Tutors' perceptions of ICTs in promoting computational thinking among pre-service teachers in Tanzanian colleges

Vicky Mrosso, Placidius Ndibalema and Abdon Ephrem

Department of Educational Foundational and Continuing Education, College of Education, The University of Dodoma, 1 Benjamin Mkapa Rd., 41218 Iyumbu, Dodoma, Tanzania

Abstract. The current study explores tutors' perceptions of using information and communication technologies (ICTs) to develop computational thinking (CT) skills among pre-service teachers. The semi-structured interviews were conducted with purposively selected 4 principals and 20 tutors, and focus group discussions were held with 32 purposely selected pre-service teachers from 4 colleges, making a total of 56 participants. The findings revealed that tutors dominantly perceive CT as a digital literacy skill while ignoring the cognitive processes that underlie CT skills such as abstraction, algorithmic thinking, decomposition, and pattern recognition. Further, the findings show that tutors had limited understanding of identifying appropriate methods for developing CT, such as block-based programming tools. The study recommends that policymakers explicitly include CT and its aspects in the teacher education curriculum and conduct pilot testing of professional development training to foster CT skills using ICT among tutors.

Keywords: information and communication technologies, computational thinking skills, tutors, pre-service teachers

1. Introduction

Computational thinking (CT) skills have recently become a catch phrase in today's 21st-century skills [3, 28, 50]. CT skills were initially introduced by Papert [41] who viewed them as procedural thinking and programming related to computer science. Nevertheless, a substantial body of literature highlights the crucial necessity for CT skills, extending beyond the realm of computer science to encompass various aspects of daily life, including disciplines like science, engineering, technology, and mathematics (STEM) [7, 12]. With the growing need for CT skills in everyday life, Wing [61] argued that CT is one of the fundamental problem-solving skills every individual needs to learn. Additionally, CT is an essential skill for enhancing students' ability to think logically while making decisions, developing a sense of creativity, innovation and preparing students for future careers such as STEM, especially when technology is integrated in teaching practice [6, 64]. Therefore, fostering CT skills in the education context from pre-primary to higher levels has become essential [47, 64].

Given the essential role of CT in education, various scholars have been prompted to introduce a CT framework in education [19, 55, 61]. For example, Wing [61] introduced a computational thinking framework with four components: abstraction, decomposition, pattern recognition and algorithmic thinking. Similarly, the International Society for Technology in Education [19] identified a CT framework with four components:

0000-0002-6836-7437 (V. Mrosso); 0000-0002-9119-4255 (P. Ndibalema); 0000-0002-1222-8219 (A. Ephrem)
vickymrosso1@gmail.com (V. Mrosso); placidius.ndibalema@gmail.com (P. Ndibalema); abdonkimario@gmail.com (A. Ephrem)
https://scholar.google.com/citations?user=rALU7e0AAAAJ (V. Mrosso); https://www.udom.ac.tz/staff/staff_profile?id=VDBSalBRPT0= (P. Ndibalema)

decomposition, gathering and analysing data, abstraction and algorithm design. In contrast, Tsai et al. [55] established a five-component framework, incorporating decomposition, abstraction, algorithmic thinking, evaluation, and generalisation. These frameworks reveal similarities and variations in how scholars conceptualise CT skills in educational contexts.

However, of all these frameworks, Wing's [61] framework has garnered support from the vast majority of researchers [29, 63, 65], establishing it as a cornerstone in defining CT skills. Wing [61] delineates the four core components of CT (decomposition, abstraction, pattern recognition and algorithmic thinking), which contribute to the general understanding of how learners engage in problem-solving tasks. Decomposition is the ability to break a problem into smaller and more manageable parts [63]. Consequently, Wing [62] perceives abstraction as the ability to identify what information to keep or ignore. Further, pattern recognition involves searching and identifying similar patterns to make classification [61]. Finally, algorithmic thinking includes an individual's ability to figure out the solution to a problem step by step [55]. With the evolution of research, Wing's framework has become an indispensable guide.

With this attention, many countries have introduced CT into compulsory education as part of general curriculum reform efforts [32, 64]. Countries such as Greece, the Netherlands, and the United States of America have made initiatives to integrate computational thinking skills in elementary and secondary curriculum [13, 24, 65]. A study conducted by Hsu, Chang and Hung [18] and Voogt et al. [60] highlights that teachers can bring CT skills into the classroom in several ways, including but not limited to subject-specific areas, project-based learning, game-based learning and information and communication technology (ICT). Subsequently, Budiyanto et al. [7] suggests ICT to be the most proficient and effective way. Many developed countries support using ICT-mediated activities such as cloud-based technologies and computer simulations to foster CT skills. For instance, to enhance STEM education, Greece and Ukraine have initiated training teachers to use developmentally mobile applications to foster CT skills in their teaching practice, particularly in preschool classrooms [24]. However, this effort suggests that most pre-service programs in developed countries often lack an emphasis on CT skills. In addition, Western studies indicate that most teachers lack confidence in using ICTs due to limited skills in selecting and applying suitable technologies to support CT skills [24, 32].

