integration of technology in mathematics lessons. *Comput Educ*., *123*(4), 26-40.

Ojo O. A., & Adu E. O. (2018). The effectiveness of Information and Communication Technologies (ICTs) in teaching and learning in high schools in Eastern Cape Province. *South African Journal of Education*, *38*(Suppl. 2): Art. #1483, 11 pages.

Olawale, B. O., Mutongoza, B. H., Adu, E. O., & Omodan, B. I. (2021). COVID-19 induced psychosocial challenges in South African higher education: Experiences of staff and students at two rural universities. *Research in Social Sciences and Technology, 6*(3), 179-193. https://doi.org/10.46303/ressat.2021.37

Rizzo A. (2003). Activity-centred professional development and teachers' take-up of ICT. In Proceedings of the 3.1 and 3.3 working groups conference on international federation for information processing. *Melbourne: ICT and the teacher of the future*, *23*, 105-108.

Tondeur J., Aesaert K., Pynoo B., Van Braak J., Fraeyman N., & Erstad O. (2017). Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands of the 21st century. *Br J Educ Technol*., *48*(2), 462-472.

Zaldívar-Colado A., Alvarado-Vázquez R. I., & Rubio-Patrón D. E. (2017). Evaluation of using mathematics educational software for the learning of first-year primary school students. *Educ Sci., 7*(4), 79.

Acknowledgments

All the authors whose works were used are duly acknowledged.

Authors contributions

Not applicable.

Funding

The university funds this research.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.