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Improving the quality of mathematics teacher education: An integrated approach to the 4C skills

Taufiqulloh Dahlan[1*], Loso Judijanto[2], Fitriyani Hali[3]

[1]*Universitas Pasundan, Bandung, Indonesia*
[2]*IPOSS, Jakarta, Indonesia*
[3]*Universitas Sembilanbelas November Kolaka, Indonesia*

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ABSTRACT

With the development of increasingly sophisticated technology, educators must have an appropriate learning model in teaching. On the other hand, a country's obligation is to provide facilities and support teachers in developing their competencies. Currently in Indonesia, there is minimal use of 4C skills teaching. Forms of support should be given to teachers to apply 4C to students in schools. However, the fact is, learning 4C skills is very difficult. Therefore, the purpose of this study is to analyze the obstacles and difficulties in teaching 4C skills. The research method used is qualitative and the data collection method is by interviewing 24 respondents. The data analysis technique is with comparative analysis. The results of the study identified five obstacles, namely lack of competency and motivation support, initial knowledge of 4C, minimal references and political mixtures into the curriculum. Pedagogical competence is also problematic. Conclusion, moral and material support is needed for teachers in preparing, designing materials, implementing, assessing and evaluating 4C learning and schools and the government need to think about the form of routine training for teachers in schools in teaching 4C skills. This study recommends that 4C skills be specifically focused on the education curriculum in Indonesia.

INTRODUCTION

Global experts in mathematics education concur that, as technology advances, schools must enhance students' critical thinking, creativity, communication, and collaboration skills to better prepare them for the future. This process can begin with preparing aspiring math teachers. (Dúo-Terrón, 2023). To critically and creatively solve problems with people from all over the world, students need to be able to communicate and work together (Yunita et al., 2021). Because 4C skills have long-term benefits, it is desirable to include them into daily teaching practice (Tang et al., 2020; Tam et al., 2020; Uworwabayeho et al., 2020). As a result, skills have always been covered in class and in the curriculum. But incorporating 4C skills into math classes can be a challenging procedure that calls for careful preparation, instruction, and evaluation.

Teaching 21st-century skills necessitates a comprehensive approach that takes into account institutional regulation, teacher preparation, content, pedagogy, assessment, and funding to assure its implementation. The breadth and speed of educational reform have overwhelmed many educators, who are still figuring out what constitutes 21st-century abilities, how to teach them, and how to assess their students (Oke & Fernandes, 2020). Nguyen et al. (2020) state that there is still a lack of national agreement on effective integration, evaluation, and quality assurance, and that the majority of educational systems require assistance to address these problems. The organization does, however, offer suggestions for dealing with this problem, such as giving teachers the chance and

*Corresponding author: taufiqulloh@unpas.ac.id

ability to work together to create learning environments, attend to the needs of particular student groups in terms of learning, advance their professional development, and teach in groups to help students develop global capacities. Each calls for a thorough and demanding teacher preparation program.

As a developing nation, Indonesia must act quickly to meet the demands of the twenty-first century. It is essential as, during the past ten years, low mathematics achievement among Indonesian students has been a source of worry and is well-documented (Phan et al., 2022; Supriyadi, 2022; Lidinillah et al., 2022; Zulkardi & Prahmana, 2021). Indonesian students' achievement was continually low and static, as seen by the recent PISA tests, which show an average score of 336, 386, and 423 in the 2012, 2015, and 2018 examinations, respectively. Furthermore, according to the OECD, only 1% of Indonesian students were able to respond to the questions on levels five and six, which evaluate critical thinking and problem-solving abilities that are a component of 4C capabilities. In contrast, level 2 student performance which assesses higher-order thinking was significantly higher at 28% (Marulis et al., 2020). Jian et al.'s local analysis from 2023 shows that subpar performance has continued. According to the study, Indonesian students are capable of building mathematical models, but they require assistance with contextual application and creative thinking. The majority of Indonesian students need to improve their mathematical reasoning skills and their ability to correctly answer HOTS-measuring mathematical problems, according to Ariati and Juandi (2022), who conducted research on the subject. Learning loss occurs during restricted school hours as a result of this problem getting worse when Covid-19 spreads (Singh et al., 2020). It leads to a decline in mathematical proficiency, and many pupils experience learning difficulties early in their academic careers, which subsequently affects their performance in the subsequent school year (Sandilos et al., 2020). The caliber of teachers is one important factor that contributes to the problem.

To provide teacher training at an international level in light of this educational dilemma, it is imperative to integrate all facets of the successful 21st-century teacher education model. According to Salamanca et al. (2020), this action is necessary to make sure that educators become aware of all the issues in their community, come up with solutions, and take a stand. However, with an emphasis on 4C skills, aspiring teachers must be suitably equipped for the demands of today's teaching and learning environments (Li et al., 2022; Burbules et al., 2020). Nugraha and Suparman (2021) state that the implementation of teaching procedures in Indonesian higher education differs from that which aims to develop 21st-century competencies in aspiring math instructors. The learning opportunities provided by the instructor must satisfy 21st-century demands. In order to provide student teachers with sufficient 21st-century training during their first education program, teacher educators generally need to increase their familiarity with 21st-century competencies (Black, 2020). Additionally, Nousheen et al. (2020) found that teacher educators encounter difficulties in obtaining the necessary methodological and material expertise for teaching 4C skills in mathematics education programs. Furthermore, according to Fang et al. (2020), faculty members' pedagogical competency in teaching 4C skills was insufficiently applied to warrant the policy direction. Consequently, the performance of aspiring teachers was mediocre or below average (Herman et al., 2020). It suggests that there is a gap between theory and practice in the first teacher education program, which is inconsistent (Radianti et al., 2020). To put it another way, Indonesian colleges are turning out math professors who are ill-prepared for the demands of the twenty-first century. Should these students go on to become educators, they might continue to use inefficient methods of instruction, which would create a vicious cycle of subpar work (Renga et al., 2020). suggests that the preparation of aspiring teachers for teaching 4C skills is a challenge for Indonesian teacher education institutions.