Further, CT skills are increasingly recognised in developing countries, though their integration into education systems remains limited [15, 25]. For instance, Namibia promotes coding skills in early education to foster problem-solving and creativity [15], but CT is often underrated in teacher training colleges. In South Africa, CT is incorporated at the primary level through subjects like natural sciences and technology, involving practical projects, and as a standalone ICT course at the lower-secondary level [15, 25]. However, tutors require further training to effectively integrate CT into pre-service teacher education [21], and CT skills are often confined to specific subjects rather than embedded across curricula, limiting students' foundational knowledge [20]. This indicates that, despite little promotion of CT skills in most countries, the skills do not cut across the curriculum; instead, they are based on specific fields.

Apart from not being evident in the curriculum, studies conducted by Moon, Cheon and Kwon [36] and Saidin et al. [42] show that teachers in developing countries face different challenges, ranging from conceptual understanding of CT skills and limited confidence in using ICT for enhancing CT skills. For instance, studies conducted by International Society for Technology in Education [19], Mills et al. [34], Nordby, Bjerke and Mifsud [40], Wing [61] indicate variation among scholars in conceptualising CT skills. While Wing [61] views CT as the thought process involved in formulating a problem and coming up with a solution, International Society for Technology in

Education [19] views CT as a skill to engage and thrive in a digital world. This highlights the significance of tutors' common understanding of CT skills in teacher education colleges for effective CT integration. Further, Turchi, Fogli and Malizia [56] reports that teachers have limited confidence in incorporating CT skills due to low ICT pedagogical knowledge. Consequently, Juškevičiene and Dagiene [22] emphasises the need for ICT pedagogical knowledge to successfully enable tutors to facilitate CT skills among the pre-service teachers. For this reason, the current study aims to study tutors' understanding of CT skills and the ways they develop CT skills among pre-service teachers through ICTs.

Similarly, the role of ICT for teaching and learning in Tanzania is evident in different government documents and research [23, 35, 49, 58]. While several studies in Tanzania [27, 30, 37] have explored the general application of ICT in Tanzanian pre-service teachers' colleges, there remains a gap in understanding how ICT can be harnessed to develop CT skills. Again, it is unlikely to find the direct role of ICT in developing computational thinking skills in the Tanzanian curriculum; one may find its associated elements, including digital literacy, critical thinking skills, reading skills, problem solving and creativity [31, 35, 58]. For example, the Tanzania Development Vision 2025 acknowledges the value of 21st-century skills and the necessity for Tanzanians to receive a high-quality, internationally competitive education while utilising technology in teaching and learning [53]. Similarly, the National curriculum framework for basic and teacher education acknowledges the role of ICT in developing problem-solving skills, creativity, and digital literacy [35]. This indicates that the teacher education curriculum does not explicitly show CT skills. This suggests the need to explore tutors' understanding of CT skills and how they use technological opportunities to enhance CT skills among the pre-service teachers.

Following the importance vested in the role of ICT in students' learning, the government has taken different initiatives including the development of ICT policy for basic education [57] and the adoption of ICT-UNESCO contextualised framework for teacher educators [51], and development of national digital strategy [54]; Mwalongo [38] and Tandika and Ndijuye [49] suggest that introduction of ICT policy and framework paved a way for teachers' integration of ICT in education. However, Ndibalema [39] reports that its implementation faced many challenges, including teachers' limited knowledge on the use of ICT, shortage of ICT facilities, presence of nonfunctional laboratories, and limited internet access. Following such challenges, the government, in partnership with different developmental stakeholders, introduced a compulsory course (ICT) in teacher colleges to equip pre-service teachers with ICT knowledge [5, 23].

Apart from that, Tanzania has witnessed several projects and initiatives related to the use of ICT in teacher education programs. For instance, in 2005, the then Ministry of Education and Vocational Training (MoEVT), in cooperation with the Swedish International Development Agency (SIDA), emphasised the campaign on the development of ICT in teacher education through the provision of training and computers to teacher colleges [9]. Another initiative for improving ICT use in teacher colleges includes the Teacher Education Support Project (TESP), which is supported by the government of Canada through Global Affairs Canada (GAC) [52]. The project has provided a wide range of ICT training and facilities, including 1120 desktop computers, 186 projectors and 35 duplicating machines to 35 government teacher colleges [48].

