Assessing the Readiness of Pre-Service Mathematics Teachers in Utilizing the Scratch Application: A Case Study at Universiti Teknologi Malaysia

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***Abstract*— This research-to-practice full paper describes the readiness of pre-service mathematics teachers to incorporate Scratch, a block-based programming application, into mathematics instruction, focusing on their knowledge, skills, and attitudes. Given the rapid technological advancements, leveraging technology in mathematics education is crucial in fostering proficient problem-solving abilities among students. Consequently, computational thinking is recognized as a vital 21st-century competency, a transferable skill for effective problem-solving methods. The study underscores the importance of integrating Scratch, a supportive tool in computational thinking, into mathematics education. However, to integrate this application into mathematics education, pre-service teachers must be prepared to acquire the necessary knowledge and skills and to be ready to accept its use in teaching in the future. The construction of knowledge by pre-service mathematics teachers regarding the Scratch application is examined through the lens of social constructivism, which emphasizes knowledge construction through experience and social interaction. A purposive sample of 60 first- and second-year students participated in an online survey. The sample selection involving two groups aimed to identify significant differences in pre-service teachers' readiness levels across gender, study year, and academic achievement. The findings revealed limited proficiency among pre-service mathematics teachers in utilizing Scratch, particularly regarding its integration into mathematics instruction. Several factors contribute to the deficiency in skills among pre-service mathematics teachers in navigating the Scratch application, including requiring additional time to grasp the programming language employed in the application, challenges in arranging blocks to achieve desired outputs, and struggles in rectifying syntax errors. However, there was a positive attitude towards the application, indicating a strong inclination to enhance their skills. The study also found no significant differences in demographic variables such as gender, study year, or academic achievement, but a slight correlation exists between knowledge, attitudes, and academic achievement. Investigating pre-service teachers' readiness to integrate Scratch into mathematics instruction sheds light into the intersection between mathematics pedagogy and computational thinking. This intersection underscores the importance of integrating programming tools like Scratch into mathematics education to cultivate computational thinking skills. Additionally, the findings contribute to the broader discourse on the role of technology in education and highlight the need for enhanced training and support for pre-service teachers in leveraging technology effectively for instructional purposes.**

Keywords— Attitudes; Knowledge; Mathematics Education; Pre-service Teachers; Scratch Application; Skills

I. Introduction

Education is a two-way process involving activities of receiving and giving systematic guidance in the learning process through various methods or teaching aids [1]. This process has evolved to reflect progress and demands from various stakeholders. The implementation of technology into the educational system is viewed as a promising way to improve the learning process in a more accessible and entertaining manner [2]. The use of technology has transformed the chalk-talk learning environment into a setting that encourages students' curiosity and exploration without relying exclusively on teacher instruction. Since 1997, Malaysian education has been striving to integrate technology into the educational system. Despite over two decades of continuous efforts, statistics show that 52.7% of schools in Malaysia are below the minimum level in the rating of the school's digitalization level, which corresponds to a moderate level of students' digital competency, particularly in terms of cognitive abilities and technology domain [3].

[4] identified numerous factors related to the failure to incorporate technology into the classroom. Among the problems mentioned are low readiness levels regardless of various training provided, willingness to accept the implications of technology use in the classroom, time constraints for exploring appropriate technology use for teaching, and restricted Internet access capabilities, particularly in remote schools. In terms of facilities, the Malaysian government has taken the matter seriously and has carried out the ICT Transformation Plan (2019-2023). This initiative intends to bridge the Internet access gap in all Malaysian schools, whether urban or rural, by increasing Internet connectivity and developing local area networks [5]. Therefore, this issue focuses on attitudes, beliefs, knowledge, and skills related to technology. Research on educators' knowledge, abilities, and attitudes toward technology use should be prioritized to increase the frequency of incorporating technology in classrooms, particularly in mathematics classrooms [6], [7]. Thus, the purpose of this study is to analyze the pre-service mathematics teachers' readiness in carrying out mathematical lessons using the Scratch application in terms of knowledge, abilities, and attitudes.

II. TECHNOLOGY IN MATHEMATICS EDUCATION

Technological advancements have created numerous opportunities and challenges that necessitate adjustments in teaching and learning methods. Educators recognize the need to reshape learning environments as well as instructional strategies and to make them more student-centered [8]. The rise of technology has also influenced the characteristics of modern-day students who grow up in a digital world where technology is integral in their daily lives. This shift has prompted changes in teaching methodologies to cater to the preferences and learning styles of contemporary students [9]. The integration of technology in mathematics classrooms offers considerable benefits such as facilitating the visualization of complex mathematical concepts [10]. Furthermore, it provides students with opportunities to explore conceptual knowledge, justify mathematical ideas, and engage in discussions with peers and teachers [11]. However, recent reports suggest a shift in focus toward Artificial Intelligence (AI) and the Internet of Things (IoT) in technology usage, leading to a greater emphasis on analytical thinking and problem-solving skills for future workforce readiness [12].

Both of these abilities are closely linked to the skills outlined in the Malaysian Ministry of Education's mathematics curriculum standard document, which aims to cultivate individuals who think critically, creatively, and innovatively in mathematics, and who are proficient in applying mathematical knowledge and skills to solve problems in accordance with advancements in science and technology and the challenges of the 21st century. Hence, the integration of technology in the mathematics classroom is imperative. According to a meta-analysis conducted by [13], the use of technology in mathematics education has been shown to positively impact students' attitudes, motivation, and academic performance, while [10] asserts that such technology can enhance understanding of mathematical concepts through visualizing complex relationships. Drawing on the documented effects of technology usage, its implementation has reshaped the mathematics learning environment to become more engaging and student-centered, thereby fostering positive effects on students' motivation and perceptions toward mathematics learning.

