

Empowering Digital Pedagogy through ICT-Based Deep Learning for Numeracy and Computational Thinking in Elementary Schools

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Abstract

This community service program aimed to strengthen elementary school teachers' capacity to integrate ICT-based deep learning pedagogy in improving students' numeracy and computational thinking (CT) literacy. The program involved 30 teachers within a local Teacher Learning Community and was implemented through participatory workshops and structured mentoring using a one-group pre-test-post-test design to examine program impact. The intervention focused on enhancing teachers' competence in designing ICT-integrated lesson plans, learning activities, and assessments aligned with numeracy and CT indicators. Data were collected through teacher self-assessment, classroom observation, and students' pre- and post-tests and analyzed descriptively to determine mean improvement and percentage gain. The results demonstrated a 24% increase in teachers' ICT pedagogical competence, indicating strengthened instructional capacity. As a follow-up impact of improved teaching practice, students' numeracy achievement increased by 24%, and computational thinking performance improved by 20%. These findings confirm that empowering teachers through ICT-integrated deep learning contributes to measurable improvements in instructional quality and supports the development of higher-order literacy skills. Overall, the program achieved its objective by reinforcing teacher capacity as the primary outcome, with positive learning gains emerging as a direct pedagogical impact within elementary classrooms.

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INTRODUCTION

In the era of digital transformation, elementary education is required to strengthen students' literacy, numeracy, and computational thinking (CT) competencies as foundational skills for lifelong learning and problem-solving. National policies have emphasized improving literacy and numeracy in response to international assessments, including PISA 2022, which indicate ongoing challenges in students' reasoning abilities (ISSED, 2023; Trianung et al., 2024). These conditions highlight the crucial role of teachers in designing learning experiences that promote conceptual understanding rather than procedural mastery alone.

However, many elementary teachers still rely on conventional instructional approaches, particularly in numeracy teaching, with limited contextual and higher-order integration ([Abidin, 2023](#)). Although computational thinking, defined as the ability to decompose problems, recognize patterns, and construct logical solutions, has been widely acknowledged as an essential 21st-century skill, its classroom implementation remains limited ([Li et al., 2020](#)). Teachers often encounter difficulties in translating CT indicators into structured learning activities suitable for elementary students ([Lee et al., 2019](#); [Yeni et al., 2024](#)).

The local situation in Lubuk Sikarah District, Solok City, particularly in the Elementary School Teacher Learning Community (Komunitas Belajar Gugus IV), reveals similar conditions. Field observations show that literacy activities remain limited to reading sessions, while numeracy practice is mostly procedural. Teachers report limited confidence in designing lessons that integrate literacy, numeracy, and computational thinking into a coherent framework. This gap is compounded by the lack of teaching aids, minimal use of ICT tools, and insufficient training opportunities that connect pedagogical theory with classroom practice. Recent years have seen a surge of professional development (PD) initiatives focusing on digital pedagogy and CT integration in teacher education. However, most of these efforts remain fragmented and contextually limited. According to ([Liu et al., 2025](#)), many PD programs show only partial success because they focus narrowly on tool training rather than pedagogical transformation. Similarly, [Ma et al. \(2025\)](#) emphasized that most ICT-related PD models fail to produce sustainable classroom changes without continued mentoring and reflective practice.

Moreover, [Palop et al. \(2025\)](#) and [Peng et al. \(2025\)](#) stressed that integrating computational thinking into STEM requires synergy between pedagogy, curriculum design, and technological fluency—precisely the foundation of our ICT-based deep learning model. Thus, in comparison to previous studies, this program uniquely operationalizes deep learning pedagogy through ICT integration, co-design mentorship, and continuous teacher reflection in a localized professional learning community, extending the empirical scope suggested by [Schwarzaupt & Wilson, 2024](#). Responding to these challenges requires a transformative professional development model that integrates pedagogy, technology, and reflective practice. The ICT-based deep learning approach offers a relevant framework to achieve this integration. Deep learning focuses on conceptual understanding, metacognitive awareness, and knowledge transfer ([Xu, 2024](#)), while ICT provides interactive, visual, and collaborative media that can enhance student engagement ([Helsa et al., 2023](#)). The combination of both can help teachers create learning environments that are inquiry-driven, problem-based, and oriented toward higher-order thinking skills ([Ayu et al., 2024](#); [Azizah et al., 2024](#)).