According to Ifinedo et al. (2020), teacher education programs ought to provide aspiring teachers with sufficient pedagogical and mathematical training throughout their initial coursework. Because the contents of mathematics teacher education are related to future teachers' knowledge and affect student accomplishment, they need to reconsider techniques to develop future teachers and provide them with the necessary knowledge for teaching (Sailer et al., 2021). It's crucial to retain outstanding educators and to invest in, support, and encourage their abilities (Vidergor & Ben-Amram, 2020). Raising the bar for education in Indonesia has so made increasing the caliber of instruction essential. Classroom activities that heavily rely on their professionals and have a direct impact on their students' learning are intrinsically linked to the quality of teaching and learning

(Huang et al., 2020). It suggests that teachers' skills need to be improved, especially when it comes to imparting 4C skills.

To guarantee that their graduates are equipped to teach successfully in 21st-century classrooms, a call for teacher education programs is also made (Almazroa & Alotaibi, 2023). In order to become certified teachers, future educators should acquire competences in mathematics education at university, including techniques, models of learning, and approaches for helping students acquire 4C abilities through lesson study. Given that Sutcher et al. (2019) report that "many countries are experiencing shortages of adequately qualified teachers of mathematics and some science disciplines," meeting the demand is imperative. In order to ensure that instruction improves continuously, teacher preparation programs should provide aspiring educators with critical concepts, abilities, and the capacity to reflect on, assess, and learn from their experiences (Yang & Kuo, 2020). According to studies like Phan et al. (2022), future math teachers should be given real-world experience in the classroom by making frequent school visits. This will allow them to see different types of learning environments, observe successful teaching techniques, comprehend the diversity of their students, and gain the skills needed to implement creative instruction. Future educators will have a well-rounded foundation thanks to the integration of academic studies, mentorships, and classroom experiences.

Research is necessary to determine the challenges faced by teacher education institutions in preparing aspiring math teachers the teachers of the future in terms of forming a reasonable understanding of 21st-century teaching and learning, the degree to which they possess 4C skills, and the capacity to teach these skills on a daily basis especially in low- and middle-income nations like Indonesia. These studies are necessary for the reasons previously mentioned. It is also critical to determine the obstacles faced by school teachers in helping students develop the 4Cs. With this information, teacher education institutions can create teacher professional development programs that effectively address the need for qualified teachers in global classrooms. According to Mohamed et al. (2020), prospective teachers often complain that their undergraduate mathematics degrees are not useful for their future careers. As a result, the purpose of this study is to examine important issues that teacher education programs face while training math teachers to teach 4C skills and to recommend suitable solutions. The following study topics were addressed in order to achieve this goal: a) what obstacles do teacher educators encounter while educating math teachers to teach 4C skills? b) Do educators face comparable difficulties while instructing pupils in 4C skills? and c) what potential remedy might be provided to get beyond such obstacles? By outlining some of the obstacles that Indonesian policymakers need to overcome in order to motivate teachers to incorporate 4C practices into mathematics education at the university and school levels, this study adds to the body of knowledge already in existence (Salas et al., 2021).

Problems with Including 4C Skills in Mathematical Education. A global issue impacting both developed and developing nations is the integration of 4C abilities into regular mathematics classroom instruction (Tang et al., 2020; Rochim et al., 2022). The difficulty was discovered and categorized into four aspects by Albahri et al. (2020). These include the following: 1) political challenge, which has to do with whether policymakers adopt the skills and whether there is a direction, guide, or supporting system to control the results; 2) methodological challenge, which has to do with whether theory and its underlying presumptions are available to support the implementation of the skills; 3) curricular challenge, which has to do with how learners' curricula align with the design of 21st-century implementation; and 4) pedagogical challenge, which has to do with how teaching methods could be employed to impart the skills and their applicability to be modified in different cultures. Moreover, the concept and approach for skill enhancement become problematic when 4C skills are implemented. Additionally, Muhonen et al. (2023) outlined the five main challenges that education policymakers currently. Raising achievement levels and reducing socioeconomic differences among students. Developing teaching as a knowledge-based profession and improving the quality of instruction. Designing school curricula to prepare students for a drastically changed and evolving world. Setting up flexible work schedules for teachers. Identifying low-achieving students' learning trajectories to mitigate early risks and problems. According to Tanhueco-Nepomuceno (2019), legislators who include 21st-century skills in their curricula should back the reforms with a well defined plan for implementation. It suggests that it is even more

important to have a thorough, well-thought-out plan to help teachers, administrators, and legislators navigate the intricate process of implementing 21st-century skill education.

