

Strengthening 21st-Century Skills: A Community Service Initiative To Improve Computational, Critical, and Creative Thinking In Pre-Service Teachers In Malaysia

Wanda Nugroho Yanuarta^{1*}, Ira Hapsari², Mohamad Ikram Zakaria³

¹Department of Mathematics Education, Teacher Training and Education Faculty, Universitas Muhammadiyah Purwokerto, Indonesia

²Department of Accounting, Faculty of Economy and Business, Universitas Muhammadiyah Purwokerto, Indonesia

³School of Education, Universiti Teknologi Malaysia, Malaysia

* Corresponding Author:

Email: wandanugrohoyanuarta@ump.ac.id

Abstract.

This community service initiative was conducted to strengthen 21st-century skills, particularly computational, critical, and creative thinking, among pre-service teachers at Universiti Teknologi Malaysia (UTM). The program was designed as a training workshop that combined interactive lectures, hands-on activities, and collaborative problem-solving tasks to expose participants to innovative approaches in teaching and learning. A total of sixty pre-service teachers participated in the program, engaging in activities that integrated computational thinking strategies with opportunities for critical reflection and creative expression. Evaluation data were collected through pre- and post-training questionnaires, reflective journals, and group discussions. The findings revealed notable improvements in participants' ability to analyze problems systematically, apply logical reasoning, and generate innovative solutions within educational contexts. Furthermore, the participants expressed positive attitudes toward adopting these skills in their future teaching practice. This initiative demonstrates the potential of structured community service programs to support the development of essential 21st-century competencies among pre-service teachers, contributing to the broader goal of preparing future educators to meet the challenges of contemporary education

Keywords: *Community service; computational thinking; creative thinking; critical thinking and pre-service teachers.*

I. INTRODUCTION

In the 21st century, education faces unprecedented challenges and opportunities shaped by globalization, rapid technological growth, and shifting societal needs [1]. Teachers are at the heart of this transformation, as they are expected not only to deliver subject knowledge but also to nurture skills that prepare students to thrive in dynamic and unpredictable environments. This has led to an increased focus on equipping pre-service teachers with higher-order thinking skills that go beyond traditional pedagogy [2]. Among the essential competencies highlighted for contemporary educators are computational, critical, and creative thinking [3]. These three skills form the backbone of 21st-century education, enabling teachers to analyze problems, think innovatively, and integrate digital technologies effectively into learning environments [4]. Preparing teachers with these skills ensures they can serve as role models and facilitators of future-ready learning in their classrooms. Computational thinking, often associated with computer science, extends far beyond programming. It involves problem decomposition, pattern recognition, abstraction, and algorithmic design, all of which are crucial for solving educational and real-world challenges [5]. For pre-service teachers, computational thinking supports the integration of digital tools into teaching practice and enhances their ability to design structured, technology-driven learning experiences [6].

Critical thinking, meanwhile, is vital in helping pre-service teachers develop the ability to assess information objectively, make sound pedagogical decisions, and reflect on their teaching practices [7]. In an era where misinformation spreads rapidly, cultivating strong analytical and evaluative skills in future educators is crucial to fostering informed and discerning students [8]. Creative thinking complements these competencies by encouraging teachers to generate new ideas, experiment with innovative teaching

approaches, and design engaging classroom activities [9]. Creativity in teaching does not merely involve artistic expression but extends to the ability to reimagine traditional practices and create meaningful learning experiences that capture students' interest and curiosity [10]. In the Malaysian context, the development of these 21st-century skills aligns with the aspirations outlined in the Malaysia Education Blueprint 2015–2025 (Higher Education), which emphasizes the creation of holistic, entrepreneurial, and balanced graduates [11]. Teacher education institutions, such as Universiti Teknologi Malaysia (UTM), are central to this mission, tasked with preparing pre-service teachers who can integrate these skills into both their professional practice and wider societal engagement.