The proposed ICT-based deep learning workshop aims to empower elementary teachers in Komunitas Belajar Gugus IV to design, implement, and evaluate learning experiences that foster literacy, numeracy, and computational thinking competencies aligned with the National Curriculum 2025. The workshop integrates digital tools such as GeoGebra, Padlet, Scratch, and Google Classroom, which support the creation of interactive and student-centered learning activities ([Helsa, 2023](#); [Melva, 2024](#)). Through this training, teachers are encouraged to transition from traditional instructional roles toward becoming learning designers who facilitate deep and meaningful learning processes. This initiative represents more than a technical intervention; it embodies a form of digital pedagogy empowerment, positioning teachers as agents of innovation who can bridge pedagogy, technology, and curriculum reform. Furthermore, the use of a *community of practice* model ensures sustainability through collaboration, reflection, and shared growth among teachers.

METHODS

This community service was conducted from March to June 2025 within a teacher learning community involving 30 elementary school teachers. Participants were purposively selected based on active membership in the community, a minimum of three years of teaching experience, and willingness to implement ICT-integrated learning (Helsa et al., 2023). The program adopted a pre-experimental one-group pre-test post-test design combined with a participatory empowerment approach.

Implementation consisted of three stages: preparation, workshop, and mentoring. During the preparation stage, learning modules, lesson plan templates, and numeracy CT rubrics were developed in alignment with the National Curriculum 2025 (Abidin, 2023). The three-day workshop provided theoretical reinforcement of deep learning and practical training in the use of ICT tools such as GeoGebra, Padlet, and Scratch (Xu, 2024), followed by microteaching and peer reflection activities. The mentoring phase lasted four weeks and applied a coaching cycle of plan, implement, observe, and reflect to support classroom implementation.

Data were collected through students’ numeracy and CT pre-test and post-test, teacher self-assessment questionnaires on pedagogical and technological competence, and structured classroom observations with reflective interviews (Helsa et al., 2023; Lee et al., 2019; Yeni et al., 2024). Quantitative data were analyzed descriptively using mean scores, standard deviation, and N-Gain calculations, while qualitative data were examined thematically following Miles et al. (2014) framework.

RESULTS AND DISCUSSION

The community engagement program involved 30 elementary school teachers and was implemented from March to June 2025. Program evaluation examined changes in teachers’ ICT pedagogical competence and students’ numeracy and CT performance using a one-group pre-test–post-test design. The quantitative findings of the program evaluation, including the comparison between pre-test and post-test scores across the assessed indicators, are summarized in Table 1.

Table 1 Summary of quantitative evaluation results

Evaluation Aspect	Pre-test Mean	Post-test Mean	Improvement
Student numeracy skills	62.3	77.2	24%
Student computational thinking	2.5 (on 4 scale)	3.0 (on 4 scale)	20%
Teacher ICT pedagogical competence (TPACK)	68.4	85.1	24%

The data indicate improvement across all measured indicators. Teachers’ ICT pedagogical competence increased by 24%, reflecting enhanced ability to design and implement ICT-integrated learning. Students’ numeracy scores improved by 24%, while computational thinking performance increased by 20% on a four-point rubric scale. To provide a clearer visual comparison of the measured outcomes before and after the program implementation, the pre-test and post-test results across the evaluated domains are presented in Figure 1.

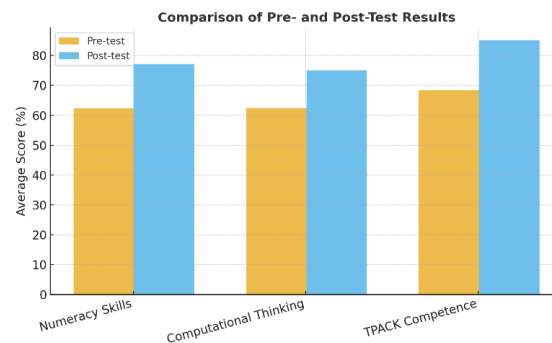


Figure 1 Comparison of pre-test and post-test results

To further illustrate these findings, Figure 1 presents a comparative bar chart of pre-test and post-test results across the three measured domains: numeracy skills, computational thinking, and TPACK competence.