According to earlier studies, there are a number of other major challenges facing modern mathematics education, such as the difficulty teachers have in teaching the 4C skills, which frequently involve solving decontextualized problems, the lack of resources available to them, time constraints, the challenge of fitting a project or inquiry-based, project-based activity into a series of 40-minute lessons, and problems creating cohesive teams (Becker et al., 2020). Furthermore, these research showed that teachers face challenges in getting pupils interested in mathematics, showcasing its application in real-world scenarios, and developing the abilities required to identify whether mathematical concepts are sustainable (Velázquez & Méndez, 2021). Since teacher quality is a major factor in determining student accomplishment, educators need to have a solid understanding of mathematics in order to effectively teach students the information that is demanded by modern society (Bardach & Klassen, 2020). Thus, officials in education came to the realization that the quality of the teachers is what determines whether or not all pupils have access to highly competent teachers.

Several sources, including Bardach and Klassen (2020b), state that the teacher education program has been found to be appropriate and sensitive to the demands of teaching mathematics in the twenty-first century. They have started to update their teacher preparation procedures in order to deliver high-quality education from foundational level primary and secondary to university level (Su et al., 2022). But there are a lot of issues with its execution that need to be quickly resolved by the government and teacher preparation programs. In a similar vein, teacher educators' perspectives might shed light on current events in the profession. Math teachers are required by the curriculum to help pupils build their 4C skills. By giving pre-service teachers learning opportunities that support the development of their ability to teach 4C abilities, teacher education institutions have made every effort to incorporate this requirement into the mathematics teacher education curriculum. Taking into account that the university still needs to amend its rules and address the issues brought up by different stakeholder groups. It is still a work in progress to equip pre-service teachers with the knowledge necessary to teach 4C skills in mathematics classrooms; therefore, researching their difficulties would be very helpful to the education sector in revising policies and guidelines and creating programs that specifically address the problems with modern mathematics education.

METHODS

The research method used is qualitative with an exploratory case study exploring the development of 4C skills in mathematics learning and aims to analyze the challenges faced by higher education in teaching prospective mathematics teachers and school teachers 4C skills. The respondents in this study numbered 24 people consisting of 12 prospective mathematics teachers who were in college and 12 more people who were mathematics teachers who were in schools. Participants and Sampling Technique. This study employed purposive sampling, also known as judgmental, selective, or subjective sampling, which is one of the non-probability sampling methodologies in which researchers select participants based on their judgment (Suryananda & Yudhawati, 2021; Suparman et al., 2021).

Using this sampling technique, there were 12 people representing colleges as prospective mathematics teachers and 12 incumbent teachers representing schools. The respondents were invited to participate in the interviews. The selection of participants was based on the following inclusion criteria: 1) having more than five years of mathematics teaching experience; 2) having voluntarily agreed to participate in the study; and 3) coming from educational institutions in Jakarta. Representation was deemed necessary to determine whether various settings and contexts could be explored to capture the essence of the experiences as experienced by the participants. After interviewing the twelfth participant, no further interviews were conducted because data accuracy had been achieved, and no new information emerged. Table 1 provides a summary and description of the participants' experiences.

Table 1
4C skills that must be mastered

4C skills			
Critical Thinking	Creativity	communication	collaboration
Difficulties and Obstacles			

Table 2
Respondents involved were 24 teachers

Teacher Group							
Male	Age Range	Length of work	Status	Female	Age Range	Length of work	Status
PU01	31-35	7 Years	Teacher	MU01	55-60	20 Years	Teacher
PU02	31-35	8 Years	Teacher	MU02	35-40	14 Years	Teacher
PU03	31-35	5 Years	Teacher	MU03	35-40	14 Years	Teacher
PU04	31-35	10 Years	Teacher	MU04	41-45	15 Years	Teacher
PU05	36-40	12 Years	Teacher	MU05	61-65	19 Years	Teacher
PU06	36-40	12 Years	Teacher	MU06	35-40	13 Years	Teacher
PU07	31-35	11 Years	Teacher	MU07	51-55	20 Years	Teacher
PU08	31-35	12 Years	Teacher	MU08	35-40	15 Years	Teacher
PU09	36-40	15 Years	Teacher	MU09	35-40	15 Years	Teacher
PU10	31-35	13 Years	Teacher	MU10	41-45	16 Years	Teacher
PU11	31-35	14 Years	Teacher	MU11	61-65	20 Years	Teacher
PU12	36-40	16 Years	Teacher	MU12	35-40	14 Years	Teacher

Data collection techniques with instruments. The instrument developed by the researcher became an interview framework guided by research questions, which referred to the challenges in equipping students with 4C skills and a literature review on the application of 4C skills in teaching and learning. The instrument consisting of fifteen initial questions was created based on four dimensions of challenges as found from the literature review, including three questions based on the conceptual understanding dimension, two questions based on the belief dimension, four questions based on the pedagogical approach dimension, and five questions based on the support dimension. In addition, participants were asked to provide a better and clearer description of their difficulties. This serves as a follow-up question that encourages participants to share more information in order to obtain the desired detailed description of the phenomenon under study. This question is also used to encourage participants to elaborate on the points mentioned in response to the main question about the description of their difficulties in teaching mathematics with 4C skills. Open-ended questions provide an overview of the purpose of understanding and explaining the nature of teaching in higher education and schools. Open-ended questions provide an overview of the focus, which is to understand and explain the nature of teaching inherent in universities and schools. In addition, because there may be information that is not captured during the online interview, respondents were given time to answer. In this data collection, ethical procedures and data collection were considered. Ethics committee approval was sought from the colleges and schools with the knowledge of the respondents before conducting the interviews. Interview data were collected with informed consent given by the respondents by fulfilling the inclusion criteria such as explaining the nature of their participation, the purpose of the study, time commitment, confidentiality of their identity, their contribution to the body of knowledge, and their right to withdraw from the study at any time. A consent document signed by the principal and the respondents supported their agreement to provide the data required for the study. The researcher coded each respondent, respondents were identified by their ID, and audio recordings were stored after they validated the basic structure presented following a mutually agreed schedule. In-depth interviews were used to explore and collect experiential material. Since the participants' locations were spread across Jakarta and Bandung, Teams and Google Meeting platforms were used to complement the face-to-face interviews. asking clarifying questions regarding the significance of their experiences.

