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Implementing a Coding-Based Learning Approach to Strengthen Students' Numeracy Literacy in Madrasah Ibtidaiyah

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ABSTRACT

Students' numeracy literacy remains a significant challenge in Madrasah Ibtidaiyah, partly because classroom instruction is still predominantly teacher-centered and many teachers have limited experience in integrating coding into their teaching practices. This study aimed to explore the implementation of a coding-based learning approach to strengthen students' numeracy literacy in two Madrasah Ibtidaiyah in East Jakarta. A qualitative descriptive design was employed, involving 20 teachers from MIN 13 and MIN 18 in East Jakarta. Data were collected through classroom observations, semi-structured interviews, and document analysis, and were analyzed using the Miles and Huberman interactive model with the support of MAXQDA software. The findings indicate that coding-based learning fostered more interactive and problem-oriented classroom practices, enhanced teachers' instructional capacity, and increased students' engagement in numeracy learning. Teachers reported that coding activities promoted logical reasoning, systematic thinking, and contextual problem-solving skills, thereby contributing to improved numeracy literacy. The study concludes that a coding-based learning approach offers a promising pedagogical strategy for strengthening numeracy literacy in Madrasah Ibtidaiyah while supporting the integration of digital competencies into Islamic primary education.

Keywords: *Coding-Based Learning; Madrasah Ibtidaiyah; Numeracy Literacy; Islamic Primary Education; Teacher Professional Development*

ABSTRAK

Literasi numerasi siswa masih menjadi tantangan yang signifikan di Madrasah Ibtidaiyah, sebagian karena proses pembelajaran di kelas masih didominasi oleh pendekatan yang berpusat pada guru dan banyak guru memiliki pengalaman yang terbatas dalam mengintegrasikan coding ke dalam praktik pembelajaran mereka. Penelitian ini bertujuan untuk mengeksplorasi implementasi pendekatan pembelajaran berbasis coding dalam memperkuat literasi numerasi siswa di dua Madrasah Ibtidaiyah di Jakarta Timur. Penelitian ini menggunakan desain kualitatif deskriptif dengan melibatkan 20 guru dari MIN 13 dan MIN 18 Jakarta Timur. Data dikumpulkan melalui observasi pembelajaran di kelas, wawancara semi-terstruktur, dan analisis dokumen, kemudian dianalisis menggunakan

model analisis interaktif Miles dan Huberman dengan bantuan perangkat lunak MAXQDA. Hasil penelitian menunjukkan bahwa pembelajaran berbasis coding mendorong terciptanya praktik pembelajaran yang lebih interaktif dan berorientasi pada pemecahan masalah, meningkatkan kapasitas pedagogis guru, serta memperkuat keterlibatan siswa dalam pembelajaran numerasi. Guru melaporkan bahwa aktivitas coding mampu mengembangkan kemampuan penalaran logis, berpikir sistematis, dan keterampilan pemecahan masalah kontekstual, sehingga berkontribusi terhadap peningkatan literasi numerasi siswa. Penelitian ini menyimpulkan bahwa pendekatan pembelajaran berbasis coding merupakan strategi pedagogis yang menjanjikan untuk memperkuat literasi numerasi di Madrasah Ibtidaiyah sekaligus mendukung integrasi kompetensi digital dalam pendidikan dasar Islam.
Kata-kata Kunci: Pembelajaran Berbasis Coding; Madrasah Ibtidaiyah; Literasi Numerasi; Pendidikan Dasar Islam; Pengembangan Profesional Guru

1. INTRODUCTION

Initial classroom observations and learning evaluations involving 30 students indicated that their numeracy literacy achievement remained below the expected level. Of these, only around 40% (12 students) met the Minimum Competency Criteria (KKM) and were classified in the good category, demonstrating the ability to understand context-based questions and solve numeracy problems correctly (Nugraha et al., 2021).

Meanwhile, approximately 33.3% of students (10 students) were in the adequate category, where they were able to solve routine problems but still had difficulty understanding reasoning-based problems. The remaining 26.7% (8 students) were in the low category, with a tendency to experience difficulties understanding basic numeracy concepts, reading data, and systematically developing problem-solving steps. These low learning outcomes can be attributed to various factors affecting the classroom learning process (G. Smith et al., 2023). One major factor is the continued dominance of conventional, teacher-centered learning approaches, where students tend to be passive recipients of information without actively engaging in the thinking process (Treve, 2024).

One promising approach to addressing this issue is coding-based learning. This approach not only introduces simple programming concepts but also trains students to think logically, systematically, and analytically, which is directly related to strengthening numeracy literacy (Selepe & Willemse, 2025). Through coding activities, students develop step-by-step problem-solving strategies that promote deeper conceptual understanding in meaningful and authentic contexts (Rahardjo, 2024).