Moreover, none of the initiatives have shown how ICTs foster pre-service teachers' CT skills. For instance, although the national digital learning strategy stresses having an ICT-integrated curriculum in Teacher education colleges to promote improved learning outcomes through a digitally enabled education system, the learning outcomes are not clearly stipulated [54]. For this reason, it is not well known how tutors in teacher colleges integrate ICT to facilitate CT skills. For, instance in Tanzania,

Saimon, Lavicza and Dana-Picard [43] conducted a study to explore the promotion of 4Cs (critical thinking, collaboration, communication and creativity), however the findings indicated that the two aspects (critical thinking and creativity) which are also components of CT were limited and not enhanced due to teachers' reluctance to adopt new technology in teaching. Similarly, the study conducted by Mashaza [33] reports tutors' ineffectiveness to promote CT and critical thinking skills (problem solving and analytical skills), particularly in Tanzania colleges, which has resulted from a lack of required skills on how to use modern technology. Given that CT is less promoted through ICTs, the current paper sought to contribute to the existing literature. First, by including and mentioning CT and its aspects in the curriculum; secondly, creating a common understanding of CT skills, third, ensuring affordable technologies are used to promote CT skills from the elementary level to higher learning education, particularly in pre-service teacher colleges and fourthly, creating awareness in the integration ICTs in promoting CT skills into teacher education as a preparation unit. With these reasons, the current study is guided by two main research questions.

1.1. Research questions

The following main research questions guide this study:

1. What is tutors' understanding of the concept of computational thinking skills?
2. How do tutors use ICTs to develop pre-service teachers' computational thinking skills?

1.2. Theoretical context

The present study was guided by social cognitive theory by Albert Bandura [4]. The theory postulates that human functioning depends on three interacting sets of factors: personal, environmental and behavioural factors [4]. The theory posits that self-efficacy beliefs are an important set of proximal determinants of human motivation towards a behavioural action [4]. Therefore, the theory elaborates on the way personal, behavioural, and environmental factors interact with one another in order to form a tendency to perform particular actions. Personal factors include individuals' knowledge, attitudes and expectations towards a particular situation [44]. Again, while environmental factors are urged to include social norms and influence from others, the behavioural factors include skills, practice and self-efficacy towards a particular action [4, 44]. In the context of this study, personal factors reflect tutors' understanding and attitudes towards both the meaning of computational thinking skills and their attitudes towards using ICT in developing CT skills.

On the other hand, behavioural factors reflect tutors' use of ICT to develop CT skills. Environmental factors are assumed to include the availability of ICT resources and institutional support in teacher training colleges. Therefore, tutors' perceptions of the use of ICT in developing CT skills are shaped by their understanding of CT (personal factors), their tendency to use ICT tools (behavioural factors), and the availability of ICT resources and appropriate institutional ICT support (environmental factors).

2. Methodological procedures

2.1. Research approach and design

The current study employed qualitative research inquiry to collect detailed insights on tutors' perceptions of CT skills and explore how they use ICTs to develop CT skills. In addition, an interpretive phenomenological research design was adopted as it focused on the theoretical perspective of understanding the meaning of a phenomenon based on participants' lived experiences [11]. Therefore, the design suits the current study because it focuses on exploring participants' lived experience of how they both understand CT and the use of ICT to foster CT skills.

2.2. Study area, sample and sampling methods

The study was conducted in four regions in Tanzania mainland (Morogoro, Mwanza, Dodoma and Iringa) at four teacher colleges (TC_1, TC_2, TC_3 and TC_4). A total of 56 participants were purposively sampled: 4 college principals, 20 tutors and 32 pre-service teachers. Colleges were selected because they had at least five years of experience using ICT in teaching, many ICT facilities and higher enrollment rates [1, 37]. It was predicted that colleges with these features, specifically the higher enrollment, had a wide pool of tutors, allowing the researcher to both thoroughly generalise participants' understanding of CT skills and explore in detail how tutors used ICT to foster CT skills in their teaching and learning practices. Principals were chosen due to their pedagogical leadership roles, tutors for their position as heads of departments (ICT, Education, Natural sciences, Social Sciences and Languages), and pre-service teachers due to their performance and gender from first and second year diploma courses. Since the study was qualitative in nature, sample size was determined by data saturation [11].

2.3. Data collection methods and analysis plan

Data were collected through semi-structured interviews with principals and tutors, and FGDs with the pre-service teachers to ensure triangulation and credibility [11]. The data collection involved recording and documenting the participants' responses using digital recorders and notebooks. An average of one hour was used to conduct the interview and FGD sessions.

The qualitative analysis was guided by three stages of thematic analysis suggested by Green et al. [16], including: immersion, creation of categories and theme generation. First, the process began by listening and re-listening to the recorded audios, and ensuring that words were directly transcribed to avoid potential bias during interpretation. The transcribed text was then translated from the Kiswahili language into English. After translating the transcripts, the translation expert verified and edited the text to ensure the original meaning was not distorted. The coding process followed the second step. The coding process involved reading and re-reading the data in the text to make sense of the data. Thereafter, the coding of raw data was done line-by-line, phrase-by-phrase and sentence-by-sentence to reduce the bulkiness of the data. The codes were extracted from the transcripts and exported to an Excel spreadsheet for the creation of categories [11]. A pivotal table was used to develop and merge the recurring codes to form categories analysed in frequencies and percentages. The third step was theme generation, which involved naming the themes and reviewing the categories to ensure they were well linked to the research objectives. After a clear definition of themes, the process was followed by report writing.