The data analysis technique collected for this exploratory study was purely qualitative and derived from interview transcripts and learning process plans. Constant comparative analysis was

applied for a comprehensive description and rigorous data analysis. This study employs Amin et al., (2020) analysis procedure outlined in Table 2.

Inductive categorization involves reading the interview transcripts carefully and identifying recurring codes and phrases. This results in a provisional code list. NVivo 20 software is used to analyze the coding and theming process. In 2, overlapping concepts are grouped and coded, aiming to create provisional codes to group themes. Comprehensive notes on the thought process behind coding aid analysis. In the case of preservice mathematics teachers, 25 codes were identified and the first five interview transcripts were analyzed. The codes related to the 4C skills categories were divided into several categories, some for preservice teachers and, others for preservice teachers, others for pedagogical challenges, support, and policies. Of the remaining 5 transcripts, two additional codes were identified, which led to tentative conclusions (Daher, 2023). All sentences were re-examined to compare the coded texts within the designated nodes and to determine whether they could be related to other codes. This process of constant comparison resulted in a tight relationship between codes and texts. The case of the teaching staff was analyzed. The analysis of twelve interview transcripts yielded 39 codes, with 32 codes from the initial analysis of five interview transcripts and seven additional codes after analysis of the remaining five interview transcripts. Thus, Phase 1 concluded with a modified inventory of 39 codes extracted from the twelve transcripts of the mathematics preservice teacher interviews and 32 codes generated from the twelve transcripts of the teacher interviews in the school. After the initial development of codes and categories is completed, reduction, merging, and subcategorization begins, called category refinement. In this , coded and uncoded segments are examined to determine any similarities. This initially requires grouping all similar themes into one provisional category. Next, the researcher must reread the data and obtain general principles. All words are re-evaluated to determine if they fall into the specified categories by considering the rules. In this 2, it results in the validation of each code that has been categorized correctly. In this second , there are 24 codes for the case of pre-service teachers and there are nine categories of pre-service mathematics teacher abilities, namely disposition, pedagogical problems, abilities, conceptual understanding, support, facilities, and policies. Under this category, twelve codes are combined into the same code group, leaving 36 codes at this stage. In teachers at school, 39 codes resulted in nine categories of learner ability, learner disposition, learner condition, implementation problems, teacher ability and motivation, teacher beliefs, and conceptual understanding, Professional Allowance program, facilities, and policies, which were then reduced to 30 codes after evaluation.

Refine categories by exploring cross-category relationships. The analysis process utilizes the matrix feature by coding NVivo 20. Measuring the frequency of code occurrence clarifies whether the facts are in line with the researcher's objectives (Carter et al., 2021). Responses were determined in terms of average proportion. This allows to assess the strength of the code by providing the right number of responses. The respondents are shown in Table 2. An analysis is needed, where an investigation should be carried out on the themes developed and the suitability of the respondents' competencies to understand the significance of the data and the integration of the data. Relevant categories can be grouped in the research questions asked to describe the significance of the data and in this case, five themes were generated for mathematics teachers. Trustworthiness. According to Díaz et al., (2023), four criteria of trustworthiness were measured: credibility, dependability, answerability, and confirmability. This involved a) checking the transcript for errors: this aimed to ensure that the interviews were transcribed with low inference and only present what the respondents said, clarifying and rereading the transcript several times to check for errors, inferences, and written interpretations, b) providing consistent codes, c) checking the codes and reducing them (Point & Baruch., 2023).

FINDINGS

The results and findings in this study are that there are five things that are highlighted in this study and are new findings. The first part is the lack of learning ability and teacher motivation. It was found that the lack of teacher ability and motivation to learn mathematics is one of the most significant obstacles faced by higher education institutions in preparing mathematics teachers to teach with 4C. Several respondents said they needed help in teaching mathematics material with the

help of 4C. This is because mathematics teachers have minimal motivation. Respondents assume that in teaching 4C, they must practice mastering 4C. Respondents assume that prospective mathematics teachers cannot think critically and creatively in solving problems if they do not master the basic concepts of mathematics. Table 3 and Table 4 show, There are three participants [PU02, PU04, and PU05] who think that their abilities are below average and their basic mathematics abilities are very low. This can be seen from the evidence of low achievement in learning basic mathematics. Other participants [PU03, PU06], think that their cognitive abilities are low when solving difficult mathematics problems. The respondents also think that their understanding of basic mathematics is low, such as not understanding and remembering previous lessons. Even if forced, they still don't understand. This is because their basic skills and abilities are minimal. Respondents [PU07, PU09, and PU10], think that prospective mathematics teachers have minimal mathematical concepts and have difficulty thinking with 4C. Respondents think that teaching mathematics material with 4C takes a long time and must be done patiently. Respondents [PU08, PU012] think that there is a relationship between poor performance and 4C skills. Because critical and creative thinking requires reasoning and understanding basic concepts. The problem of student abilities is also seen in teachers at school. A total of 10 teachers experienced difficulties in teaching 4C skills because their students' abilities were low, including mastery of basic knowledge such as multiplication and division concepts, and were only able to solve procedural problems. Respondents [MU01, MU02, MU03, MU05, MU08, and MU09] said "The knowledge of the students I teach is very minimal, so I have to re-teach things like multiplication concepts, but as a high school teacher I have to re-teach them". Respondents also argued that some students were only able to solve procedural problems, if the questions were changed even slightly, they needed teacher assistance. Respondents [MU04, MU06, MU07, and MU010], argued that most students had minimal basic knowledge. Students did not understand basic mathematical concepts. This indicates problems related to student abilities that hinder educators at all levels of education in teaching 4C skills.