However, implementing a coding-based approach in schools remains challenging, primarily because many teachers lack coding-based learning skills and strategies. This limited competence hinders the effective implementation of innovative

classroom practices. Therefore, ongoing training and mentoring are needed to enable teachers to effectively integrate the coding approach into literacy and numeracy learning (Rati & Tri Esaputra, 2025).

Numeracy literacy extends beyond basic arithmetic skills to include the ability to interpret quantitative information, analyze data, and apply mathematical concepts in everyday contexts (Yerizon et al., 2025). However, empirical conditions in the field show that students' numeracy literacy competencies are still relatively low, including at the Madrasah Ibtidaiyah level in the East Jakarta area, especially at MIN 13 and MIN 18 (Zhang et al., 2025).

Recent studies on numeracy literacy have increased substantially; however, few have examined the integration of coding-based pedagogy to strengthen numeracy literacy in elementary education. Existing research primarily focuses on coding as a computer science subject rather than as a pedagogical strategy for mathematics learning (Sghaier & Meddeb, 2023). Thus, there is a gap in research that theoretically and practically links the use of coding as a pedagogical strategy to build students' numeracy literacy at the Madrasah Ibtidaiyah level (Saputri et al., 2025).

Although international studies have explored coding within mathematics education and computational thinking, research directly linking coding to numeracy literacy among elementary school students, particularly in the context of Indonesian Madrasah Ibtidaiyah, remains limited. Most previous studies employed quantitative or experimental designs to examine the effectiveness of coding-based learning in improving numeracy or computational thinking (Ye et al., 2023).

This study adopts a descriptive qualitative approach which positions teachers as designers and teaching practices as the center of empirical analysis, thus providing a coherent and contextual picture of how the coding approach is actually implemented and experienced by teachers and students in a procedural manner that has an impact on improving learning outcomes (Li et al., 2025).

This context provides a distinctive contribution to understanding the implementation of coding-based pedagogy for numeracy literacy in elementary Islamic education, a practice that has not been widely reported in reputable international journals (Chiang & Thurston, 2022). This study was conducted in two Madrasah Ibtidaiyah in East Jakarta, representing a cultural and educational context that differs from many international studies focusing on public elementary schools.

This study not only explores the implementation of coding-based learning but also contributes to understanding how such practices support the development of students' numeracy literacy (Savaengkan & Chaijaroen, 2025). By positioning teachers as both designers and facilitators of the learning process, this research provides a rich empirical representation of real-life classroom learning practices. Coding-based

activities encourage students to internalize numeracy concepts, think systematically, and develop contextual problem-solving skills (Calma, 2025).

This study seeks to provide a comprehensive overview of the dynamics of teacher-student interactions, the teaching strategies implemented, and student responses and engagement in the learning process (Rahimi & Teimouri, 2025). The study is expected to contribute to the literature on constructivist learning and computational thinking in mathematics education, by demonstrating the potential of coding-based learning to meet the demands of 21st-century education that emphasizes critical, creative, and reflective thinking. Thus, this study not only enhances understanding of numeracy literacy but also provides relevant practical and theoretical contributions to the development of modern mathematics curricula and teaching strategies (De Gagne et al., 2025).

Developing students' numeracy literacy competencies at the Madrasah Ibtidaiyah level is a top priority in improving the quality of education in Indonesia, particularly in facing the challenges of the 21st century, which demand critical thinking, analytical skills, and problem-solving (Srinivas et al., 2025). Numeracy literacy is not merely the ability to perform arithmetic calculations but also the capacity to understand, analyze, and apply mathematical concepts in various real-life situations (Carpendale et al., 2025).

Mathematics instruction is often presented in a procedural and mechanical manner, leaving little room for students to develop critical and creative thinking skills (J. Smith et al., 2025). Furthermore, Limited innovation in instructional media and teaching strategies also hinders creating an engaging and meaningful learning environment (Suripah et al., 2025).

Rapid advances in digital technology have created opportunities for more innovative and meaningful instructional approaches, including coding-based learning (Yaseen et al., 2025). This approach focuses not only on programming skills but also on developing computational thinking skills, including problem decomposition, pattern recognition, abstraction, and algorithmic thinking (Liu et al., 2022).

In the context of mathematics learning, a coding approach can help students understand numeracy concepts in a more structured, logical, and applicable way (Tang et al., 2020). The implementation of coding-based learning by teachers at MIN 13 and MIN 18 represents a strategic effort to improve students' numeracy literacy (McLean et al., 2025). Teachers are expected to design learning experiences that emphasize students' thinking processes rather than merely learning outcomes (Arifin, Sirih, & Anggi Puspita Sari, 2025).

Based on preliminary data, students' low numeracy literacy competency requires intervention through innovative and contextual learning approaches (Azubuike et al., 2024). The coding approach is an effective alternative for improving student learning

outcomes while developing 21st-century skills (Molla et al., 2023). Therefore, commitment and support from various parties are needed to optimize the implementation of this approach, including through teacher training, provision of supporting facilities, and development of a curriculum that adapts to current developments (Hermawati et al., 2024). Accordingly, implementing a coding-based learning approach at MIN 13 and MIN 18 East Jakarta has the potential to improve students' numeracy achievement.