Community service programs have emerged as an effective platform for fostering these skills in higher education [12]. Beyond classroom instruction, such initiatives provide pre-service teachers with experiential learning opportunities that involve real-world problem-solving, collaboration, and reflection [13]. By engaging in community-oriented projects, pre-service teachers are exposed to contexts that challenge them to apply computational, critical, and creative thinking in authentic and impactful ways. This article discusses a community service initiative conducted at UTM aimed at strengthening computational, critical, and creative thinking among pre-service teachers. The program was designed as a structured training workshop that combined lectures, hands-on activities, and collaborative projects. By exploring the design, implementation, and outcomes of this initiative, the study highlights the potential of community service as a transformative approach in teacher education, ultimately contributing to the preparation of educators who can address the demands of 21st-century learning.

II. METHODS

Research Design

This community service initiative used a participatory action-based training design, combining workshops, collaborative activities, and reflective practices [14]. The program was structured to not only transfer knowledge but also actively engage participants in developing computational, critical, and creative thinking skills through experiential learning.

Participants

The participants consisted of sixty pre-service teachers enrolled in Universiti Teknologi Malaysia (UTM). Selection was based on voluntary participation, prioritizing students from the Faculty of Education. All participants were in their early stages of teacher training, ensuring that the intervention could meaningfully shape their future pedagogical practices.

Program Implementation

The community service program was implemented over four sessions and included the following stages: 1) *Orientation Session*: Participants were introduced to the objectives of the program, the importance of 21st-century skills, and the role of computational, critical, and creative thinking in teaching and learning; 2) *Training Workshops*: Hands-on training was delivered through interactive modules focusing on problem-solving tasks, algorithmic thinking exercises, case-based discussions, and creative brainstorming activities; 3) *Collaborative Projects*: Participants worked in small groups to design and present innovative teaching strategies or lesson plans that integrated computational, critical, and creative thinking; 4) *Reflection and Feedback*: Structured reflection sessions allowed participants to share their experiences, challenges, and insights. Trainers and facilitators provided constructive feedback for improvement. Figure 1 presents the stages of the program implementation.



Fig 1. Community Service Program Implementation

Data Collection

To evaluate the program's effectiveness, data were collected using a mixed-method approach [15]: 1) *Pre- and Post-Training Questionnaires*: Assessed participants' self-reported skills in computational, critical, and creative thinking; 2) *Observation Checklists*: Recorded participant engagement, problem-solving strategies, and collaboration during activities; 3) *Reflective Journals*: Participants documented their learning experiences, challenges, and perceptions of the training; and 4) *Group Presentations*: Served as evidence of skill application in designing innovative teaching strategies.

Data Analysis

Quantitative data from the questionnaires were analyzed using descriptive statistics (mean, percentage, and standard deviation) to measure skill improvement. Qualitative data from reflections and group projects were analyzed thematically to identify recurring patterns, insights, and challenges [16].

III. RESULT AND DISCUSSION

Improvement in Computational Thinking

The pre- and post-training questionnaire data showed a marked increase in participants' ability to apply computational thinking skills. Before the program, only 35 of the students reported confidence in breaking down problems into smaller components and using logical steps to solve them. After the training, this number increased to 76%, reflecting the effectiveness of the structured problem-solving activities. Observation notes also indicated that participants became more adept at identifying patterns and designing algorithmic solutions during group projects.

Enhancement of Critical Thinking Skills

Participants demonstrated significant growth in critical thinking throughout the training. Thematic analysis of reflective journals revealed that many students began questioning assumptions, considering multiple perspectives, and applying reasoned judgment in problem-solving. For example, during case-based discussions, students engaged in deeper analysis of teaching scenarios, offering alternative strategies rather than relying on conventional methods. Questionnaire results showed an increase in the mean score of critical thinking competencies from 71 to 85. Figure 2 shows the students' activity for critical thinking skills.



Fig 2. Students' Activity for Critical Thinking Process

Development of Creative Thinking Abilities

The collaborative projects allowed participants to exercise creativity in designing innovative lesson plans. Group presentations highlighted novel approaches, such as integrating storytelling with digital tools or gamifying mathematical concepts to capture students' interest. Reflective data confirmed that students felt more confident in experimenting with new teaching methods. Overall, creative thinking scores improved significantly, with participants noting that the program helped them to "think outside the box" in designing engaging classroom experiences. Figure 3 expresses the development of the creative thinking skills among students.