In order to foster students' problem-solving abilities and enhance the learning atmosphere, block-based programming applications are viewed as advantageous tools. Therefore, this study focuses on one programming application that can be implemented in mathematics teaching and learning, namely the Scratch application. Scratch is an open-source application that uses graphical programming language and object-oriented programming to manipulate graphics, audio, and video through coding activities. This implies that it falls under the category of interactive applications, converting code-based programming languages into object-generated outputs through the assembly of symbolic and numeric blocks using the 'drag and drop' approach within the interface [14], [15]. Moreover, the concept presented by Scratch is akin to assembling jigsaw puzzles, in which each block needs to be arranged according to the suitability of its shape. Through a systematic study conducted by [16], Scratch has the potential to make learning and teaching more meaningful due to its effectiveness in transforming students' interests and motivation, enhancing mathematical and computational thinking skills, and fostering deeper mathematical concepts. Throughout the coding activities using Scratch, students are encouraged to employ a trial-and-error approach in generating desired outputs, thereby boosting their motivation to tackle coding problems by seeking and arranging suitable blocks, thus enhancing their problem-solving skills [14].

Additionally, the animation feature offered by Scratch captures students' attention during the learning process, besides aiding them in creating mental models by visualizing problems. This contributes to the retention of students' long-term memory and motivation when tackling mathematical questions [17]. Studies by [18] and [19] also demonstrate that the Scratch application can significantly contribute to enhancing creative and logical thinking as well as cognitive development. Through Scratch, students can develop logical and abstract skills through hands-on experiences involving textbook content. Moreover, research conducted by [20] and [21] highlights the development of computational thinking resulting from the use of the Scratch application in mathematics teaching and learning. The importance of enhancing computational thinking in the mathematics curriculum is seen as one of the aspects needed by society today, in line with current technological advancements [20]. There are several processes and skills that can be classified under computational thinking, including problem formulation, organizing and analyzing data using logic, creating data representations through abstraction with the help of simulations, evaluating problems and solutions, breaking down main problems into sub-problems, implementing multiple solutions, and evaluating the solutions [21].

Despite the positive outcomes observed from using Scratch, [16] indicate that the absence of courses addressing fundamental programming skills has hindered teachers' ability to utilize the application effectively. Nevertheless, pre-service teachers' perspectives on challenges related to using applications like Scratch differ from those of experienced educators. Pre-service teachers show greater willingness to adopt teaching methods involving Scratch, recognizing its potential to create a more enjoyable learning environment [20]. While pre-service teachers demonstrate a favorable acceptance, their proficiency in navigating the Scratch application according to established educational standards poses a challenge to their confidence in their own abilities. This uncertainty stems from their experiences in using Scratch at the university level, leading to doubts about their readiness to utilize it effectively and to ensure the development of computational thinking skills for future students [21]. This apprehension likely arises from uncertainties in selecting appropriate pedagogical approaches, affecting their confidence in leveraging technology effectively. Hence, pre-service teachers, especially in mathematics, should prepare themselves not only to integrate technology into their daily routines but also to understand the optimal strategies for incorporating technology into mathematics instruction. Comprehensive readiness is essential for enhancing professionalism among future educators, particularly for those who are less familiar with programming resources like the Scratch application.

III. Theoretical Framework

In the context of this study, the knowledge constructed by pre-service mathematics teachers regarding the Scratch application was examined through the social constructivism approach by [22]. This approach focuses on knowledge construction occurring through experience and social interaction. Two principles emphasized through this approach are the Zone of Proximal Development (ZPD) and the More Knowledgeable Other (MKO). According to [23], considering these two principles, the zone of proximal development (ZPD) becomes one of the hurdles for pre-service teachers in building knowledge of newly acquired things. In the context of this study, these new things correspond to the development of knowledge about the implementation of Scratch in mathematics education. In order to maximize the potential of pre-service mathematics teachers in incorporating Scratch, instruction on its use is required. Vygotsky believed that through guidance, social interaction takes place between lecturers and pre-service teachers, or amongst pre-service teachers themselves, which can have a lifetime impact on personality development and cognitive progress [24].

However, the integration of programming-based technology requires an understanding of teaching methods for mathematical concepts using technology and practical pedagogical techniques to effectively deliver instructional content, as well as knowledge of technology methods that can impact learning comprehension. Therefore, this study adopted Bryant et al.'s (1974) Educational Model in determining the readiness aspects among pre-service mathematics teachers in integrating the Scratch application. This model focuses on three factors that influence an individual's learning process: input, process, and attitude. [25] define input factors as knowledge construction, process factors as teacher skills, and attitude factors as teachers' attitudes toward their teaching.

IV. Methodology of the Study

Based on the research objective that aimed to identify the readiness level among pre-service mathematics teachers in using the Scratch application, this study was conducted using a quantitative research approach. It was carried out through an online survey using the Google Form platform among selected respondents. The online survey approach was chosen based on financial and time considerations, in which online surveys are known to be more cost-effective [26].

A total of 60 pre-service mathematics teachers, comprising 31 first-year students and 29 second-year students, participated as respondents in this study. The study population refers to the students enrolled in the Bachelor of Science with Education (Mathematics) Honors program at Universiti Teknologi Malaysia (UTM). Based on the total population, this study applied purposive sampling, which is a non-probabilistic method to determine the required sample size. In accordance with the stated research objectives, the respondents for this study were students enrolled in the Bachelor of Science with Education (Mathematics) Honors program, particularly first- and second-year students. The students with a mathematics education background were selected because this study was conducted in the field of mathematics education. Both first- and second-year students were recruited to examine potential differences in readiness levels across academic years of study.

The research instrument of the present study consisted of four main sections: Section A: Demographics, Section B: Knowledge of Scratch usage, Section C: Skills in Scratch usage, and Section D: Attitudes toward the Scratch application. Section A focused on demographic data, such as age, gender, academic year, and academic achievement. Sections B and C, on the other hand, focused on items related to knowledge and skills that were assessed from two perspectives: first, general knowledge and skills in using Scratch, and, second, practical application in teaching mathematics. The final section of the questionnaire, Section D, focused on items such as the respondents' acceptance, belief, and motivation when using the Scratch application in mathematics instruction. In order to ensure that the instrument was reliable and appropriate for the research setting, it was validated by three experts in mathematics education and educational technology. Following the validation phase, the instrument underwent several improvements based on the experts' opinions.

V. Data Analysis

Table 1 below shows the research findings on the readiness level among pre-service mathematics teachers in using the Scratch application in terms of knowledge, skills, and attitudes. Scale 1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, and 5: Strongly Agree.