This rationale is consistent with findings from previous studies demonstrating that integrating coding and computational thinking into mathematics instruction enhances students' understanding of numeracy concepts (Rodríguez-Martínez et al., 2020). For example, the use of Scratch among elementary school students has been shown to promote mathematical understanding while simultaneously developing computational thinking skills (X. Fang et al., 2023).

Scratch-based programming activities, such as developing a "fraction magic calculator," enable students to construct mathematical understanding through authentic problem-solving experiences. Furthermore, computational thinking-based mathematics instruction enables students to integrate mathematical reasoning with computational reasoning, allowing them to construct logical and systematic solutions (Ye et al., 2023).

2. METHOD

The participants in this study consisted of 20 teachers, including 10 teachers from MIN 13 and 10 teachers from MIN 18 in East Jakarta. Participants were purposively selected based on preliminary information indicating that they had limited experience in implementing coding-based learning. In-depth interviews were conducted with five teachers and five students to obtain more detailed information regarding the implementation of coding-based learning. The interview transcripts were subsequently processed and analyzed using MAXQDA software. Teacher interviews explored their experiences and instructional practices in implementing coding-based learning, while student interviews focused on their learning experiences and perceptions of numeracy learning through coding activities (Widiawati et al., 2025).

This study employed a descriptive qualitative approach to obtain an in-depth understanding of the implementation of coding-based learning in Madrasah Ibtidaiyah (Inayat & Younas, 2025). Teachers served as the primary participants because they acted as both designers and implementers of coding-based learning (Ma et al., 2023). Through this approach, the researchers sought to understand how teachers design learning strategies, integrate coding concepts into numeracy materials, and evaluate their impact on student skill development (Pitorini et al., 2025).

Data were collected through classroom observations, semi-structured interviews, and document analysis (Wei et al., 2022). Classroom observations were conducted to

examine the dynamics of the teaching and learning process. Observations focused on teachers' implementation of coding-based learning, classroom interactions, the use of instructional media, and students' engagement in learning activities (M. Fang et al., 2023). Semi-structured interviews were conducted with teachers, and the resulting interview transcripts were subsequently managed and analyzed using MAXQDA software (Consoli, 2021). Supporting documents, including lesson plans, teaching materials, and field notes, were analyzed to triangulate the findings obtained from classroom observations and interviews.

Data analysis was conducted iteratively throughout the study to ensure that emerging findings accurately reflected the research context (D'Souza et al., 2023). MAXQDA software was used to organize, code, categorize, and identify patterns across the qualitative data. This process enabled the researchers to identify patterns related to student engagement, changes in teachers' instructional practices, and the influence of coding-based learning on students' understanding of numeracy concepts (Astudillo et al., 2025).

The data were analyzed using the interactive analysis model proposed by Miles, Huberman, and Saldaña, which includes three main stages: data condensation, data presentation, and conclusion drawing (Asipi et al., 2022). Data condensation involved selecting, coding, organizing, and simplifying information relevant to the research objectives before presenting the findings and drawing conclusions. Particular attention was given to data concerning teachers' instructional strategies, the implementation of coding-based learning, students' numeracy activities, students' responses, and learning barriers, as these aspects were directly aligned with the research objectives (Thompson et al., 2025). Figure 1 presents the overall research framework employed in this study, outlining the sequence of research activities from identifying the research focus to interpreting the findings.