Fig 3. Developing Creative Thinking Skills Among Students

Participant Engagement and Feedback

Feedback collected from the post-training survey indicated a high level of satisfaction among participants. Over 89% of students agreed that the program was engaging, practical, and directly applicable to their future teaching careers. Students particularly valued the balance between theoretical input and hands-on activities, which they described as both “challenging” and “rewarding.” Many also expressed a desire for similar programs to be extended into future teacher training courses at UTM. Figure 4 impresses the students’ engagement in the classroom.



Fig 4. Students’ Engagement in the Classroom

Overall Impact of the Program

The combination of computational, critical, and creative thinking activities provided a holistic approach to skill development. The integration of community service with structured training allowed pre-service teachers to experience meaningful, real-world applications of 21st-century competencies. The results affirm the potential of such initiatives to prepare future educators who are content-competent and innovative problem-solvers capable of adapting to the evolving demands of education. Table 1 presents the pre- and post-test for the mean score in the implementation process.

Table 1. Pre- and Post-Test Mean Scores of 21st-Century Skills

Skill	Pre-Test Mean	Post-Test Mean	Improvement
Computational Thinking	3.1	4.2	+1.1
Critical Thinking	3.3	4.4	+1.1
Creative Thinking	3.2	4.5	+1.3
Overall Average	3.2	4.4	+1.2

The table shows clear improvement across all three targeted skills. The highest gain was in Creative Thinking (+1.3), followed by Computational and Critical Thinking (+1.1 each). The results demonstrate that the community service training effectively strengthened pre-service teachers’ 21st-century skills. As shown in Table 1, participants demonstrated notable improvement in all three targeted 21st-century skills. The mean scores increased from 3.1 to 4.2 in computational thinking, 3.3 to 4.4 in critical thinking, and 3.2 to 4.5 in creative thinking. The greatest gain was observed in creative thinking (+1.3), indicating that the program

particularly encouraged innovative approaches to teaching and learning. Overall, the findings suggest that the training was effective in enhancing the competencies of pre-service teachers at UTM. The results of this study demonstrate that the community service initiative significantly enhanced the 21st-century skills of pre-service teachers at Universiti Teknologi Malaysia (UTM). The structured training approach, which combined computational, critical, and creative thinking activities, allowed participants to engage actively in experiential learning. Improvements in post-test scores across all three competencies suggest that the program was effective in equipping future educators with essential skills to navigate the demands of modern classrooms. Among the three targeted competencies, creative thinking showed the most significant improvement.

This finding highlights the effectiveness of collaborative projects and problem-based activities in encouraging participants to explore innovative teaching strategies. Pre-service teachers became more confident in experimenting with unconventional methods, which aligns with previous research indicating that creativity flourishes when learners are placed in environments that promote exploration and originality [10]. This improvement is crucial for teachers who must continuously adapt to diverse student needs. The gains in computational thinking reflect the participants' ability to adopt systematic approaches to problem-solving [9]. Activities such as algorithmic exercises and digital task design encouraged logical reasoning and the breakdown of complex challenges into manageable steps. These skills are not only vital in STEM education but also provide transferable strategies for tackling challenges across other subject areas. This result reinforces the growing recognition of computational thinking as a universal problem-solving framework in education [12]. Critical thinking also demonstrated notable growth, as reflected in participants' improved ability to evaluate information, question assumptions, and justify their pedagogical decisions [7].

The case-based discussions and reflective journaling played a significant role in this outcome. Such findings are consistent with the view that critical thinking develops when learners are encouraged to reflect deeply on practice, analyze different perspectives, and construct evidence-based conclusions. This competency is particularly valuable for teachers in today's complex and information-rich environment [17]. The integration of community service as the medium for this initiative proved to be a key factor in the program's success [18]. Unlike traditional classroom-based instruction, community service situated learning is in authentic, real-world contexts [19]. Participants were required to collaborate, solve problems, and reflect on their learning in ways that directly linked theory to practice. This experiential approach not only enhanced skill development but also instilled a sense of civic responsibility and professional purpose among pre-service teachers. These outcomes are closely aligned with the Malaysia Education Blueprint 2015–2025 (Higher Education), which emphasizes the cultivation of holistic, entrepreneurial, and balanced graduates [11]. They also contribute directly to the realization of Sustainable Development Goal 4 (SDG 4), which advocates for inclusive and quality education [20]. By strengthening computational, critical, and creative thinking, this initiative prepares future educators to support quality-driven and sustainable teaching practices, ensuring that they are better equipped to nurture globally competent learners. Despite its strengths, the study has certain limitations.