The obstacles are more significant if the prospective mathematicians lack interest and motivation in learning. Respondents [PU10, PU06, and PU05] argued that the majority chose the math material they liked and disliked and this is a very big problem. Respondents [PU02, PU07, and PU08] said that prospective teachers do not have the motivation to seek information in solving math problems outside the classroom, prospective teachers seem unwilling to find their way out of math problems. Respondents [PU03, PU04 and PU09] gave the same response. They do not want to look for more solutions to understand the material given. In math teachers at school is very low, such as dependency, the assumption that math is a difficult subject. Respondents [MU08, MU07, and MU05] argued that students in math lessons are very low in interest. There are only eight to seven students out of forty who are very motivated to learn math. The majority do not like math and often do not get a response. Respondents [MU02, MU03, MU04, and MU06] have the same opinion, "students are less interested in learning mathematics, especially with 4C skills. Respondent [MU10] thinks that students' interest is low, and there is a lack of concepts in learning mathematics. This indicates that one of the difficulties facing higher education institutions is providing aspiring math teachers with the knowledge to teach 4C skills in low mathematical ability, talent, interest, and motivation. Teachers of mathematics in schools likewise deal with comparable issues. Tatto et al. (2020) attribute this to a lack of rigor in the teacher training program in the area as well as a lack of quality control over graduates who attend teacher training programs. One reason why mathematics education departments receive so many low-performing teacher candidates is that teacher training institutions are unable to draw in more capable students for their courses. It is also feasible because student teachers face challenges while transferring from secondary to postsecondary education, needing to adopt significantly different learning practices than they did in high school (Scherer et al., 2021).

Table 3
Interview Coding Results 1

Challenges and difficulties	Weak in 4C Skills	Mastery of 4C	Minimum Reference
Weak literacy	Drinking Habits	Communication style Minimal	Minimum books in the library
Minimal independence	Low self-confidence	Form of implementation	No study groups
Learning motivation	Minimal Capital	Lack of ability	No internet
Minimal preparation	Minimal Concept	Minimal 4C skills	Minimal access
Laziness	No preparation	Minimal technology	Limited Computers
Curriculum politics	Minimal evaluation	Minimal concept	Minimal pedagogy
Minimal pedagogy	Lack of planning	No principles	Information Often Late
Low learning outcomes	Drinking Habits	Minimal mastery of facts	Minimal Implementation of New Curriculum
Not familiar with 4C	To postpone	Communication style Minimal	Presenting experts rarely

Table 4
Coding of Interview Results 2

Limited Competence	Difficulties and Obstacles	4C Skills	Minimum Reference
Professional competence	Lack of communication	Lack of communication	Minimal source books
Pedagogical	Difficult Subjects	Curriculum Implementation	Discussion
Planning	Minimal Basic Knowledge	Minimal Pedagogic	Minimal Internet Access
Model and Strategy	Minimal Independent Work	Independence	Few books
Implementation	Minimal Cooperation	Minimal Collaboration	Lack of planning
Assessment	Dependence	Minimal Critical Thinking	Very minimal pedagogy
Implementation	Preparation	Lack of Creativity	Limited computers
Professional competence	Attitude	Minimal mastery	Rare use of technology

The second is to identify the obstacles that prospective math teachers and math teachers face in their pedagogy. Instructors think it's critical to provide 4C skills to aspiring math educators. According to twelve respondents, using 4C abilities in the classroom raised student attention. Nine respondents, however, claimed that their pedagogical expertise was insufficient for imparting the skills to their students. Similar claims were made by respondents [PU02, PU03, and PU04], who said that while they cognitively understood the 4C abilities, they still needed to learn how to teach them. Respondents [MU8, MU09, and MU10] contended that the teacher is the first point of contact. Instructors need to be capable critical thinkers. Respondents [PU02, PU03, and PU04] contended that educators had a difficult time giving students the appropriate approach to problem-solving in mathematics and honing their 4C skills. Although a lot of people said the issues were HOTS, they weren't at all. Respondents [PU03, PU06, and PU07] contended that lecturers needed to be able to explain concepts in an understandable manner and be able to transition from a complex language to one that aspiring math instructors could easily comprehend. One obstacle to preparing preservice teachers to teach the 4C competencies was found to be pedagogy. Students struggled with pedagogical issues like choosing appropriate mathematical problems for the development of the 4C skills, providing analogies to explain content in a comprehensible way, designing tasks for students with varying ability levels, and the time-intensive nature of the work, even though teachers were aware of the demand, understood the concept, believed in its significance, and were willing to adopt it. These results align with earlier study by Sheppard and Wieman (2020), who detail many obstacles faced by instructors. Teachers in schools are less affected by pedagogical barriers. Throughout the installation phase, they run into issues. These include challenges with group formation, lesson planning, scheduling, media use, and pedagogical application. MU03, MU05, MU06, and MU07, the respondents, stated that forming diverse student groups is challenging. There are still a lot of pupils with limited skill sets. According to respondents [MU01, MU02, MU04, and MU10], problem-based learning was completely ineffective since it assumed that students would be able to solve problems right away. due to their disinterest in education. Problem-based learning cannot be finished due to time constraints. Because of the somewhat denser distribution of mathematics class time and teacher teaching approaches, educators find it challenging to apply 4C skills instruction in schools. According to respondents [MU07, MU08, MU09, and MU10], since math classes are typically scheduled for the afternoon or evening, students tend to feel sluggish. As a result, it is important to take this time issue into consideration and schedule the lessons earlier. According to respondents (MU10 and MU08), a