TABLE I READINESS LEVEL AMONG PRE-SERVICE MATHEMATICS TEACHERS

Item	1	2	3	4	5
Aspect: Knowledge					
I know how to create basic projects using the Scratch application.	0	3	11	37	9
I know how to use various teaching strategies using the Scratch application.	2	3	17	27	11
Aspect: Skills					
I am able to construct projects in the Scratch application without assistance from peers or lecturers.	2	8	21	23	6
I possess skills in utilizing the Scratch application as a teaching aid for mathematics	0	2	18	34	6
Aspect: Attitudes					
I am confident in using the Scratch application for teaching mathematics.	0	0	7	30	23
I enjoy using the Scratch application for teaching and learning mathematics.	0	0	1	32	32
I am eager to invest more time in improving my skills using the Scratch application.	0	0	3	25	32

A. *The Readiness Level Among Pre-Service Mathematics Teachers In Terms Of Knowledge.*

Based on the table above, the findings indicate that pre-service mathematics teachers possess basic familiarity in using the Scratch application like dragging blocks onto the stage, changing background images, or selecting Sprites. However, despite this basic understanding, only nine (9) pre-service mathematics teachers strongly agree with the statement "I know how to create basic projects using the Scratch application." This is because, as indicated in the open responses, they state that certain functions and elements of the Scratch application are challenging to comprehend. Consequently, constructing basic projects related to mathematics, and even arranging fundamental blocks like directing sprites to take ten steps, is difficult for those with limited application knowledge. Similarly, the item "I know how to use various teaching strategies using the Scratch application" is deemed crucial for ensuring suitable teaching strategies that are aligned with the use of the Scratch application. The study also reveals that 17 respondents selected the 'Neutral' scale for this item. This underscores that most pre-service mathematics teachers lack confidence in their knowledge of optimal teaching strategies tailored for the application. This 'Neutral' response signifies existing gaps in exposure or training concerning the Scratch application in mathematics teaching and learning. Additionally, responses reveal respondents' limited practice with Scratch in mathematics education, thus contributing to pre-service teachers' uncertainty in adapting Scratch to complex mathematical topics.

B. The Readiness Level Among Pre-Service Mathematics Teachers In Terms Of Skills.

Basic proficiency in managing elements and blocks correctly is an essential skill when utilizing the Scratch application in order to prevent syntax errors during the construction of mathematical projects. However, the results reveal that pre-service mathematics teachers possess only theoretical comprehension based on knowledge aspects, rather than practical competencies in operating the Scratch application, as indicated by the frequency values in the skills item. Through responses provided in open-ended questions, several factors contribute to the deficiency in skills among pre-service mathematics teachers in navigating the Scratch application. The factors include additional time to grasp the programming language employed in the application, challenges in arranging blocks to achieve desired outputs, and struggles in rectifying syntax errors and identifying their origins. Although some pre-service mathematics teachers feel confident in developing projects within the Scratch application independently, the majority still rely on assistance from peers or lecturers, as demonstrated by responses to the statement "I am able to construct projects in the Scratch application without assistance from peers or lecturers." This dependency stems from a lack of technical skills in manipulating the application elements using individual block functions and from the uncertainties arising from limited experience with the Scratch application. Conversely, the subsequent statement "I possess skills in utilizing the Scratch application as a teaching aid for mathematics" encompasses abilities such as crafting or adapting mathematical projects using Scratch to fulfill specific educational objectives. The higher frequency value associated with the 'Neutral' scale compared to 'Strongly Agree' suggests pre-service teachers' reservations regarding their proficiency in employing Scratch as a mathematics teaching tool. Based on the insights gleaned from open-ended responses, pre-service mathematics teachers express that their aptitude in employing Scratch as a teaching aid is confined only to selecting mathematical topics.

C. The Readiness Level Among Pre-Service Mathematics Teachers In Terms Of Attitudes.

The findings regarding attitudes reveal a significant contrast compared to the aspects of knowledge and skills. The absence of negative perceptions toward this application indicates that pre-service mathematics teachers are open to embracing Scratch as an educational innovation tool and incorporating it into mathematics teaching and learning in the future. Although the item "I am confident in using the Scratch application for teaching mathematics" shows the highest percentage value for the Likert scale 'Neutral', it does not fully capture pre-service mathematics teachers' attitudes toward using Scratch. This is because the findings suggest that pre-service mathematics teachers' lack of confidence in integrating this application into teaching stems from inadequate knowledge and skills. The findings also reveal that pre-service mathematics teachers' limited ability to use this application in teaching mathematics affects their confidence levels. Furthermore, the acceptance of using this application is also influenced by pre-service mathematics teachers' feelings when exploring Scratch. This is evident from the findings for the item "I enjoy using the Scratch application for teaching and learning mathematics". Despite the challenges in improving skills with Scratch, these teachers find joy in mathematics learning through this interactive tool. The positive attitude exhibited while using Scratch has motivated pre-service mathematics teachers to further enhance their abilities and understanding of the application. This is supported by the findings for the item "I am eager to invest more time in improving my skills using the Scratch application", which indicates a high percentage for the Likert scale 'Strongly Agree.' Their eagerness to enhance their skills is viewed as a crucial step in the learning process. Additionally, zero percentages for the 'Strongly Disagree' and 'Disagree' scales reflect the proactive approach among pre-service mathematics teachers in expanding their knowledge of Scratch and not solely relying on lecturer-led instruction.

D. Relationship between Demographic Factors and Readiness Level Among Pre-Service Mathematics Teachers.

The demographic factors considered in this study were gender, year of study, and academic achievement. Academic achievement was assessed through the CGPA of pre-service mathematics teachers. The findings indicate that there is no relationship between gender and year of study with the level of readiness among pre-service mathematics teachers in terms of knowledge, skills, and attitudes. Additionally, the value of $p > 0.05$ indicates that the null hypothesis is accepted, suggesting no significant relationship between gender and year of study with all three aspects of readiness. However, for the aspect of academic achievement, the correlation coefficient, r, for the knowledge, skills, attitude, and academic achievement aspects shows a weak correlation between the year of study and the knowledge aspect. Furthermore, the value of $p < 0.05$ indicates sufficient evidence to reject the null hypothesis, indicating a significant relationship between academic achievement and the knowledge aspect.