Strengthening Teacher ICT Pedagogical Competence (TPACK)

The primary objective of this community service was to strengthen teachers' capacity to integrate ICT-based deep learning. The 24% increase in TPACK scores indicates that the workshop and mentoring model effectively enhanced teachers' instructional design competence. This result aligns with [Helsa et al. \(2023\)](#), who emphasized the importance of integrating pedagogy and technology in developing computational thinking-oriented learning. The finding also supports [Xu \(2024\)](#), who highlights that deep learning approaches foster reflective and conceptually grounded instruction. Thus, the improvement in TPACK directly reflects the achievement of the program's main objective: teacher capacity building ([Helsa, Yullys, Turmudi, & Juandi, 2023](#); [Xu, 2024](#)).

Impact on Numeracy Development

Students' numeracy improvement (24%) suggests that enhanced teacher competence translated into more structured and conceptually oriented mathematics instruction. The use of interactive digital tools such as GeoGebra supported visual representation and contextual problem-solving, consistent with findings by [Ziatdinov \(2022\)](#) that digital visualization promotes deeper mathematical understanding. Rather than attributing change solely to student factors, this improvement can be interpreted as a pedagogical impact of strengthened teacher practice. Moreover, the increase in teachers' TPACK competence indicates that the deep learning model effectively strengthened pedagogical integration of technology, consistent with [Liu et al., \(2025\)](#), who emphasized that authentic ICT-based practice enhances teachers' digital confidence and classroom innovation.

Development of Computational Thinking (CT)

The 20% increase in CT performance indicates growth in students' ability to structure solutions and apply logical reasoning within learning tasks. This outcome is consistent with [Lee et al., \(2019\)](#), who argued that CT integration requires deliberate instructional scaffolding. The mentoring process enabled teachers to embed CT indicators more systematically in classroom activities, contributing to measurable student progress. These findings demonstrate that teacher empowerment serves as an entry point for fostering higher-order thinking skills.

Role of Mentoring and Sustainability

Sustained mentoring through a plan, implement, and reflect cycle contributed to instructional consistency during implementation. Similar to [Ma et al. \(2025\)](#) and [Oyelere et al. \(2025\)](#), structured professional collaboration appears to support deeper pedagogical integration compared to one-time workshops. However, as noted by [Villavicencio et al. \(2025\)](#), long-term sustainability requires institutional support beyond the intervention period. In this program, the formation of a local mentoring team represents an initial step toward continued professional learning.

The consistent improvement across all indicators suggests that deep learning pedagogy promotes a shift from surface learning toward conceptual and reflective understanding. According to [Xu \(2024\)](#), deep learning environments encourage metacognitive engagement, enabling learners to construct knowledge rather than memorize procedures. This pedagogical shift explains why teachers reported higher confidence and students demonstrated better reasoning in numeracy and CT tasks.

Beyond numerical improvement, the results indicate a meaningful instructional shift among participating teachers ([Putri et al., 2025](#)). Classroom observations and reflective notes revealed that ICT was no longer used merely as a presentation tool but functioned as a learning scaffold that supported problem-solving, discussion, and conceptual exploration ([Syaiful et al., 2024](#)). This shift was particularly visible in numeracy lessons, where students engaged more actively with visual representations and contextual tasks ([Wakit et al., 2025](#)).

The impact of this program aligns with previous studies emphasizing that sustained mentoring is more effective than short-term ICT training ([Liu et al., 2025](#); [Oyelere et al., 2025](#)). However, unlike many professional development models reported in the literature, this program was embedded within a local teacher learning community, allowing pedagogical change to emerge gradually through peer reflection and iterative lesson redesign ([Tyas et al., 2025](#)). This context-sensitive approach strengthens the relevance of ICT-based deep learning for elementary education settings ([Nasrulloh et al., 2024](#)). Documentation of community service activities is shown in Figure 2.



Figure 2 Documentation of community service activities

Overall, the combination of ICT and deep learning pedagogy proved to be a transformative approach that not only enhanced teacher digital competence but also fostered meaningful numeracy and CT development among students, reaffirming the need for continuous professional learning ecosystems in elementary education ([Palop et al., 2025](#)).