common barrier in schools is subpar instruction from teachers on a daily basis. It is necessary for students to take twelve subjects from twelve different teachers. As a result, if many teachers have beliefs about time restrictions and challenges in executing 4C skills-based instruction, it will be challenging to encourage 4C skills among students.

Prospective math instructors' conceptual knowledge and competence to teach 4C skills is lacking. As seen in Table 3, the incapacity and conceptual lack of knowledge of 4C skills among teachers arises from two categories constructed from fifteen codes. Out of ten participants, only four are able to fully define what 4C skills are and why 21st-century teaching and learning are necessary. All 12 respondents, however, feel that 4C skills are essential for aspiring math teachers because the current curriculum demands them, which motivates them to make every effort to implement 4C skills. Ten respondents acknowledge that they need to get better at teaching 4C skills. Respondents [MU09 and MU08] contended that the lecturing staff is the source of the challenges as, while we want aspiring teachers to interact and communicate, we fail to provide them with learning opportunities that foster the development of 4C abilities. Respondents [PU05, PU06, PU07, and PU08] contended that because of challenges such inadequate competence development, aspiring math teachers are less likely to adopt 4C skills. According to respondents [PU01 and PU02], one of the things that determines how well potential math teachers are able to enhance their 4C skills is their ability to teach. As math coordinators, respondents [MU08 and MU09] contended that there weren't usually any barriers. Many senior teachers, though, resisted change. According to this research, one of the things impeding higher education's teaching staff's ability to assist aspiring math instructors in honing their 4C skill teaching abilities is their ability to plan 4C skill-based lectures. This result is in line with the arguments made by Ghosn-Chelala (2020), who contend that a few of the challenges include insufficient training for teaching staff, a shortage of certified teacher educators, and a lack of focus in educational institutions. Table 4 illustrates this pattern in the situations of school teachers. Ten educators acknowledged that they needed more training and development to fully grasp the 4C competencies of the 21st century. Respondents [MU01, MU02, MU03, and MU05] contended that teachers need to be highly competent since teaching will become more difficult in the future and if we don't prepare for this now, our education would fall behind. Teachers need to read a lot, according to respondents [MU04, MU06, and MU07]; they are lifelong learners, not just transitory ones. Students would suffer if a teacher lacks competency, and [MU09 and MU10] stated that teacher aptitude is crucial, particularly in learning methodology and learning models. According to the respondent [MU08], teachers require a guidance program since they are having trouble grasping the topic. Furthermore, there are issues with teachers' motivation to implement 4C skill-based instruction in this instance. The absence of excitement among students for learning has made teachers less motivated. For instance, [MU08] claimed that pupils had little enthusiasm in studying, which is a difficulty I encounter. Teachers become less motivated as a result of this predicament. According to respondent [MU10], pupils are uninterested in math classes. When pupils show no interest, we must be more creative and self-motivated. It was discovered that there is a need to enhance instructors' capacity and drive to teach mathematics in a way that develops students' 4C skills. Higher education institutions should base their professional development programs for teachers on this conclusion. In this instance, 4C skills education and innovation should be prioritized in mathematics teacher preparation programs at universities so that aspiring math educators can fulfill the needs of teaching and learning in the twenty-first century.

The poor ability of aspiring math instructors to teach 4C skills is a result of a lack of support, resource facility programs, and human resource capacity. Twelve members of the teaching staff who instruct aspiring math teachers feel that they can improve their 4C abilities by taking part in professional development activities like webinars, conferences, workshops, and conversations with learning communities. According to respondents [PU01, PU02, and PU03], universities do not offer teaching staff members any facilities or help when it comes to teaching 4C skills. According to respondents [PU04, PU05, PU06, and PU07], there is still a dearth of 4C skills in higher education's teaching staff competency development programs, and the institution does not offer webinars or other forms of support. The opinions of respondents [PU08, PU09, and PU10] are consistent in that educators must grow personally, but they are not often provided with resources to aid in the acquisition of 4C abilities. There is no connection between 4C skills and the workshops that have been supported thus far. Teachers at the school [MU01, MU02, and MU03] who believe they have