VI. Discussion

A. The Readiness Level Among Pre-Service Mathematics Teachers To Implement Scratch In Terms Of Knowledge.

This discussion aims to address the research question regarding the readiness level among pre-service mathematics teachers in using the Scratch application in terms of knowledge, skills, and attitudes. The knowledge aspect examined in this study focuses on two aspects: basic knowledge of using the Scratch application and knowledge of practicing Scratch in mathematics teaching. Based on the Technological Pedagogical Content Knowledge (TPACK) framework, this knowledge aspect covers aspects of Technological Knowledge (TK), Technological Pedagogical Knowledge (TPK), and Technological Content Knowledge (TCK). Findings reveal that pre-service mathematics teachers exhibit higher TK regarding Scratch compared to TPK and TCK. Their heightened technological awareness stems from growing up in a digital-native era. Moreover, their familiarity with technology in daily life and school activities has honed pre-service teachers' competency and ease with technology [27].

Pre-service teachers with limited teaching experience tend to possess strong technological knowledge due to their youth [28]. Their everyday use of technology serves as an additional advantage to integrate technology into their classroom practices. However, when it comes to understanding programming language-based technological knowledge, [29] notes that pre-service teachers struggle with grasping computational concepts involving arranging the blocks within such applications. This difficulty stems from a lack of understanding about how to utilize the function of each block in order to achieve the desired outcomes. Additionally, pre-service mathematics teachers in this study highlight that, due to the novelty of learning the Scratch application, comprehending the function of each block within Scratch is challenging, particularly those involving variable construction. The use of programming language applications such as Scratch helps shape the computational thinking among pre-service mathematics teachers, which requires knowledge in decomposing main problems into several sub-problems and developing algorithms before executing projects through the Scratch application [30]. Furthermore, understanding how to use this application necessitates knowledge of developing effective approaches for solving real-world problems in a computer-readable language [31]. Therefore, in the context of this study, the knowledge that has to be improved is problem-solving strategies, specifically the ability to arrange appropriate blocks to ensure that the output corresponds with the planned solution path.

Past studies also suggest that pre-service mathematics teachers should not only comprehend theoretically but also understand the practical application of technology in the context of mathematics teaching to ensure that theoretical knowledge can be transferred into practical teaching [32]. This aspect also impacts the development of TPK and TCK. [27] assert that both TPK and TCK contribute to the overall TPACK among pre-service mathematics teachers. This indicates that possessing technological knowledge alone is insufficient for determining the readiness among pre-service teachers to employ technology. While acquiring this knowledge, pre-service teachers encounter various challenges such as difficulties in sustaining students' engagement and concentration, as well as obstacles in facilitating students' learning processes [12]. Additionally, findings also reveal that assisting students' learning through curriculum adjustments and technology integration presents challenges for pre-service teachers. These future teachers perceive that incorporating problem-solving concepts within authentic contexts through revised curricula and devising instructional approaches that link mathematical concepts with the Scratch application present considerable hurdles in mathematics classrooms. These results highlight the necessity for specific interventions to enhance pre-service teachers' readiness to utilize technology more effectively in mathematics classrooms.

B. The Readiness Level Among Pre-Service Mathematics Teachers To Implement Scratch In Terms Of Skills.

The general perspective on classifying the current generation as digital natives stems from their environment and daily life activities, which rely heavily on technology usage. This perspective has led to the conclusion that current pre-service teachers are also part of the digital native group. However, [33] argues that this perception is unsubstantiated, as there is no evidence to suggest that growing up surrounded by digital media automatically makes someone digitally proficient. Similarly, [34] suggests that merely being exposed to technology is not enough to determine proficiency in its use. This perspective is supported by the findings of this study, which reveal that despite having good knowledge of the Scratch application, pre-service mathematics teachers exhibit low skills in using it.

Educators' proficiency in incorporating technology is a significant determinant of how effectively mathematical concepts are transmitted from teachers to students or how students independently acquire mathematical knowledge with technological support [35]. Hence, the adeptness of pre-service teachers in utilizing Scratch is crucial for ensuring that students can easily grasp abstract mathematical concepts and improve their problem-solving abilities in mathematics. The lack of fundamental skills in using Scratch has impacted pre-service mathematics teachers' capability to create Scratch projects without assistance from peers or instructors. However, according to [29], seeking help from peers is among the most effective strategies employed by pre-service teachers to address challenges and enhance their project-building skills using the Scratch application. Moreover, pre-service teachers, as noted in [36], express agreement that additional training focusing on practical exercises and integrating technology in the classroom would be beneficial. Future teachers encountering challenges in the initial use of technology undergo a natural learning process experienced by everyone, and this experience aids in the professional development of these teachers [37]. However, [38] refutes this assertion, arguing that pre-service teachers have dual responsibilities as both learners and future educators. Therefore, this group requires digital competence and the ability to integrate technology in education in order to enhance active digital engagement in society. Additionally, the skills possessed by pre-service teachers are now crucial in shaping future teaching practices.

The study conducted by [39] highlights a significant challenge encountered by pre-service teachers when utilizing programming language applications, which is understanding programming concepts. For example, the "loop" block necessitates additional conditions, ensuring that the provided instructions do not endlessly repeat, leading to subsequent instructions failing to generate and resulting in errors in the final output [40]. This underscores the importance of comprehending the function of each block thoroughly to ensure projects yield accurate outputs. The findings indicate that pre-service teachers lack a proper grasp of concepts during coding activities and struggle to convey them in the correct code sequence, resulting in syntax errors. This shows a lack of skills in handling elements in the Scratch application. Identifying and rectifying these errors is time-consuming if pre-service teachers are not adept at arranging blocks. Additionally, recurrent encounters with errors lead to feelings of anxiety and pressure, ultimately causing individuals to become disheartened from further attempts at coding activities [41]. Therefore, to mitigate this, pre-service teachers must first master the use of the Scratch application, particularly in correctly arranging blocks in order to effectively support students during coding tasks.

C. The Readiness Level Among Pre-Service Mathematics Teachers To Implement Scratch In Terms Of Attitude.

A positive attitude significantly impacts the motivation among pre-service teachers to enhance their skills and knowledge in using programming language-based technology [42]. This study also suggests that attitudes toward using Scratch stem from and also impact knowledge and skills. Past studies indicate that pre-service mathematics teachers with limited knowledge and skills are less confident in integrating the Scratch application into mathematics teaching. Conversely, pre-service teachers who have a deep understanding of Scratch and possess good technical skills tend to exhibit a more positive attitude toward the application. Additionally, prospective teachers who demonstrate confidence in their abilities have a high motivation to apply Scratch in mathematics teaching.