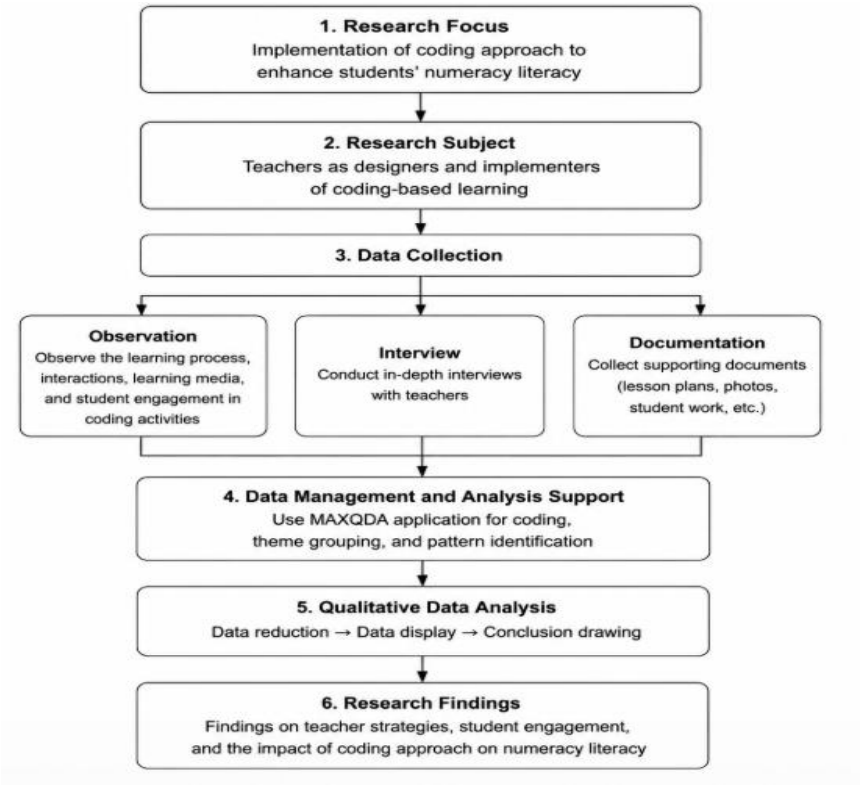

Figure 1. Research steps

As illustrated in Figure 1, the study began with identifying the research focus, followed by participant selection, data collection, qualitative data analysis using the Miles and Huberman interactive model supported by MAXQDA, and the interpretation of the findings.

3. RESULTS AND DISCUSSION

Initial classroom observations revealed that fourth-grade students at MIN 13 and MIN 18 in East Jakarta had not yet achieved the expected levels of literacy and numeracy competence. In daily learning activities, students were generally able to read texts mechanically, but still experience difficulties in understanding deeper meanings, drawing conclusions, and connecting information to real-life contexts (Siregar et al., 2025).

From a numeracy perspective, students demonstrated basic skills in performing simple arithmetic operations such as addition and subtraction, but struggled when faced with word problems or contextual problems. Many students struggled to identify important information, translate problems into mathematical models, and determine appropriate solution strategies. These findings indicate that students' critical thinking and mathematical problem-solving skills had not yet developed to their full potential.

Observations also showed that classroom learning was still dominated by conventional, teacher-centered methods. Learning activities primarily involved direct

explanations of material and practice exercises, leaving students limited opportunities for exploration, discussion, and creative thinking. The instructional media used were relatively simple and do not utilize technology optimally, even though most students are already interested in digital devices.

Initial findings indicated a tendency for students to show low self-confidence in expressing opinions or attempting to solve problems using different methods. Students often wait for examples from the teacher before completing assignments, which results in a lack of independent learning. Interactions between students during the learning process also do not demonstrate active collaboration, thus the potential for social learning is not fully explored.

In classroom learning, teachers still tended to use conventional approaches that focus on direct delivery of material. Learning strategies were dominated by lectures, question-and-answer sessions, and textbook practice exercises. Although some teachers have attempted to implement contextual learning, the integration of literacy, numeracy, and problem-based approaches has not been fully structured and systematic. This has resulted in less than optimal development of students' critical thinking and analytical skills (Wahyuningtyas & Widiyono, 2024).

In terms of understanding the concept of numeracy literacy, some teachers have grasped the importance of these two competencies as the foundation of 21st-century learning. However, this understanding remains limited to the conceptual aspect and has not yet been fully translated into implementation skills in the classroom. Teachers still experience difficulties in designing learning activities that effectively integrate literacy and numeracy, particularly in the form of real-life context-based questions or exploratory activities that encourage problem-solving.

Regarding technology utilization, observations indicated that most teachers are still in the adaptation phase. The use of digital tools in learning is generally limited to simple presentation media like PowerPoint, and had not yet extended to interactive and constructive technology use such as coding or simple programming. This is influenced by several factors, including limited relevant training, a lack of technical assistance, and the perception that coding is a complex skill and difficult to implement at the Madrasah Ibtidaiyah level.

Teachers also tended to position themselves as the primary source of knowledge, leaving little room for students to explore and learn independently. However, in the coding approach, the teacher's role shifted more to that of a facilitator, guiding students through the process of discovery and problem-solving. This paradigm shift presents a unique challenge for teachers, particularly in terms of pedagogical readiness and confidence in managing technology-based learning (Essaid et al., 2025).

From a lesson planning perspective, the teaching tools used by teachers, such as lesson plans or teaching modules, still do not explicitly incorporate coding elements as

part of the learning strategy (E. H. H. Huang et al., 2024). Learning activities remain focused on achieving basic cognitive indicators, without optimally developing higher-order thinking skills (HOTS) (Kwangmuang et al., 2021).

The coding approach is a relevant alternative to be developed as an innovative learning strategy (Fu et al., 2025). Coding is not only related to technological skills but also trains computational thinking, which includes logical, analytical, problem-solving, and systematic thinking skills (Tezcan, 2025).

Through contextually designed and engaging coding activities, students can develop numeracy concepts through simulations, educational games, and simple projects that encourage active engagement (Metin et al., 2025). Teachers also recognized that students showed strong interest in technology, highlighting the need for learning strategies that accommodate these characteristics (Papadakis, 2022).

a. Word cloud analysis of MAXQDA application

To identify the dominant concepts emerging from teachers' and students' interviews, the qualitative data were coded and visualized using MAXQDA. The resulting word cloud highlights the most frequently occurring concepts that characterize participants' perceptions of coding-based learning and numeracy literacy, as presented in Figure 2.