The program was implemented with a relatively small sample of pre-service teachers from a single institution, which limits the generalizability of the results. Additionally, much of the data relied on self-reported measures, which may introduce bias in assessing the true extent of skill development [21]. To build on this initiative, future studies should consider larger, more diverse samples and include longitudinal tracking to evaluate the long-term impact of such training once participants enter the teaching profession. Overall, the findings underscore the value of community service as a pedagogical strategy in higher education. When designed purposefully, such programs provide authentic opportunities for pre-service teachers to practice and refine essential 21st-century skills. By fostering computational, critical, and creative thinking, this initiative demonstrates how community engagement can serve as a powerful complement to teacher education curricula [4]. Ultimately, equipping future educators with these competencies ensures that they are prepared to meet the evolving challenges of education while contributing to broader national and global development goals.

IV. CONCLUSION

This community service initiative at Universiti Teknologi Malaysia (UTM) demonstrated that structured training can effectively enhance pre-service teachers' computational, critical, and creative thinking skills, which are essential 21st-century competencies. The significant improvements observed, particularly in creative thinking, highlight the value of experiential and collaborative learning in preparing innovative and reflective educators. By integrating community service into teacher education, the program successfully bridged theory and practice while fostering civic responsibility and professional growth. These outcomes align with the Malaysia Education Blueprint 2015–2025 and Sustainable Development Goal 4 (SDG 4), underscoring the potential of higher education institutions to develop future-ready teachers capable of meeting the evolving demands of education.

V. ACKNOWLEDGMENTS

We would like to extend our heartfelt gratitude to the Institute for Research and Community Initiative (LPPM) of Universitas Muhammadiyah Purwokerto for their generous financial support of our community initiative. Number A.11-III/7882-S.Pj./LPPM/II/2024.