Emotions during the use of programming language applications like Scratch are crucial aspects that need to be assessed to ensure acceptance of programming learning [43]. This acceptance aspect is also supported by previous studies, including research by [44] and [7], which state that comfort and enjoyment in using this technology stem from its user-friendly nature. Additionally, this attitude falls under the category of technology acceptance beliefs, which can influence its frequency of use [45]. However, research conducted by [46] suggests that programming languages are considered difficult to understand and can negatively impact interest in using such learning applications. Nevertheless, the study also indicates that this negative perception can be overcome when pre-service teachers believe that applications like Scratch can contribute to the development of students' thinking and problem-solving skills, even though it may take longer to familiarize students with the application. This statement is also supported by [7], who states that acceptance of the effectiveness of using technology has a greater influence on pre-service teachers' attitudes toward using technology than its ease of use.

The findings indicate that through a positive perception of using Scratch, pre-service mathematics teachers are more motivated to enhance their knowledge and skills before applying it in actual teaching. [37] describe this action as a form of epistemological belief among pre-service mathematics teachers. In this study, this belief involves not only confidence in the knowledge of using the Scratch application but also knowledge of its effectiveness in the context of mathematics teaching. A positive attitude towards the Scratch application serves as a catalyst for pre-service teachers to build knowledge of the application through self-directed learning without relying on resources from lecturers or peers [47]. This demonstrates that motivation can be categorized as a long-term learning behavior when learning something new despite facing various challenges. This can be observed when past studies indicate that challenges and difficulties in understanding coding have made the learning experience more enjoyable to explore even after experiencing failures several times [21].

D. Relationship between Demographic Factors and Readiness Level Among Pre-Service Mathematics Teachers.

Through demographic factors such as gender, differences in access to technology use in terms of time and purpose have resulted in a gap between males and females [48]. Moreover, these discrepancies arise from societal perceptions of how males and females engage with technology [49]. Despite common stereotypes about gender-based technology use, research by [46] suggests that attitudes toward technology integration significantly impact both genders. This is because male pre-service teachers show more eagerness and interest in exploring programming concepts compared to their female counterparts. This trend is also linked to male pre-service teachers' belief that programming language applications are easier to comprehend when they spend more time on computers [50]. Additionally, female pre-service teachers tend to doubt their capabilities in coding activities compared to males, who exhibit higher confidence levels. However, [51] found different findings, indicating that female pre-service mathematics teachers exhibit greater enthusiasm for learning the Scratch application compared to males, who show a preference for gaming activities within the application. The higher level of theoretical knowledge among female pre-service teachers drives their eagerness to engage with Scratch, unlike their male counterparts who are already confident in their abilities and less inclined to explore the application further. These findings suggest that female pre-service teachers display more favorable attitudes during learning sessions. These observed attitudes will motivate female pre-service teachers to cultivate proficiency in the teaching profession in the future, thereby increasing the likelihood of their utilization of technology in education [52].

The differences revealed through these findings illustrate that gender plays a role in influencing the knowledge, skills, and attitudes among pre-service teachers toward programming applications, and understanding these aspects can aid in designing more tailored professional development approaches. The utilization of such applications is contingent upon the technological proficiency of both genders in incorporating technology into their teaching practices, rather than solely focusing on utilizing the Scratch application for personal use. Previous findings indicate that irrespective of gender disparities, the attitudes among pre-service teachers toward employing the Scratch programming application serve as intermediaries between their knowledge and skills [53]. However, [7] suggests that apart from self-efficacy, subjective norms, a form of social pressure, can also serve as predictors of technology adoption. Hence, recent studies have revealed that the academic year is another factor that can fulfill subjective norms, given the common belief that final-year pre-service teachers should exhibit greater readiness compared to their first-year counterparts due to their longer duration of study and imminent transition into the real educational environment.

However, research by [54] suggests that despite receiving high praise from lecturers toward final-year pre-service teachers, these pre-service teachers still exhibit hesitation in integrating technology into their classrooms after experiencing difficulties in handling the technology during their teaching practicum. Thus, the primary determinant of technology integration in teaching lies in having a strong command and proficiency in using technology, whether for instructional purposes or self-learning [55]. Furthermore, regardless of whether these pre-service teachers are in their first or second year of study, a thorough understanding of technology use, particularly programming-based technology, has a more significant influence on their willingness to devise teaching activities involving technology. Additionally, having professional knowledge of the teacher's role alone isn't adequate for implementing quality technology without possessing advanced skills [56]. This underscores that considering the academic year factor, the proficiency of pre-service teachers in utilizing technology has been a focal point in previous studies when assessing their readiness for technology integration.

[46] further argue that despite universities offering the same curriculum content for pre-service teachers, there are other factors contributing to differences in their readiness levels in using technology, such as attitudes towards learning activities, peer influence, acceptance of coding activities, and the level of thinking among pre-service teachers. In the context of this study, the level of thinking can be observed through their academic achievement. Therefore, the third demographic factor examined in this study is the relationship between the readiness level of pre-service mathematics teachers in using Scratch and their academic achievement. Regarding attitude aspects, a study conducted by [41] indicates that pre-service teachers with high academic achievements demonstrate positive attitudes toward using programming applications, and vice versa. This suggests that pre-service teachers with different academic achievements show varying levels of interest and motivation toward programming applications, while those with lower achievements have less motivation and interest in programming applications. However, these findings contrast with the study conducted by [21], which states that due to their low achievement, pre-service teachers are more motivated to enhance their skills in using the Scratch application. They regard the challenges as encouragement in solving coding-related issues. This indicates that struggles with programming applications do not hinder pre-service teachers from making efforts to improve their skills. Therefore, through the factor of academic achievement, the motivation aspect of pre-service teachers toward using the Scratch application emerges as a key factor distinguishing their readiness levels. Whether they have higher or lower academic achievements, they will continue learning the application to boost their skills. If they have lower academic achievement, it serves as motivation for them to strive harder in learning Scratch.