CONCLUSION

This community service program aimed to strengthen elementary school teachers' capacity to integrate ICT-based deep learning pedagogy in supporting numeracy and CT development. Based on the quantitative findings, this primary objective was achieved, as

indicated by a 24% increase in teachers' ICT pedagogical competence (TPACK) following the workshop and mentoring phases.

The improvement in teacher competence was followed by measurable gains in student learning outcomes, with numeracy scores increasing by 24% and computational thinking performance improving by 20%. These results demonstrate that strengthening teachers' instructional capacity contributed directly to enhanced classroom practice and student achievement.

Overall, the findings confirm that a participatory empowerment approach combined with structured mentoring can effectively reinforce teachers' ability to design ICT-integrated deep learning. By positioning teacher capacity-building as the central strategy, the program successfully addressed the identified instructional challenges and supported the development of higher-order literacy skills in elementary education.

AUTHOR CONTRIBUTION

YH designed the community service program and led the implementation of the ICT-based deep learning workshop. SA contributed to the integration of digital tools and technical mentoring during the program. MZ supported data analysis and instructional design refinement. BR assisted in data collection, documentation, and manuscript preparation.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to the publication of this article.

AI DISCLOSURE STATEMENT

The author used language editing tools such as DeepL during the preparation of this work to improve clarity and readability. After using these tools/services, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the content of this publication. The authors declare that the research design, data collection, analysis, interpretation, and the main scientific contributions of this study were conducted independently by the authors without reliance on artificial intelligence (AI) for generating research results.

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REFERENCES

- Abidin, Z. (2023). The computational thinking in elementary school in the indonesia new curriculum : A teacher ' s perspective. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, 32(02), 178–185.
- Ayu, G., Robithoh, S., & Deswita, Y. (2024). Peningkatan hasil belajar matematika melalui model pembelajaran kooperatif tipe talking stick berbantuan geogebra. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 08, 737–749.
- Azizah, N., Setiadi, D., Lestari, T. A., & Jufri, A. W. (2024). Pengaruh model problem based learning berbantuan smart apps creator terhadap kemampuan computational thinking siswa. *Journal Of Classroom Action Research*, 6(2).
- Helsa, Y., Turmudi, T., & Juandi, D. (2023). *TPACK-based hybrid learning model design for computational thinking skills achievement in mathematics. Journal on Mathematics Education*, 14(2), 225–252.