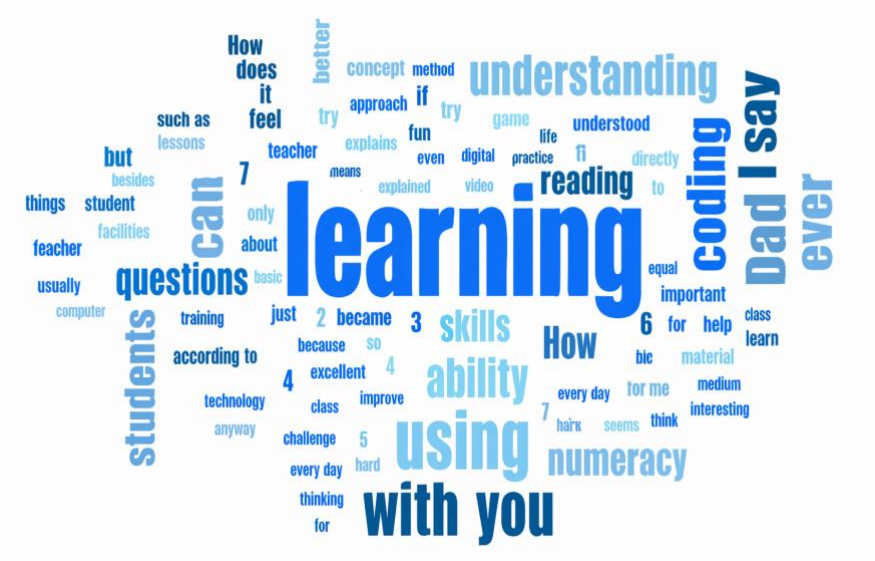

Figure 2 Word Cloud of Interview Results Using the MAXQDA Application

Figure 2 presents a word cloud generated from the interview data, illustrating the most frequently occurring concepts related to coding-based learning and numeracy literacy (Bao & Wang, 2021). In this visualization, the word "learning" appears as the most dominant element, indicating that the core of the entire process being studied is centered on the learning experience itself.

This emphasizes that developing numeracy literacy through a coding approach is not solely oriented towards the final result, but rather on how the learning process takes

place meaningfully for students (Y. Huang et al., 2019). As quoted from the teacher's interview, *"In my opinion, literacy is not only the ability to read, but also understand, analyze and convey information. Numeracy, on the other hand, is the ability to use numbers and mathematical concepts in everyday life. Both are very important as a basis for students' thinking, especially when facing more complex learning."* (Jain, 2021)

Other frequently occurring words, such as "using," "with you," and "ability" also appear prominently, indicating a close relationship between the learning process and active student involvement. The phrase "with you" reflects a collaborative and participatory learning approach, where interaction between teacher and student is a crucial factor in building numeracy understanding. Meanwhile, the word "ability" indicates that the primary focus of this learning is skill development, not simply theoretical mastery of the material (Wang et al., 2022).

The significant occurrence of the words "coding" and "numeracy" indicates that these two concepts are key pillars of the research. Coding is understood as an approach or tool used to strengthen students' numeracy literacy (Cahyani et al., 2025). In other words, coding serves as a medium that bridges the understanding of abstract numeracy concepts into more concrete, applicable, and understandable ones. This is reinforced by the emergence of words such as "understanding," "reading," and "skills," indicating that learning emphasizes not only basic cognitive aspects but also in-depth understanding and higher-order thinking skills (An et al., 2023).

The words "students," "teacher," and "questions" indicate the dynamic interactions within the learning process. The presence of "questions" suggests that a question-and-answer method or problem-based learning approach is likely part of the learning strategy being implemented. These findings are consistent with the present study, in which students were better able to explain their reasoning when constructing code to solve numerical problems.

Frequently occurring words such as "interesting," "fun," and "better" suggest that students perceived coding-based learning as engaging and motivating. This is an important indicator that the learning innovation implemented is not only academically effective but also able to increase student motivation and interest in learning. On the other hand, the emergence of words like "challenge" and "hard" indicates that while this approach offers many benefits, there are still challenges faced by both students and teachers, particularly in adapting to technology and mastering new concepts.

Equally important, the words "technology," "digital," and "computer" reinforce that this learning is based on the use of digital technology. This demonstrates that teachers play a role not only as transmitters of material but also as facilitators capable of effectively integrating technology into learning. Thus, teacher competence is a key factor in the successful implementation of the coding approach to improving students' numeracy literacy.