VII. IMPLICATIONS

Through this study, there is significant awareness among pre-service teachers, especially in the field of mathematics, regarding the importance and positive impact of technology usage, particularly the Scratch application, in shaping students' mathematical skills. The present study found an urgent need for pre-service mathematics teachers to enhance their technical skills in using the Scratch application, whether in general usage or implementation within mathematics teaching plans. These improvement measures are seen as crucial aspects to be incorporated into pre-service teacher education, as they not only facilitate innovation in teaching processes but also provide advantages to these future teachers in meeting students' needs in the technological era. Therefore, the readiness and improvement of prospective teachers' skills in utilizing technology, especially the Scratch application, are considered fundamental to enhancing the effectiveness and quality of mathematics teaching in the future. Furthermore, the ability to use programming applications like Scratch also has implications for computer education. By integrating Scratch into mathematics education, pre-service teachers have the opportunity to lay a strong foundation for computer education. Introducing pre-service teachers to basic programming concepts through practical experiences with Scratch can help them develop their computational thinking. These implications are particularly evident in the development of problem-solving skills, algorithmic thinking, and computational creativity among pre-service mathematics teachers. Through the process of designing and creating interactive projects using Scratch, students not only learn about mathematical concepts but also sharpen their computational skills.

VIII. LIMITATIONS

This study has some limitations, which could be addressed in future research. The sample size of only two academic years may not accurately reflect the readiness level among pre-service mathematics teachers. As a result, future studies could include an additional number of respondents from various academic years to improve the trustworthiness of generalizing findings. Furthermore, to acquire a more comprehensive picture, future research may involve a variety of areas, such as physics, to encourage STEM-related studies. This would allow for the analysis of gaps in preparation levels among pre-service teachers across fields of study. Assessing the development of teaching plans by pre-service teachers could also be utilized as a tool for future research in terms of skill evaluation. This is because analyzing teaching plans allows for a more practical understanding of teachers' abilities to integrate the Scratch application into their classroom lessons.

IX. CONCLUSION

In conclusion, pre-service mathematics teachers encounter significant challenges when incorporating the Scratch application into their teaching practices, particularly due to a lack of understanding of computational concepts. This includes difficulties in decomposing problems into manageable sub-problems before engaging in the block assembly process. This challenge arises from their limited knowledge of how to effectively utilize Scratch, which, in turn, impacts their ability to apply it practically in teaching mathematics. Despite these challenges, pre-service mathematics teachers demonstrate a positive attitude toward the use of programming applications, with Scratch being a notable example. Their recognition of Scratch's benefits in mathematics education serves as a primary motivator, enhancing their self-efficacy in utilizing this tool for teaching purposes. However, it is essential to note that effectively integrating Scratch into mathematics instruction requires a solid foundation in computational thinking skills. Given that proficiency in computational thinking is essential for utilizing Scratch effectively, pre-service teachers would benefit from additional training and support in mastering the basics of the application. Strengthening their grasp of Scratch's functionalities and computational principles will better prepare them to seamlessly integrate it into their mathematics teaching practices. This approach ensures that pre-service mathematics teachers are equipped with the necessary skills and knowledge to leverage Scratch's full potential as a teaching tool in the classroom.

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References

[1] J. Dron, "Educational technology: what it is and how it works," AI Soc, vol. 37, no. 1, pp. 155–166, Mar. 2022, doi: 10.1007/s00146-021-01195-z.

[2] S. Mlambo, J. Chukwuere, and C. Ndebele, "Perceptions of pre-service teachers on the use of ICTs for instructional purposes," Journal of Gender, Information and Development in Africa, vol. 7, no. 2, pp. 77–101, Aug. 2018, doi: 10.31920/2050-4284/2018/v7n2a4.

[3] Kementerian Pendidikan Malaysia, "Dasar Pendidikan Digital," 2023.

[4] A. Z. Zainal and S. Z. Zainuddin, "Technology adoption in Malaysian schools: An analysis of national ICT in education policy initiatives," Digital Education Review, no. 37, pp. 172–194, Jun. 2020, doi: 10.1344/der.2020.37.172-194.

[5] Kementerian Pendidikan Malaysia, "Ringkasan Eksekutif Pelan Transformasi ICT Kementerian Pendidikan Malaysia 2019-2023," 2019.

[6] D. Farjon, A. Smits, and J. Voogt, "Technology integration of pre-service teachers explained by attitudes and beliefs, competency, access, and experience," Comput Educ, vol. 130, pp. 81–93, Mar. 2019, doi: 10.1016/j.compedu.2018.11.010.

[7] M. D. Gurer, "Examining technology acceptance of pre-service mathematics teachers in Turkey: A structural equation modeling approach," Educ Inf Technol (Dordr), vol. 26, no. 4, pp. 4709–4729, Jul. 2021, doi: 10.1007/s10639-021-10493-4.

[8] J. Engelbrecht, S. Llinares, and M. C. Borba, "Transformation of the mathematics classroom with the internet," ZDM, vol. 52, no. 5, pp. 825–841, Oct. 2020, doi: 10.1007/s11858-020-01176-4.

[9] S. Dineva, V. Nedeva, and Z. Ducheva, "Digital Generation and Visualization in E-Learning," in The 14th International Conference on Virtual Learning Virtual Learning – Virtual Reality, 2019.

[10] K. K. D. Liburd and H.-Y. Jen, "Investigating the Effectiveness of Using a Technological Approach on Students' Achievement in Mathematics–Case Study of a High School in a Caribbean Country," Sustainability, vol. 13, no. 10, p. 5586, May 2021, doi: 10.3390/su13105586.

[11] S. Hwang, E. Flavin, and J.-E. Lee, "Exploring research trends of technology use in mathematics education: A scoping review using topic modeling," Educ Inf Technol (Dordr), vol. 28, no. 8, pp. 10753–10780, Aug. 2023, doi: 10.1007/s10639-023-11603-0.

[12] T. Valtonen, U. Leppänen, M. Hyypiä, E. Sointu, A. Smits, and J. Tondeur, "Fresh perspectives on TPACK: pre-service teachers' own appraisal of their challenging and confident TPACK areas," Educ Inf Technol (Dordr), vol. 25, no. 4, pp. 2823–2842, Jul. 2020, doi: 10.1007/s10639-019-10092-4.