- Helsa, Y., Suparman, S., Juandi, D., & Turmudi, T. (2023). A meta-analysis of the utilization of computer technology in enhancing computational thinking skills: Direction for mathematics learning a meta-analysis of the utilization of computer technology in enhancing computational thinking skills: Direction for mathematics learning. *International Journal of Instruction*, 16(April). <https://doi.org/10.29333/iji.2023.16239a>
- ISSED. (2023). *The development of PISA in Indonesia: Challenges and hopes on international literacy day*. https://www.issed.id/the-development-of-pisa-in-indonesia-challenges-and-hopes-on-international-literacy-day?utm_source=chatgpt.com
- Lee, I., Lee, I., & Malyn-smith, J. (2019). Computational thinking integration patterns along the framework defining computational thinking from a disciplinary perspective. *Journal of Science Education and Technology*, 29(1), 9-18.
- Li, Y., Schoenfeld, A. H., Andrea, A., & Graesser, A. C. (2020). Computational thinking is more about thinking than computing. *Journal for STEM Education Research*, 1–18.
- Liu, Z., Gearty, Z., Richard, E., Orrill, C. H., & Kayumova, S. (2025). Bringing computational thinking into classrooms : A systematic review on supporting teachers in integrating computational thinking into K - 12 classrooms. *International Journal of STEM Education*, 11(1), 51.
- Ma, H., Dong, Y., Jing, B., Zeng, Y., & Sun, J. (2025). Effectiveness of in - service computer science teachers ' professional development in K - 12 education : a systematic review and meta - analysis. *International Journal of STEM Education*, 12(1). <https://doi.org/10.1186/s40594-025-00548-0>
- Melva Zainil, et all. (2024). Development of Learning Management System Model and Numerical Literacy-based Message Content. *International Journal of Instruction*, 16(4), 1041–1060.
- Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis*. sage.
- Nasrulloh, I., Solihati, E., & Nugraha, W. (2024). Developing Professional Teachers in the Digital Age Through ICT Learning in the Cijeungjing Regional Office. *Indonesian Journal of Community Empowerment (IJCE)*, 5, 69–80.
- Oyelere, A., Friday, S., Agbo, J., & Suhonen, J. (2025). Co - design Pedagogy for Computational Thinking Education in K - 12 : A Systematic Literature Review. In *Technology, Knowledge and Learning*, 30(1). Springer Netherlands. <https://doi.org/10.1007/s10758-024-09765-y>
- Palop, B., Díaz, I., Rodríguez, L. J., & Santaengracia, J. J. (2025). Redefining computational thinking : A holistic framework and its implications for K - 12 education. *Education and Information Technologies*, 30(10), 13385–13410. <https://doi.org/10.1007/s10639-024-13297-4>
- Peng, J., Hao, M., Chen, B., & Wang, M. (2025). Cultivating computational thinking in a STEM course through the ICDCO instructional model. *Education and Information Technologies*, 30(17), 25137-25175.
- Putri, D. E., Fransiska, F. W., Krisnawati, N., & Husnita, L. (2025). Empowering elementary school teachers through technology-enhanced pedagogical mentoring. *Communnity Development Journal*, 6(3), 4843–4849.
- Schwarzaupt, R., & Wilson, J. P. (2024). Broadening participation of teachers in computing: examining postsecondary educational experiences and prospective educators' cs teaching interests. *Journal of Computer Science Integration*, 7(1), 1–16. <https://doi.org/10.26716/jcsi.2024.02.01.44>
- Syaiful, S., Halizah, N., & Fauziah, N. (2024). Pendampingan pembelajaran teknologi informasi dan komunikasi kepada siswa madrasah aliyah nurul. *Kolaborasi: Jurnal Hasil Kegiatan Kolaborasi Pengabdian Masyarakat*, 2(4), 81-92.

- Trianung, T., Susanto, D., Solihin, R. R., Fauziyah, E. P., Vita, N., Yanti, I., & Ramadhania, A. P. (2024). The efforts of Indonesian government in increasing teacher quality based on pisa result in 2022 : A literature review. *Perspektif Ilmu Pendidikan*, 38(1), 57-65.38(1), 57–65.
- Tyas, Z., Rifayanti, E., Prameswari, N. K., & Aditya, L. (2025). Pendampingan komunitas belajar di platform merdeka mengajar sekolah. *JPMD: Jurnal Pengabdian Kepada Masyarakat Desa*, 6(1).
- Villavicencio, A., Martin, W., Fancsali, C., Israel, M., Villavicencio, A., Martin, W., Fancsali, C., & Israel, M. (2025). Examining two different models for developing teachers new to computer science : lessons from a CS4All district. *Journal of Research on Technology in Education*, 57(1), 178-200. <https://doi.org/10.1080/15391523.2024.2410183>
- Wakit, A., Hidayati, N., Wahono, B. B., Arif, M. N., Fauziah, A., Islam, U., & Ulama, N. (2025). Pkm penguatan literasi numerasi siswa sd melalui pelatihan media digital pada kelompok ibu belajar. *Madiun Spoor: Jurnal Pengabdian Masyarakat*, 5(April).
- Xu, Z. (2024). *AI in education : Enhancing learning experiences and student outcomes. Applied and Computational Engineering*, 51(1), 104-111. <https://doi.org/10.54254/2755-2721/51/20241187>
- Yeni, S., Nijenhuis-voogt, J., Saeli, M., Barendsen, E., & Hermans, F. (2024). Computational thinking integrated in school subjects A cross-case analysis of students' experiences. *International Journal of Child-Computer Interaction*, 42(September), 100696. <https://doi.org/10.1016/j.ijcci.2024.100696>
- Ziatdinov, R., & Valles Jr, J. R. (2022). Synthesis of modeling, visualization, and programming in GeoGebra as an effective approach for teaching and learning STEM topics. *Mathematics*, 10(3), 398.

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