2.4. Ethical matters

The ethical clearance was secured from the University of Dodoma on behalf of the Tanzania Commission for Science and Technology (COSTECH) and a research permit from the Ministry of Education, Science, and Technology (MOEST) to visit the 4 teacher training colleges. Ethical issues were employed to protect participants from risks that could harm them [10]. The researcher considered ethical issues like informed consent, confidentiality, safety and anonymity. During the data collection, participants were given an informed consent form to endorse their voluntary participation in the study. To ensure confidentiality, participants' anonymity was protected by pseudonyms and by assuring them that their names would not be identified. To ensure safety, participants were assured that there would be no physical or emotional harm. However, the participants' privacy was ensured by creating a conducive environment where participants felt free to express themselves.

2.5. Trustworthiness of the study

To ensure trustworthiness in this study, the researcher implemented several rigorous methods. First, an expert review was conducted by submitting research instruments to an ICT expert for evaluation. Triangulation was achieved by employing multiple data collection techniques, including interviews and focus group discussions, involving diverse informants such as tutors, principals, and pre-service teachers. To enhance reliability, three independent coders were used to establish inter-rater reliability and coding consistency [11]. The researchers also ensured that the data enumerator was thoroughly trained. Participants' responses about tutors' conceptions of computational thinking skills and their use of ICT to promote these skills were accurately captured by carefully reviewing recorded audio and maintaining detailed notebooks. Finally, bracketing was employed through an audit trail to minimise personal bias, with clear documentation of the entire research process.

3. Results

This section presents the findings from tutors, principals and pre-service teachers regarding tutors' understanding of computational thinking skills. These findings were obtained from the participants through interviews and focus group discussions. Figure 1 summarises tutors' conceptions of computational thinking skills in teaching and learning.

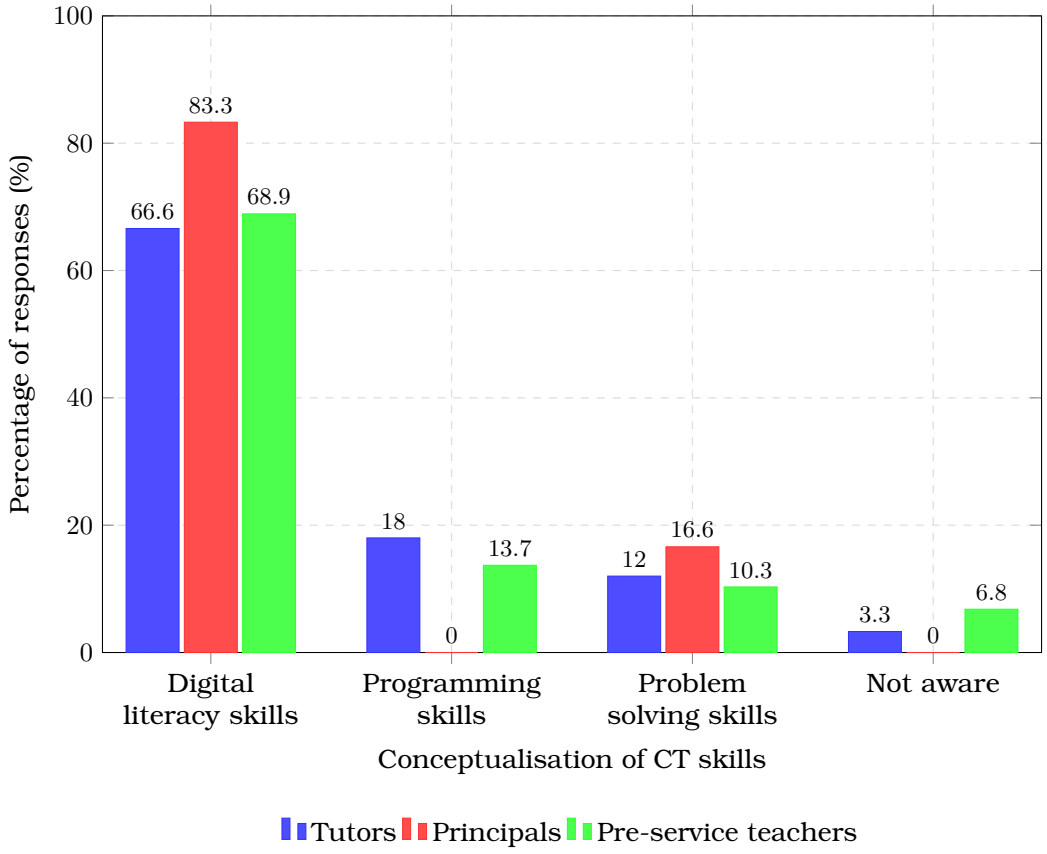

Figure 1: Tutors' conceptions of computational thinking skills in teaching and learning.