[13] K. Higgins, J. Huscroft-D'Angelo, and L. Crawford, "Effects of Technology in Mathematics on Achievement, Motivation, and Attitude: A Meta-Analysis," Journal of Educational Computing Research, vol. 57, no. 2, pp. 283–319, Apr. 2019, doi: 10.1177/0735633117748416.

[14] N. Calder, "Using Scratch to facilitate mathematical thinking," Waikato Journal of Education, vol. 23, no. 2, Feb. 2019, doi: 10.15663/wje.v23i2.654.

[15] N. Poobalan, R. Zaharudin, and V. Y. Ting, "Penggunaan bahan multimedia interaktif 3D animasi ('scratch') dalam kaedah pembelajaran teradun terhadap minat dan pencapaian murid Tahun 5 bagi mata pelajaran Sains," Jurnal Pendidikan Sains & Matematik Malaysia, vol. 9, no. 1, 2019.

[16] A. S. Mohd Asri and K. A. Jamaludin, "Potential Scratch Games in Developing Students' Thinking Skills," Malaysian Journal of Social Sciences and Humanities (MJSSH), vol. 7, no. 12, p. e002004, Dec. 2022, doi: 10.47405/mjssh.v7i12.2004.

[17] N. Günbaş, "Students Solve Mathematics Word Problems in Animated Cartoons," Malaysian Online Journal of Educational Technology, vol. 8, no. 2, 2020.

[18] J. Nouri, L. Zhang, L. Mannila, and E. Norén, "Development of computational thinking, digital competence and 21st century skills when learning programming in K-9," Education Inquiry, vol. 11, no. 1, pp. 1–17, Jan. 2020, doi: 10.1080/20004508.2019.1627844.

[19] S. Gökçe and A. A. Yenmez, "Ingenuity of scratch programming on reflective thinking towards problem solving and computational thinking," Educ Inf Technol (Dordr), vol. 28, no. 5, pp. 5493–5517, May 2023, doi: 10.1007/s10639-022-11385-x.

[20] Á. Molina-Ayuso, N. Adamuz-Povedano, R. Bracho-López, and M. Torralbo-Rodríguez, "Introduction to Computational Thinking with Scratch for Teacher Training for Spanish Primary School Teachers in Mathematics," Educ Sci (Basel), vol. 12, no. 12, p. 899, Dec. 2022, doi: 10.3390/educsci12120899.

[21] O. Broza, L. Biberman-Shalev, and N. Chamo, "'Start from scratch': Integrating computational thinking skills in teacher education program," Think Skills Creat, vol. 48, p. 101285, Jun. 2023, doi: 10.1016/j.tsc.2023.101285.

[22] L. S. Vygotsky, Mind in society: Development of Higher Psychological Processes. Harvard University Press, 1978.

[23] Q. K. L. Ong and N. Annamalai, "Technological pedagogical content knowledge for twenty-first century learning skills: the game changer for teachers of industrial revolution 5.0," Educ Inf Technol (Dordr), May 2023, doi: 10.1007/s10639-023-11852-z.

[24] A. Saleem, H. Kausar, and F. Deeba, "Social Constructivism: A New Paradigm in Teaching and Learning Environment," Perennial Journal Of History, vol. 2, no. 2, pp. 403–421, Dec. 2021, doi: 10.52700/pjh.v2i2.86.

[25] N. F. Mohamed Hata and S. N. D. Mahmud, "Kesediaan Guru Sains dan Matematik dalam Melaksanakan Pendidikan Stem dari Aspek Pengetahuan, Sikap dan Pengalaman Mengajar," Akademika, vol. 90, pp. 85–101, 2020, doi: 10.17576/akad-2020-90IK3-07.

[26] D. Stockemer, "A Short Introduction to Survey Research," in Quantitative Methods for the Social Sciences, Cham: Springer International Publishing, 2019, pp. 23–35. doi: 10.1007/978-3-319-99118-4_3.

[27] J. M. Santos and R. D. R. Castro, "Technological Pedagogical content knowledge (TPACK) in action: Application of learning in the classroom by pre-service teachers (PST)," Social Sciences & Humanities Open, vol. 3, no. 1, p. 100110, 2021, doi: 10.1016/j.ssaho.2021.100110.

[28] L. Yang, F. Martínez-Abad, and A. García-Holgado, "Exploring factors influencing pre-service and in-service teachers´ perception of digital competencies in the Chinese region of Anhui," Educ Inf Technol (Dordr), vol. 27, no. 9, pp. 12469–12494, Nov. 2022, doi: 10.1007/s10639-022-11085-6.

[29] F. Gok and K. Kwon, "A Case Study Exploring Pre-Service Teachers' Programming Difficulties and Strategies when Learning Programming Languages," Psychol Cogn Sci, vol. 6, no. 1, pp. 1–6, Sep. 2020, doi: 10.17140/PCSOJ-6-152.

[30] C. Angeli and M. Giannakos, "Computational thinking education: Issues and challenges," Comput Human Behav, vol. 105, p. 106185, Apr. 2020, doi: 10.1016/j.chb.2019.106185.

[31] A. Peel, T. D. Sadler, and P. Friedrichsen, "Learning natural selection through computational thinking: Unplugged design of algorithmic explanations," J Res Sci Teach, vol. 56, no. 7, pp. 983–1007, Sep. 2019, doi: 10.1002/tea.21545.

[32] J. Piedade, N. Dorotea, A. Pedro, and J. F. Matos, "On Teaching Programming Fundamentals and Computational Thinking with Educational Robotics: A Didactic Experience with Pre-Service Teachers," Educ Sci (Basel), vol. 10, no. 9, p. 214, Aug. 2020, doi: 10.3390/educsci10090214.

[33] P. A. Kirschner and P. De Bruyckere, "The myths of the digital native and the multitasker," Teach Teach Educ, vol. 67, pp. 135–142, Oct. 2017, doi: 10.1016/j.tate.2017.06.001.

[34] N. H. Ayob, I. S. Hamzah, and M. A. Aziz, "Bridging The Digital Divide In Education: Policies And Strategies In Malaysia." Journal of Tourism, Hospitality and Environment Management, vol. 6, no. 25, pp. 157–170, Oct. 2021, doi: 10.35631/JTHEM.625012.