never attended workshops or training linked to 4C skills also find themselves in this scenario. Suryawan et al. (2023) note that current research focuses on fostering higher-order thinking abilities, which include critical thinking and other thinking-related 4C skills. The teaching staff enrolled for the training, but most of them did not attend, according to respondents [PU02 and PU04], because their schedules were too hectic and the program was unrelated to the 4C abilities. Furthermore, they are infrequently found in higher education settings in learning situations that promote their professional development, such as learning communities and lesson study. They are unfamiliar with information regarding the use of lesson study in higher education. There is no such thing as a lesson study community in the higher education where ten of the members teach. Data study reveals that the availability of resources, IT equipment, and other learning facilities in higher education makes it more difficult for teaching staff to impart 4C skills.. Respondent [PU03] argued that the lack of facilities such as the availability of laptops and computers has an impact on the lack of smooth communication. They argued that implementing technology-based learning in teaching 4C skills in the classroom, these things are needed. They attended useful workshops but were unable to attend due to limited facilities. Respondents [PU08 and PU01] argued that the facilities in private higher education and state higher education are not comparable. They often prepare themselves to learn 4C skills, but because of the lack of facilities, the learning process is hampered. The challenge is to try hard because the current learning facilities are minimal and inadequate to support prospective mathematics teachers in developing 4C skills. Respondents [PU09 and PU10] said that prospective teachers often have difficulty getting relevant references, perhaps because most of the references are written in English, and sources in Indonesian are difficult to find. Respondent [PU07] argued that the references for prospective mathematics teachers are limited. Meanwhile, as teachers, they must provide references that are by the teaching materials. Respondent [PU05] argued that there are minimal books on teaching and learning 21st-century skills that are not yet available, there are books on HOTS, but the content is not HOTS. This finding is consistent with Thomson et al., (2020), said that context-specific understanding of teaching practices and meaningful approaches to supporting the professional development of prospective mathematics teachers were significant barriers.

This barrier is a recent issue in higher education, which seeks to develop qualified future math teachers. According to Table 4, There is proof of the absence of professional allowances, facilities, and programs. Twelve respondents shared the same view, stating that they require assistance in order to incorporate 4C skills into math classes. The majority of seminars don't focus on finding solutions to HOTS math problems. Furthermore, mathematics teachers do not profit from the Professional Allowance program due to its inadequate duration. Respondents [MU01 and MU02] contended that although teacher workshops lasted for two days, it was insufficient for them to fully understand the subject; continuous programs, like coaching, are required to guarantee that the program is implemented correctly in the classroom and has an impact. The activities in the teacher forum, as respondents [MU01 and MU02] pointed out, only address how to solve HOTS problems—as everyone is aware. Lesson plan creation is the subject; the planning outcomes are never brought up. Respondents [MU06 and MU07] stated that if the school is merely providing instructions without any training or coaching, then that is not the best approach. They had the same opinion. With coaching, instructors may offer direction and we can discuss any challenges so that we can carry on teaching effectively. This demonstrates the need for 4C skill knowledge and application techniques to be part of ongoing educational initiatives. There are relatively few resources available to help integrate 4C skills into math classes. This covers reading materials, teaching aids, and classroom supplies (such as projectors and power cords). According to eight educators, this equipment is bare minimum for their setting. There aren't as many projectors as the respondents (MU01, MU02, MU03, M04, MU06, MU07, MU08, and MU09) believe. Similar to respondent [MU01], who stated that the government provides the school with limited resources, respondent [MU05] stated that in my school, there is little assistance for the development of 4C skills, only a few classes have projectors, and the installation is frequently broken. We also have to write by hand on the board.

Political barriers, which fall into six categories—demand, money, curriculum, curriculum implementation, higher education and school administration, and evaluation—are evident from the data analysis results. It was specifically mentioned by four respondents that they were not required to teach 4C skills as part of their higher education program's mathematics teacher education

curriculum. The respondents (PU01 and PU02) claimed that 4C skills were not covered in their curriculum. According to responders [PU03 and PU6], there is no guidance available for teaching 4C skills. Nevertheless, an examination of the curricula and lesson plans of every university that trains candidates to teach mathematics has revealed that the current curriculum already encompasses a wide range of 21st-century skills. However, the challenges still lie in putting professional development programs, assessment, pedagogy, and appropriate monitoring and evaluation into practice. There are no rules in higher education on teaching 4C skills, as many who asserted that doing so was mandated by the curriculum acknowledged. One respondent [PU05] brought up the subject of higher education's lack of synchronization. It is mandatory for aspiring educators to instruct sessions that enhance pupils' 4C skills in classrooms. However, no rule in higher education establishments mandates that teaching personnel train aspiring math teachers to possess these abilities. 4C skills are a must, according to NCTM and educational foundations. Respondent [PU04]: Rules are necessary, and the education department must follow them. Respondents [PU03 and PU02] contended that 4C skills cannot be taught in the curriculum at this time. While some university curricula are prepared for 4C skills, educators are not, and this is a problem. Students are not yet able to learn using 4C skills, even when they are applied. While not yet part of the curriculum, numerous campuses of Jakartan universities are discussing the inclusion of 4C competencies. This condition may result from inadequate preparation for future instructors in this sector by training programs, budgetary restrictions that restrict the availability of funding, or a lack of understanding or awareness of the significance of certain abilities. Policies must be updated to align with the curriculum, placing a stronger focus on developing skills and establishing systemic rules to guarantee day-to-day execution. The integration of 4C skills at the school level is a well-established policy in Indonesia. To assist teachers in putting the policy into practice, curricula, instructions for instructors, and assessment tools are offered. The principal and the supervisor of 4C skills do not monitor the teaching process. Respondents [MU01 and MU03] contended that although there is oversight in schools, the delivery of 4C skills teaching is not particularly observed. According to responders [MU05 and MU06], there was little emphasis on 4C abilities during the two-year oversight procedure.