This word cloud reflects that learning numeracy literacy through a coding approach is a complex, interactive process oriented toward developing 21st-century skills. Learning is no longer one-way, but involves active student participation, collaboration, technology utilization, and an emphasis on understanding and critical thinking skills. This visualization reinforces the finding that the coding approach has great potential in creating more effective, engaging, and relevant learning, particularly in the context of elementary education in East Jakarta.

The word cloud indicates that coding-based learning encouraged active participation, collaboration, and the development of higher-order thinking skills. Students are no longer positioned as passive recipients of information, but rather as active subjects involved in the process of exploration, asking questions, experimenting, and finding solutions (Børte et al., 2023). Interactions between students and teachers, as well as among students, are crucial in building a deeper understanding of numeracy. In this context, the teacher acts as a facilitator guiding the learning process, not simply as the primary source of knowledge (Opdal, 2022).

The coding approach used in learning also reinforces the focus on developing 21st-century skills. Through coding, students are trained to think logically, systematically, and critically, while simultaneously developing problem-solving abilities (Zeeshan et al., 2024). Coding is an effective medium for connecting abstract numeracy concepts with more contextual and applicable real-world practices (Totan & Korucu, 2023).

b. Word Trend Analisis MAXQDA

To further examine how key concepts developed throughout the interview transcripts, a word trend analysis was conducted using MAXQDA. This analysis illustrates the changing prominence of major themes across different sections of the interviews, as shown in Figure 3.

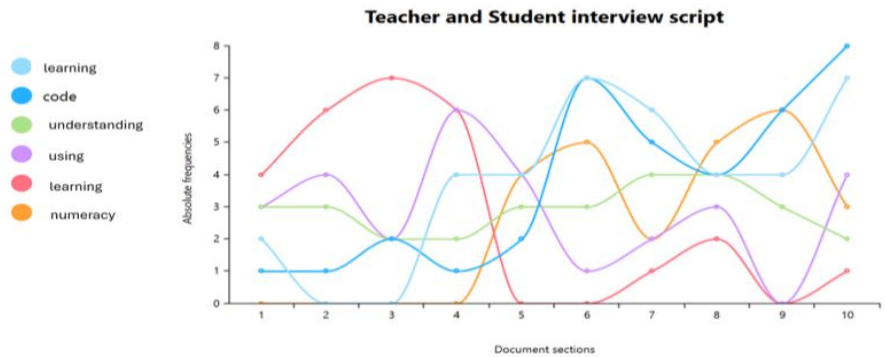

Figure 3. Word trend analisis MAXQDA

The "Teacher and Student Interview Script" graph displays the dynamics of the emergence of six main themes: learning, code, understanding, using, learning (in the

context of a more explicit learning process), and numeracy across ten sections of the interview document. When linked to research on developing students' numeracy literacy competencies through a coding approach among Madrasah Ibtidaiyah teachers in East Jakarta, this pattern provides a fairly rich picture of how coding integration influences numeracy learning practices and understanding.

In the initial section (sections 1–3), the themes of “learning” and “learning” (presented in two different contexts) were quite dominant, while “code” remained relatively low. This indicates that in the initial stages of the interviews, the focus of teachers and students was still on general learning processes and conventional learning experiences.

Coding was not yet a core part of the discussion, but rather served as an introduction or additional context. On the other hand, “understanding” and “using” showed moderate fluctuations, which could mean that students’ understanding of the initial concepts was already present, but had not yet been fully integrated into practical use, particularly in the context of coding-based numeracy.

In the middle sections of the interview transcripts (Sections 4–6), a significant shift was observed. The theme of "code" increases sharply, along with an increase in "learning" in a more applied context. In this phase, coding began to take center stage in the learning process. Teachers appeared to begin implementing coding-based activities that encourage students to think logically and systematically. The increase in "numeracy" that begins to emerge in section 5 indicates a direct link between coding activities and strengthening numeracy skills. This means that students are not only learning coding as a technical skill, but also using it to understand mathematical concepts such as patterns, sequences, and problem-solving.

At the same time, the theme of "using" peaked around section 4, then declined drastically in section 6. This can be interpreted as an initial exploration phase where students attempted to use coding, but then encountered challenges or adjustments as the material became more complex. This decline does not indicate failure, but rather part of the learning process, indicating the need for more intensive teacher support in integrating coding with numeracy.

To validate these findings, the researcher conducted a follow-up interview with the school principal, who stated: *“I observed that teachers are now utilizing digital devices more frequently in their learning, and students really enjoy it. This psychological condition has led to improved student learning outcomes. For teachers, the coding approach to learning has made classroom conditions livelier.”*

In the next section (sections 7–10), the analysis showed that "code" increases again and even reaches its highest point at the end of the document. This indicates that both teachers and students are becoming more accustomed to and confident in using the coding approach. Interestingly, "numeracy" also shows a fairly consistent upward trend,

despite some fluctuations. This confirms that the gradual integration of coding has a positive impact on students' numeracy skills.