[35] N. Ishartono, S. H. binti Halili, and R. binti A. Razak, "Instruments for Measuring Pre-service Mathematics Teachers' TPACK Skill in Integrating Technology: A Systematic Literature Review," International Journal of Information and Education Technology, vol. 13, no. 8, pp. 1177–1191, 2023, doi: 10.18178/ijiet.2023.13.8.1919.

[36] B. W. Akaadom, "Pre-service teachers' technology skills and its effects in using technology for instruction: In pursuit for quality teacher training," 2020. [Online]. Available: www.researchinventy.com

[37] D. Thurm and B. Barzel, "Effects of a professional development program for teaching mathematics with technology on teachers' beliefs, self-efficacy and practices," ZDM, vol. 52, no. 7, pp. 1411–1422, Dec. 2020, doi: 10.1007/s11858-020-01158-6.

[38] E. J. Instefjord and E. Munthe, "Educating digitally competent teachers: A study of integration of professional digital competence in teacher education," Teach Teach Educ, vol. 67, pp. 37–45, Oct. 2017, doi: 10.1016/j.tate.2017.05.016.

[39] S.-W. Kim and Y. Lee, "Effects of Programming-based TPACK Education Program on the Teaching Expertise of Pre-service Teachers," Journal of the Korea Society of Computer and Information (한국컴퓨터정보학회논문지), vol. 25, no. 7, 2020, doi: https://doi.org/10.9708/jksci.2020.25.07.213.

[40] C. Frädrich, F. Obermüller, N. Körber, U. Heuer, and G. Fraser, "Common Bugs in Scratch Programs," in Proceedings of the 2020 ACM Conference on Innovation and Technology in Computer Science Education, New York, NY, USA: ACM, Jun. 2020, pp. 89–95. doi: 10.1145/3341525.3387389.

[41] V. Amnouychokanant, S. Boonlue, S. Chuathong, and K. Thamwipat, "A Study of First-Year Students' Attitudes toward Programming in the Innovation in Educational Technology Course," Educ Res Int, vol. 2021, pp. 1–10, Oct. 2021, doi: 10.1155/2021/9105342.

[42] S. Gökoğlu and S. Kilic, "Programming learning and teaching of pre-service computer science teachers: Challenges, concerns, and solutions," E-Learning and Digital Media, vol. 20, no. 5, pp. 498–518, Sep. 2023, doi: 10.1177/20427530221117331.

[43] R. Zatarain Cabada, M. L. Barrón Estrada, J. M. Ríos Félix, and G. Alor Hernández, "A virtual environment for learning computer coding using gamification and emotion recognition," Interactive Learning Environments, vol. 28, no. 8, pp. 1048–1063, Nov. 2020, doi: 10.1080/10494820.2018.1558256.

[44] H. Y. Durak, "Preparing pre-service teachers to integrate teaching technologies into their classrooms: Examining the effects of teaching environments based on open-ended, hands-on and authentic tasks," Educ Inf Technol (Dordr), vol. 26, no. 5, pp. 5365–5387, Sep. 2021, doi: 10.1007/s10639-021-10511-5.

[45] D. Thurm and B. Barzel, "Teaching mathematics with technology: a multidimensional analysis of teacher beliefs," Educational Studies in Mathematics, vol. 109, no. 1, pp. 41–63, Jan. 2022, doi: 10.1007/s10649-021-10072-x.

[46] E. Çoban, Ö. Korkmaz, R. Çakır, and F. Uğur Erdoğmuş, "Attitudes of IT teacher candidates towards computer programming and their self-efficacy and opinions regarding to block-based programming," Educ Inf Technol (Dordr), vol. 25, no. 5, pp. 4097–4114, Sep. 2020, doi: 10.1007/s10639-020-10164-w.

[47] S. Schweder, "Mastery goals, positive emotions and learning behavior in self-directed vs. teacher-directed learning," European Journal of Psychology of Education, vol. 35, no. 1, pp. 205–223, Mar. 2020, doi: 10.1007/s10212-019-00421-z.

[48] N. Mumporeze and M. Prieler, "Gender digital divide in Rwanda: A qualitative analysis of socioeconomic factors," Telematics and Informatics, vol. 34, no. 7, pp. 1285–1293, Nov. 2017, doi: 10.1016/j.tele.2017.05.014.

[49] E. Ferreira, "The co-production of gender and ICT: Gender stereotypes in schools," First Monday, vol. 22, no. 10, 2017.

[50] M. Kallia and S. Sentance, "Are boys more confident than girls?," in Proceedings of the 13th Workshop in Primary and Secondary Computing Education, New York, NY, USA: ACM, Oct. 2018, pp. 1–4. doi: 10.1145/3265757.3265773.

[51] H. Y. Durak and T. Guyer, "Programming with Scratch in primary school, indicators related to effectiveness of education process and analysis of these indicators in terms of various variables," Gifted Education International, vol. 35, no. 3, pp. 237–258, Sep. 2019, doi: 10.1177/0261429419854223.

[52] J. Weidlich and M. Kalz, "How well does teacher education prepare for teaching with technology? A TPACK-based investigation at a university of education," European Journal of Teacher Education, pp. 1–21, Aug. 2023, doi: 10.1080/02619768.2023.2243645.

[53] M. L. Wu, Y. Zhou, and L. Li, "The effects of a gamified online course on pre-service teachers' confidence, intention, and motivation in integrating technology into teaching," Educ Inf Technol (Dordr), vol. 28, no. 10, pp. 12903–12918, Oct. 2023, doi: 10.1007/s10639-023-11727-3.

[54] M. Hou, Y. Lin, Y. Shen, and H. Zhou, "Explaining Pre-service Teachers' Intentions to Use Technology-Enabled Learning: An Extended Model of the Theory of Planned Behavior," Front Psychol, vol. 13, Jul. 2022, doi: 10.3389/fpsyg.2022.900806.

[55] I. Backfisch, A. Lachner, K. Stürmer, and K. Scheiter, "Variability of teachers' technology integration in the classroom: A matter of utility!," Comput Educ, vol. 166, p. 104159, Jun. 2021, doi: 10.1016/j.compedu.2021.104159.

[56] S. Dogan, N. A. Dogan, and I. Celik, "Teachers' skills to integrate technology in education: Two path models explaining instructional and application software use," Educ Inf Technol (Dordr), vol. 26, no. 1, pp. 1311–1332, Jan. 2021, doi: 10.1007/s10639-020-10310-4.