3.1. Digital literacy skills

Most participants' responses (tutors 66.6%, principals 83.3% and the pre-service teachers 68.9%) regarding their conceptualisation of CT skills highly relied on Digital

literacy skills. Digital literacy skills were associated with using ICTs to search for information to gain a deeper understanding, incorporating ICT in teaching and learning, and using ICT to prepare teaching and learning materials. For example, one tutor from the natural science department reported:

> According to my understanding, CT is the skill to use modern technology, such as a computer, in both academic and non-academic matters. In academic matters, a teacher may use ICT, such as a digital projector, computer, and tablet. You know ICT is very vital, we use it to prepare teaching and learning materials and sometimes students use it to learn by themselves even when they are at home. (Interview with tutor from TC_2, in 2024)

In addition, one pre-service teacher commented:

> In my opinion, computational thinking skills are having the ability to think in a modern way. This is where a teacher or students have the ability to solve problems and simplify daily tasks by using ICT. (Focus group discussion with pre-service teacher from TC_1, in 2024)

The participants' expressions highlight some variations in the way participants perceive digital literacy skills. Tutors view digital literacy skills as individuals' ability to integrate ICTs in teaching, prepare materials and support personalised learning. Tutors pointed to ICT tools such as digital projectors, computers, smartphones and tablets. In contrast, the pre-service teachers view digital literacy skills as using ICTs to solve problems and simplify tasks. Although the findings suggest a potential gap in how participants conceptualise CT, the pre-service teachers had a relatively better understanding because they linked CT skills with the ability to engage in problem solving with ICT.

3.2. Programming skills

The participants (tutors 18% and the pre-service teachers 10.3%) less associated CT skills with programming skills. Tutors view programming skills as the ability of individuals or educational experts to come up with new educational software, such as AI and PhET. The pre-service teachers view programming skills as the capacity of both tutors and students to design subject apps and simulated educational materials, as well as to understand programming languages. However, there were no comments from college principals on programming skills. For example, one tutor commented:

> It is the skills utilised by ICT professionals in developing programs. A person with computational thinking skills can design creative educational software, such as AI and PhET. This software may be used in the instructional teaching process. I think a good designer is the one who knows how to follow one step after another. (Interview with tutors from TC_1, in 2024)

In the same line, another pre-service teacher explained:

> You know, for us who are studying computer science, we have a programming language. So, I think computational thinking may involve the ability to design new programs. For example, last year we designed a student election program. In order to achieve this goal, we had to plan to use code to assign the computer to perform such a task. (Focus group discussion with pre-service teacher from TC_4, in 2024)

The participants' responses show that the participants had limited understanding of conceptualising CT skills, with tutors and the pre-service teachers holding similar views. Tutors view programming skills as the ability of educational experts to create advanced ICT tools such as AI and PhET simulations for instructional purposes. In contrast, the pre-service teachers' perception of CT skills was more inclusive because it focused on the practical application of ICTs. The practical application of ICT could involve planning, coding and task execution. Therefore, the two preceding quotes represented teachers and pre-service teachers from the ICT field, suggesting a likelihood of more understanding of CT from the ICT (computer science) fields. However, the lack of responses from principals suggests doubts regarding effective supervision of curriculum implementation, particularly integrating CT skills in Tanzania's teacher education curriculum.

Surprisingly, the findings revealed the presence of 'not aware' responses among the participants. This suggests a limited understanding of CT skills in teaching and learning practices. To affirm this, one tutor reports: "... I could try *but I really don't know...*" (Interview with tutors in TC_2, in 2024). In addition, one pre-service teacher asserted: "*To be honest, I am not aware of it, it is my first time I am hearing this*" (Focus group discussion with pre-service teachers, in 2024). The findings suggest a notable lack of awareness among the participants in understanding computational thinking and its aspects in teaching and learning practices. Tutors' responses indicate a significant gap in knowledge and skills for applying CT skills in their instructional practices. Further, the pre-service teachers' expressions show that CT skills are less integrated in teacher-training programs, highlighting a gap in training.

3.3. Methods tutors use to apply ICTs to develop computational thinking skills

The participants identified several methods that were being used to develop CT skills through the use of ICTs. The ICT-based methods the participants pointed out included using ICT-enhanced research skills, digital presentation, ICT-enhanced summarisation, design thinking approach and ICT-based assessment (figure 2).