Meanwhile, "understanding" tended to be stable with a slight decrease at the end, which could mean that although students were actively using coding, their conceptual understanding needed to be continuously strengthened so that it was not merely procedural. On the other hand, the "learning" theme (which was more general) experienced a decrease in the middle but increased again at the end, reflecting reflection or reinforcement of the learning experience after going through the coding exploration process.

Overall, this graph shows that the coding approach has significant potential in developing Madrasah Ibtidaiyah students' numeracy literacy (Indrawatiningsih et al., 2024). The process is not linear, but rather involves phases of introduction, exploration, challenge, and reinforcement. The teacher's role is crucial in guiding students to meaningfully connect coding activities with numeracy concepts (Arifin, Sirih, Munir, et al., 2025). Thus, this study indicates that integrating coding into learning not only improves technological skills but also strengthens mathematical thinking skills, provided it is supported by appropriate and sustainable pedagogical strategies (Connolly et al., 2023).

c. Interview Analysis With MAXQDA Single Case Model Application

To explore the relationships among the major themes identified during qualitative coding, a MAXQDA Single Case Model was generated. Figure 4 illustrates the interconnectedness of coding implementation, teacher practices, student engagement, and numeracy literacy development.

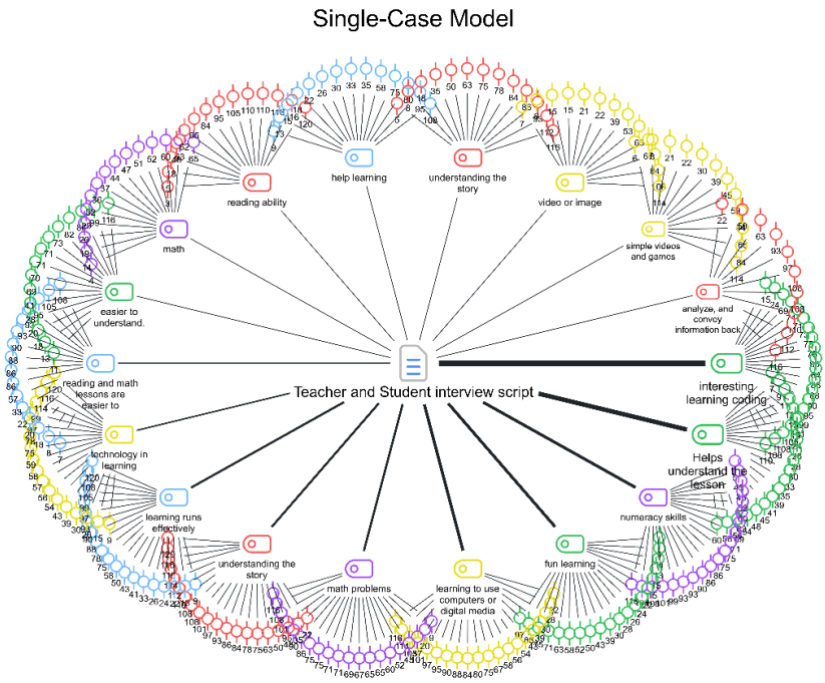

Figure 4. Single case MAXQDA analysis model

Figure 4 demonstrates a strong interconnectedness between the coding approach implementation process, teachers' roles, student involvement, and the strengthening of numeracy literacy competencies. This systemic relationship structure demonstrates that numeracy literacy development does not occur in isolation but is influenced by teacher preparedness in designing learning, coding implementation strategies in the classroom, and active student responses throughout the learning process (Guetterman & James, 2023).

These findings address the research objective by confirming that the coding approach contributes to improving the numeracy literacy of elementary school students in East Jakarta through a more interactive, logical, and problem-solving-based learning mechanism. Furthermore, the interconnectedness between the components in the figure also demonstrates that the improvement in numeracy literacy competency occurs gradually through synergy between teachers, students, and a structured coding-based learning design. (Gupta & Ahuja, 2025).

Each main branch is visualized with a different color, such as red, yellow, green, blue, purple, to represent the broad categories within the research. These colors are not merely aesthetic; they represent important dimensions in numeracy literacy development. For example, one branch might be interpreted as students' mastery of basic numeracy concepts, another as the integration of coding into learning, while yet another branch reflects innovative pedagogical strategies used by teachers.

There are also branches that describe the development of digital-based learning media, evaluation and assessment systems, and aspects of collaboration and reflection within teacher learning communities. Interestingly, each main sub-theme doesn't stop at one point, but develops into smaller branches in the form of circles arranged in a circular pattern around the outermost part (Adula et al., 2023).

These smaller circles represent more specific indicators, activities, or operational variables. This structure demonstrates that each aspect of the research is described in depth and detail. For example, in the context of coding, these indicators might include students' ability to understand patterns, develop simple algorithms, and interpret numerical data through simple programs. Meanwhile, in the pedagogical aspect, indicators might include the use of project-based learning models, problem-based learning, and contextual technology integration.