REFERENCES

- [1] M. Magdalena, "Preparing Teachers To Deliver 21st-Century Skills," *Journal of Educational Studies*, vol. 12, no. 4, pp. 42–58, 2022, [Online]. Available: www.atc21s.org.
- [2] E. Darwin, "Teaching 21st-Century Skills in the Classroom: How to Include Transferable Skills in Education," *American Studies in Education and Learning*, vol. 21, no. 5, pp. 42–59, 2023.
- [3] M. Bower, L. N. Wood, J. W. M. Lai, C. Howe, and R. Lister, "Improving the computational thinking pedagogical capabilities of school teachers," *Australian Journal of Teacher Education*, vol. 42, no. 3, pp. 53–72, 2022, doi: 10.14221/ajte.2017v42n3.4.
- [4] E. Ronald, "Active Learning in the 21 st Century Classroom Increasing learning efficacy using interactive technology," *British Education and Studies*, vol. 24, no. 2, pp. 44–57, 2020.
- [5] W. L. Tan, M. A. Samsudin, M. E. Ismail, N. J. Ahmad, and C. A. Talib, "Exploring the Effectiveness of STEAM Integrated Approach via Scratch on Computational Thinking," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 17, no. 12, pp. 1–19, 2021, doi: 10.29333/ejmste/11403.
- [6] L. Cabrera *et al.*, "Designing a framework for teachers' integration of computational thinking into elementary science," *J Res Sci Teach*, 2023, doi: 10.1002/tea.21888.
- [7] J. Heard, C. Scoular, D. Duckworth, D. Ramalingam, and I. Teo, "Critical Thinking: Skill Development Framework," *The Australian Council for Educational Research (ACER)*, vol. 4, no. 2, pp. 1–26, 2020.
- [8] W. Karmila, S. Achmad, and U. Utami, "High-Order Questions Improve Students' Critical Thinking Skills In Elementary Schools," *International Journal of Elementary Education*, vol. 7, no. 2, pp. 196–203, 2023.
- [9] R. Dwi Indranuddin, E. Susetyarini, F. Jaya Miharja, J. Raya Tlogomas, and E. Java, "Developing STEM-PjBL worksheet to lift students' critical, creative, and computational thinking skill," *Research and Development in Education*, vol. 4, no. 1, pp. 86–101, 2024, doi: 10.22219/raden.v.
- [10] A. Sukarso, I. P. Artayasa, S. Bahri, and A. Azizah, "Provision of Creative Teaching Materials in Improving Creative Disposition and Creative Thinking Skills of High School Students," *Jurnal Penelitian Pendidikan IPA*, vol. 8, no. 6, pp. 2728–2736, Dec. 2022, doi: 10.29303/jppipa.v8i6.2514.
- [11] A. H. A. Rahman, A. Abdullah, S. Selvadurai, S. Z. S. Zakaria, N. Lyndon, and K. Abidin, "Social media literacy among oil palm smallholders in east malaysia and association with oil palm integration practices," *Sustainability (Switzerland)*, vol. 13, no. 24, pp. 1–17, 2021, doi: 10.3390/su132413802.
- [12] S. Liu, C. Peng, and G. Srivastava, "What influences computational thinking? A theoretical and empirical study based on the influence of learning engagement on computational thinking in higher education," *Computer Applications in Engineering Education*, vol. 31, no. 6, pp. 1690–1704, Nov. 2023, doi: 10.1002/cae.22669.
- [13] N. Ivanenko, A. Rud, A. Hurbanska, Y. Cheban, and S. Syrtseva, "Digitalization of Education of the Future-A Trend or a Requirement of the Time?," *Journal of Higher Education Theory and Practice*, vol. 24, no. 2, pp. 22–32, 2024.
- [14] A. K. Burbage, Y. Jia, and T. Hoang, "The impact of community of inquiry and self-efficacy on student attitudes in sustained remote health professions learning environments," *BMC Med Educ*, vol. 23, no. 1, pp. 1–10, Dec. 2023, doi: 10.1186/s12909-023-04382-2.

- [15] Ö. Özçakir Sümen, R. Assistant, and H. Çalışici, “Examining the 21st Century Skills of Secondary School Students: A Mixed Method Study,” *Journal of Education & Social Policy*, vol. 4, no. 4, 2017.
- [16] M. Ishtiaq, “Book Review Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (4th ed.). Thousand Oaks, CA: Sage,” *English Language Teaching*, vol. 12, no. 5, pp. 40–51, 2019, doi: 10.5539/elt.v12n5p40.
- [17] M. N. Fita, B. Jatmiko, and E. Sudiby, “The Effectiveness of Problem Based Learning (PBL) Based Socioscientific Issue (SSI) to Improve Critical Thinking Skills,” *Studies in Learning and Teaching*, vol. 2, no. 3, pp. 1–9, 2021, doi: 10.46627/silet.v2i3.71.
- [18] M. Akcaoglu and M. O. Akcaoglu, “Understanding the Relationship Among Self-Efficacy, Utility Value, and the Community of Inquiry Framework in Preservice Teacher Education,” *International Review of Research in Open and Distributed Learning*, vol. 23, no. 2, pp. 1–13, 2021.
- [19] M. L. Tucker, A. M. Mccarthy, J. A. Hoxmeier, and M. M. Lenk, “Community Service Learning Increases Communication Skills Across the Business Curriculum,” *Business Communication Quarterly*, vol. 61, no. 2, pp. 88–99, 2018, doi: 10.1177/108056999806100211.
- [20] R. Akpalu, P. Agyekum Boateng, J. Owusu, and E. A. Asare, “Strategic Workforce Development Through Mathematics Education to Support SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth),” *International Journal of Research and Innovation in Social Science*, vol. 9, no. 2, pp. 3265–3273, 2025, doi: 10.47772/IJRISS.
- [21] S. I. Perwitasari, E. Hariyono, and E. Susantini, “Implementation of ESD (Education for Sustainable Development) in Climate Change Learning: A Literature Review,” *IJORER : International Journal of Recent Educational Research*, vol. 4, no. 4, pp. 399–415, Jul. 2023, doi: 10.46245/ijorer.v4i4.317.