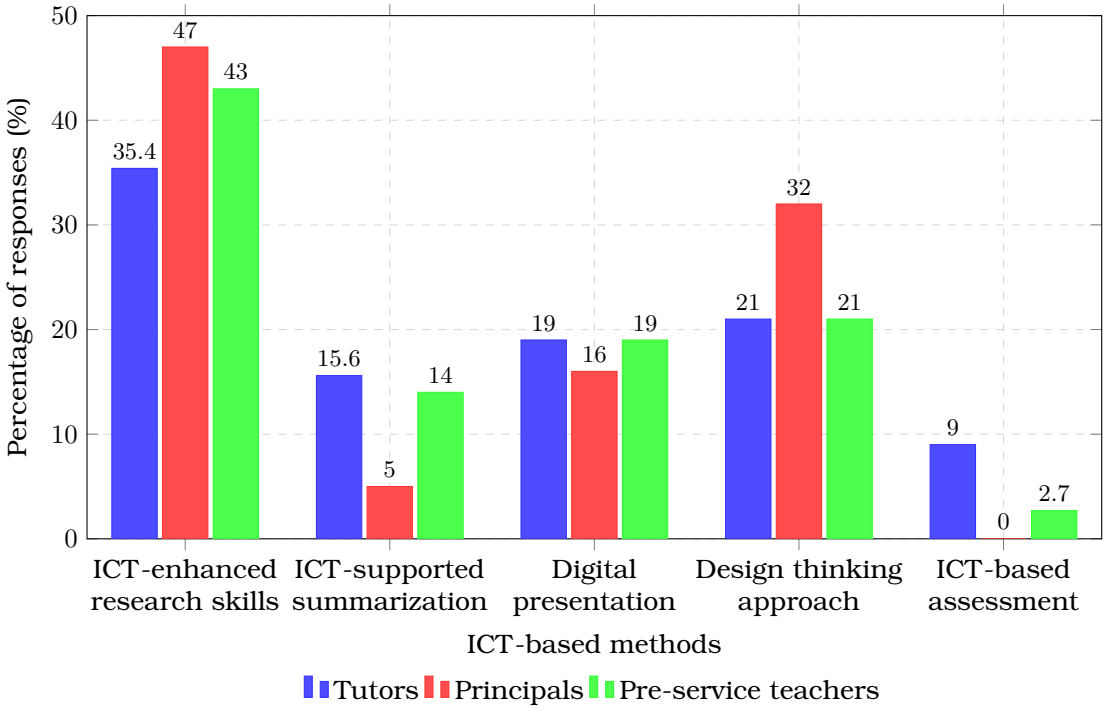

Figure 2: Methods tutors use to apply ICTs to develop computational thinking skills.

3.3.1. ICT-enhanced research skills

ICT-enhanced research skills were highly preferred by the participants (tutors 35.4%, principals 47% and the pre-service teachers 43%) as a prominent method to foster CT skills. The participants reported that ICT-enhanced research skills include teachers' ability to engage the learners in searching activities, using digital scenarios in teaching and learning activities to develop questioning skills. To foster searching skills, tutors reported that they guide the pre-service teachers in searching different materials through different search engines such as Google Scholar on the internet. This way, the pre-service teachers may learn to identify reliable and credible materials. Similarly, college principals emphasised that when pre-service teachers are given different search activities, they can develop searching, analytical, and note-taking skills. To affirm this statement, one principal reported:

> Often, teachers instruct their students on how to search scholarly materials through Google Scholar and other search engine tools. I think this is a good way to develop computational thinking skills because students can develop search skills, analytical skills, and note-taking skills. We normally insist that our students avoid taking materials from every source, such as Wikipedia. In other circumstances, teachers in our college can use YouTube videos to introduce students to different scenarios to help students understand some concepts during the teaching and learning process. (Interview with principals from TC_1, in 2024)

In the same argument, one tutor commented:

> Personally, when I give my students tasks to search on the internet, I always guide them in presenting their findings. So, I ensure they present a summary of what they were instructed to search. I may guide them to use a PowerPoint presentation or just present in traditional format. Therefore, my task is to assess if they can make a presentation in chronological order. I can pose some questions and prompt them to formulate their own questions. (Interview with tutor from TC_4, in 2024)

Consequently, one pre-service teacher added:

> In my view, when teachers assign us a task to Google on the internet and prepare summaries for classroom presentations, we are using CT skills. (Interview with pre-service teacher from TC_3, in 2024)

The participants' representative quotes highlight that the use of ICT-enhanced research skills, particularly those on fostering searching skills, appears to develop a wide range of skills such as analytical, summarisation, logical thinking and evaluative skills. These skills are essential in cultivating abstraction, algorithmic thinking, decomposition and pattern recognition. The expressions suggest that tutors use Google search engines to search for materials from different online sources. Also, tutors reported the use of digital scenarios through downloading videos from YouTube to clarify various concepts and foster explorative skills among the pre-service. Despite having higher mentions among all the participants' categories, the use of ICT-enhanced research skills was less commonly referred to by the tutors, suggesting its limited use in teaching and learning practices.