DISCUSSION

This study discovered that in order to apply mathematics material learning with the aid of 4C skills, aspiring math teachers must first obtain 4C capabilities. Some instructors worry that graduates of Jakarta's prospective mathematics teacher program lack the necessary 4C skills and are unmotivated. ICT equipment, learning activities, appropriate assessment tools, and appropriate pedagogical approaches are all necessary for prospective math teachers to teach mathematics content. However, their limited knowledge of the subject makes it difficult for them to develop 4C skills and overcome obstacles that stand in the way of their ability to teach 4C skills.

There are two strategies to lessen the issue and raise awareness of 4C abilities. First, throughout the registration process, universities make sure that registrants who want to become teachers have a good foundation in mathematics, high levels of literacy and numeracy, a desire to learn more, and a willingness to continue their study. Control teacher education admissions to maintain a balance among teacher enthusiasts. Educators with a strong sense of love for their work employ highly pedagogical methods and obtain advanced topic knowledge. Indonesia's academic performance will suffer and teacher education institutes will generate unqualified math teachers if these conditions are not fulfilled. Second, in practice, it is imperative to offer supportive programs like academic training, workshops, learning communities, and school visits. Teachers that are innovative must view their pupils as assets, and they must plan lessons according to each student's individual abilities and skill levels. This can assist them in developing a more engaging and inclusive learning environment where all students, who are aspiring teachers, feel encouraged to participate and work together. This will raise motivation and foster a deeper comprehension of the subject matter of mathematics. It is anticipated that student aptitude will no longer be the cause of Indonesian education's shortcomings. But teacher educators require a new sort of training to face the increasing obstacles; they need to be able to grasp the curriculum and impart a love of learning in their students. In particular, new learning is required to advance the knowledge and abilities of aspiring math teachers to teach the 4C skills. This will inspire them to become lifelong learners who are creative, connected, collaborative problem solvers. Teacher education institutions must provide

mentorship, workshops, research funding, and facilities to support teacher educators who lack the competences and conceptual understanding of the 4C abilities. This will enable them to acquire the necessary skills to provide mathematics training based on the 4C skills. It is imperative to foster the professionalism of aspiring educators in order to sustain, inspire, incentivize, and develop creative and innovative teaching. The teaching strategies of lecturers who work as teaching staff in higher education are visible to aspiring math teachers. Prospective math teachers may adopt teaching strategies that are influenced indirectly by the conduct and methods displayed by educators in the classroom. Teachers that use creative ways to encourage critical thinking, creativity, communication, and teamwork among students during lectures are likely to set an example for aspiring educators. On the other hand, future educators are more likely to implement these principles in their classrooms if educators model an inclusive and respectful learning environment. In addition to influencing the teaching philosophies and methods of the faculty, aspiring educators contribute their distinct experiences, viewpoints, and expertise to the mathematics classroom.

This study suggests using the lesson study platform as a means of helping aspiring teachers become more professional. One possible lesson study platform that can help aspiring math teachers from higher education and in-service teachers from schools develop knowledge to teach 4C skills is to build more partner institutions between schools and higher education. In order to develop creative methods for teaching 4C skills, it is imperative that educators, in-service teachers, and future teachers collaborate on lesson studies in schools and higher education within a predetermined framework. This is made possible by the professional allowance model (Tai & Wei, 2020; Risan, 2020; Ungureanu & Bertolotti, 2020). Collaboration is a crucial part of the mathematics learning process to promote improvement, especially change mathematics classroom teaching and learning. School-higher education collaborations are effective teacher training programs for preservice and in-service teachers. This pertains to problems in education, a lack of facilities and resources, and political obstacles and calls for a revision of policies. Content, pedagogy, assessment, facilities, professional development activities, follow-up programs, and quality control must all be carefully planned in order to execute a curriculum that emphasizes the 4C competencies. Changes in funding, technology, and governance procedures are also necessary for its adoption at teacher training institutes. In order to execute successful change strategies, educational institutions must always search for fresh chances and approaches to enhance the 4C skills that are taught and learned in the classroom. In order to satisfy the needs of teaching pupils in the twenty-first century, they must give aspiring math teachers the chance to actively refine their methods. Initiatives for educational change from the government or higher education will be ineffective otherwise.

CONCLUSIONS

There is a need for improvement in the conclusion of higher education research regarding preparing aspiring math instructors to teach 4C skills. The similar issue was discovered when schools tried to enhance 4C teachers' abilities in instructing students on their materials. identified as two major issues facing higher education in the analysis of instructor capability and student ability. While student aptitude and real-world difficulties appear to be the primary barriers at the school level. To give math teachers the knowledge and abilities to teach 4C skills, a lot of effort needs to be done. In order to give recent graduates the resources they need, higher education must take a proactive stance. One way to do this is by streamlining the graduation, learning, and registration procedures. To satisfy the demand for math teachers in the twenty-first century, they must give aspiring educators the chance to gain 4C skills. Both schools and higher institutions must regularly assess students' acquisition of 4C competencies. In order to properly educate future math teachers, higher education must take into account the difficulties experienced by teachers in incorporating the 4C abilities into the design of the teaching and learning process. As a school that trains future math teachers, higher education must create curricula that are appropriate for classroom use.

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