3.3.2. ICT-supported summarization

Tutors (21%), principals (32%) and the pre-service teachers (21%) highlighted the use of ICT-supported summarisation method as one among the ways to foster CT skills in pre-service teacher colleges. Tutors view ICT-supported summarisation as involving the pre-service teachers in preparing the slides, using a computer and particularly Microsoft Word software to highlight, edit, cut and paste information, and drawing conclusions from the subject matter presented. While summarising, students may use ICT tools such as smartphones, tablets and computers. For instance, one principal, when interviewed, reported:

> The majority of tutors here are using projectors in teaching and learning activities, although there are not enough projectors. They also use the same projectors to teach students how to prepare slides by assigning them tasks. I once saw a teacher assigning students to search for materials online and asking students to prepare slides for presentation. (Interview with principals from TC_1, in 2024)

Similarly, one tutor had the following to narrate:

> You know the computer lab is open for all students. Thus, we may take the pre-service teachers there and teach them to highlight a part of information; we can teach them to cut, edit and organise a particular piece of information to create their own summaries. (Interview with tutor from TC_3, in 2024)

Additionally, one pre-service teacher remarked:

> A teacher may ask us to draw a flow chart before designing a certain client app. (Focus group with pre-service teacher from TC_2, in 2024)

The findings revealed similarities and variations in how participants understand using the ICT-supported summarisation method. While the principals view it as the preparation of slides for presentation, the tutors perceive the ICT-supported summarisation as students' interaction with the digital texts to sort out the more important information and remove the unnecessary patterns. However, both attributes rely on filtering unnecessary information from the bulk of materials. Contrary to principals and tutors, the pre-service teachers view ICT-supported summarisation as representing ideas in a pictorial or diagrammatic form, indicating a limited understanding of methods for applying ICT to enhance CT skills.

3.3.3. ICT-based assessment methods

The participants (tutors 9% and the pre-service teachers 2.7%) preferred using ICT-based assessment to foster CT skills in teacher training programs. Participants attributed ICT-based assessment with learning management systems (LMS) to assign students questions to perform and share a Google link online for students to respond on Google Forms. Tutors reported that they preferred to upload assignments and tasks so that students could navigate through the platform via their smartphones, tablets, and computers to attempt the assignment. Further, a limited number of tutors highlighted using Google Forms to evaluate their students' learning. Additionally, pre-service teachers view ICT-based assessment as using WhatsApp groups to share assignments and tasks. However, the findings revealed no mention from principals, indicating a limited understanding of ICT-based assessment methods that may promote CT skills. For example, one tutor argued:

> You cannot conduct direct assessment using ICTs, but we used to ask questions verbally most of the time. Once the LMS was functioning, I assigned tasks to my students. They could just navigate through the systems and find the attached assignments. Concerning the use of Google Forms, I remember in one training, we were taught to assess digital content via that method. (Interview with tutor from TC_3, in 2024)

In the same line, the pre-service teachers reported:

> I am not sure if our teachers use ICT in the classroom to evaluate the learning process. I think they normally use either question and answer model to make evaluation. For example, the practice here is that, teachers can only share questions in either word or PDF format via WhatsApp groups. (Focus group discussion with pre-service teachers from TC_3, in 2024)

The participants' quotes indicate that tutors are less likely to apply ICT-based assessment methods to assess the learning process. The limited application of these methods to foster CT skills appears to be linked to the functionality of the LMS that was formally implemented in teacher education colleges. The reliance on verbal question and answer methods indicates a dominance of traditional teaching approaches, suggesting a non-digital approach to assessment. However, confinement of participants' responses to LMS and Google Forms highlights a potential gap in awareness of a broader range of ICT tools that could enhance CT skills among the pre-service teachers.

4. Discussion of the findings

This study aimed to explore tutors' conceptualisation of computational thinking skills and the methods for using ICTs to develop CT skills. CT skills are vital for problem-solving and critical thinking skills, especially in this digital era [17]. The findings have revealed that tutors dominantly conceive CT skills with digital literacy skills, indicating a narrow conceptualisation of CT. These perspectives align with studies conducted by the International Society for Technology in Education [19] and Kalogiannakis and Papadakis [24], which emphasise the critical role of digital literacy skills in developing CT skills. However, the findings do not fully encompass the cognitive processes involved in CT, such as abstraction, decomposition, pattern recognition and algorithmic thinking [61]. Bandura [4] emphasises the significant role of cognitive processes in driving human motivation towards a particular behavioural action. While focusing on environmental factors such as the availability of ICT facilities, personal factors such as the understanding of CT components are important in developing CT skills. In Tanzania, although the government documents acknowledge promoting problem solving and creativity, essential for CT, it is unlikely to explicitly find CT skills in policy documents [35, 59]. This suggests limited understanding among tutors of a distinctive cognitive framework that extends beyond using digital tools. Therefore, the findings suggest limited tutors' understanding of conceptualising CT skills. Dong et al. [14] supports this observation, noting that tutors' limited understanding of CT is one of the primary hurdles, compounded by difficulties in implementing CT skills in teacher education programs. Consequently, this impacts the pre-service teachers, leaving them unprepared, particularly in acquiring essential problem-solving skills, logical thinking and analytical skills [2].

Further, the findings found that some participants linked CT and problem-solving skills. Tutors associated problem-solving skills with engaging pre-service teachers to create innovative products through using design-based tools and analysing data

patterns with a spreadsheet. The findings align with Wing [63], who support learners' engagement in problem solving with ICT. Although the findings do not explicitly indicate how the use of design-based tools to create new products is articulated in CT components, Butler and Leahy [8] highlights that CT encompasses a systematic problem-solving process. From this perspective, the findings suggest that along the problem-solving process, abstraction (focusing on important information and reducing the unnecessary), decomposition (breaking information into smaller parts), pattern recognition (identifying similar patterns) and algorithmic thinking (solving problems step-by-step) may be enhanced during the solving process. However, the findings also indicate a gap among tutors on integrating the cognitive process underlying CT skills into their instructional practice, indicating a significant gap in pre-service teachers' preparation.

The findings found several methods for using ICT to promote CT skills, ranging from ICT-enhanced research skills, ICT-supported summarisation, to ICT-based assessment. The findings revealed that ICT-enhanced research skills involve using Google search engines such as Google Scholar to identify and analyse information and using digital scenarios such as YouTube videos to clarify the lesson. This influences the enhancement of abstraction and pattern recognition skills. This is supported by Bakala et al. [3] and Butler and Leahy [8], who argued that abstraction involves identifying what information to keep and ignore. At the same time, algorithmic thinking is the step-by-step process of finding a solution. From this perspective, the searching process may promote some CT skills. Further, while the ICT-enhanced summarisation includes the preparation of slides, highlighting, editing and organising information, the ICT-based assessment involves using Google Forms to evaluate the learning process.

Additionally, these methods will likely foster CT skills such as abstraction, decomposition and pattern recognition. Further, the findings align with the studies conducted by Angeli et al. [2], Kusaka [26] and Solanki [46], which suggested the use of Google search engines, slide preparation and Google Forms are essential for enhancing digital literacy skills. However, these technologies do not directly foster CT skills. In contrast, Kalogiannakis and Papadakis [24] and Butler and Leahy [8] suggested using block-based programming as an effective way to develop CT skills. For example, Butler and Leahy [8] put forward that block-based programming such as Scratch, ScratchJr, and Lego WeDo fosters CT skills. Shute, Sun and Asbell-Clarke [45] added that with these modules in the digital learning specialism, students get the opportunity to work collaboratively, engage in the lesson and engage in hands-on learning experiences. However, limited use of block-programming methods in teacher training programs suggests less enhancement of CT skills in pre-service teachers, indicating a gap in awareness of methods appropriate for developing CT skills.

The findings revealed that a limited number of tutors use ICT-based assessment methods. Even though the tutors reported using Google Forms to foster evaluation skills, Wing [61] has not explicitly shown the evaluation aspect in his framework. This suggests the need to explicitly indicate the evaluation aspect, despite being conducted iteratively across the four main aspects of Wing's framework.

5. Conclusions

Based on the findings, the participants varied in how they understood CT skills, thus indicating a limited understanding. Tutors mainly conceive CT as a digital literacy skill while ignoring the cognitive process of promoting CT skills such as abstraction, decomposition, pattern recognition, and algorithmic thinking. Further, the findings indicated that CT and their aspects are not explicitly mentioned in

the teacher education curriculum. The findings revealed limited tutors' awareness of effective methods for integrating ICTs to develop CT skills, including minimal knowledge of block-based programming tools like Scratch. While tutors employed digital techniques to assess learning, Wing's framework does not explicitly include an evaluation component, suggesting the need for its inclusion.

6. Limitation

The study sample size is not sufficient to generalise the study findings. However, the sample size allows the transferability of the findings in contexts similar to the current study. The findings may not apply to colleges with insufficient ICT resources or varying enrollment rates. Therefore, future studies may use a broader survey to allow for the generalizability of tutors' conceptions of using ICT to develop CT skills across all Tanzanian teacher education contexts.

7. Recommendations

The study recommends the inclusion of CT skills in the teacher education curriculum through a framework that aligns ICT tools with CT. Besides, tutors should receive a structured professional development program to foster a common understanding of CT and teach them block-based programming models. The government should also try to train tutors to leverage the opportunities of ICT to develop CT by adapting to the local context and using affordable ICTs. Further, the study should ensure piloting ICT-based CT training programs. The findings recommend explicitly including the evaluation aspect within Wing's framework to ensure assessment of learning.

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