The circular pattern that unites all the branches on the outside indicates a close relationship between the subthemes. No single aspect stands alone; they are all interconnected and form a complete learning ecosystem. This indicates that developing numeracy literacy through a coding approach cannot be done in isolation. Instead, it requires synergy between material mastery, teacher pedagogical skills, technology utilization, and an appropriate evaluation system.

Conceptually, this visualization also emphasizes that the coding approach acts as a bridge that integrates these various aspects. Coding is positioned not only as a technical skill, but as a computational thinking tool that can help students understand numeracy concepts more concretely (Kuckartz & Rädiker, 2019). Through coding, abstract concepts in mathematics can be visualized in the form of simulations, patterns, and algorithms that are easily understood by Madrasah Ibtidaiyah students (Star et al., 2025).

This complex yet organized network structure reflects a systematic and comprehensive research approach. The analysis focused not only on the end result of improving student skills, but also considers the processes, strategies, and supporting factors that influence successful implementation (Hazin et al., 2025). The role of teachers is crucial, not only as learning facilitators but also as innovators capable of effectively integrating technology into learning (Wulandari et al., 2024).

This visual illustrates that developing students' numeracy literacy competencies through a coding approach is a multidimensional process involving various interrelated components (Niklas et al., 2022). The success of its implementation is largely determined by the ability to manage the interrelationships between these subthemes in an integrated, sustainable, and contextual manner (Suardipa et al., 2024). Thus, this study confirms that numeracy literacy in the digital era can no longer be separated from the use of technology, particularly coding, as a means to build deeper, more critical, and more applicable understanding in Madrasah Ibtidaiyah students .

d. Interview Analysis Results on Code Map

To visualize the relationships among codes generated from the interview data, a code map analysis was performed using MAXQDA. Figure 5 presents the conceptual connections among the dominant themes identified during the analysis.

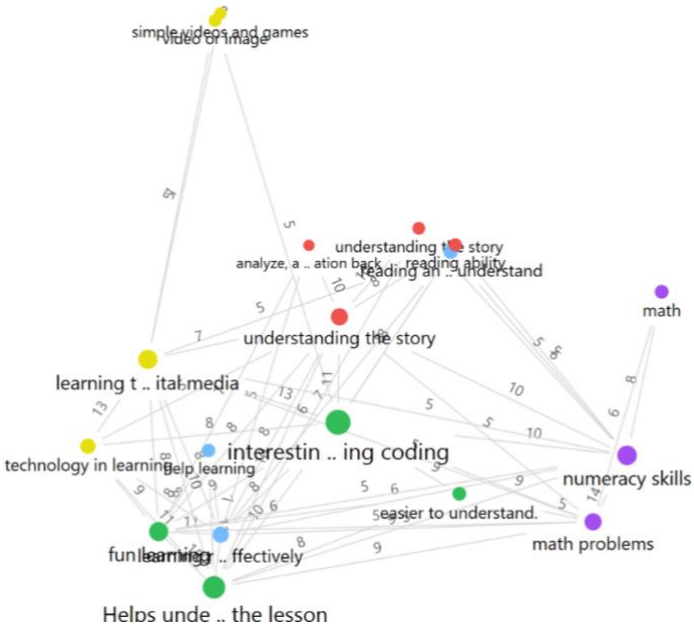

Figure 5. MAXQDA code map

At the center of the code map, the most prominent node is "interesting coding." This central position indicates that students' interest in coding is key to successful numeracy literacy learning. This interest acts as a driving force connecting various other aspects of learning, from conceptual understanding to problem-solving skills. This indicates that when students feel interested and engaged, the learning process becomes more effective and meaningful.

Meanwhile, from a computational thinking perspective, the network of relationships represents thought processes such as decomposition (breaking down a story problem into smaller parts), pattern recognition (identifying patterns in text or mathematics), abstraction (filtering important information), and algorithmic thinking (arranging steps to solve the problem). The interconnectedness between code and concepts suggests that learning to code not only improves technical skills but also simultaneously strengthens numeracy and story comprehension through systematic thinking processes.

The figure displays a conceptual network map depicting the relationships between themes, subthemes, and indicators in research on numeracy literacy competency development through a coding approach (Fitrianingrum & Murtiyasa, 2023). This visualization demonstrates that the learning process under study is not linear, but rather a network that is interconnected, dynamic, and multidimensional (Süğümlü, 2020).

From this center, various branches can be seen leading to other subthemes such as "understanding the story," "reading ability," and "understand." This shows that the coding approach not only directly impacts numeracy skills but also contributes to

improving literacy skills, particularly in understanding the text and context of story problems. In other words, coding helps students interpret information, analyze problems, and connect them to relevant mathematical concepts (Purnomo et al., 2022).

Nodes such as "numeracy skills," "math problems," and "math" are located in a separate cluster. This cluster represents the ultimate goal of learning, which is to improve students' numeracy skills (Astuti et al., 2024). The strong relationship between this cluster and the central node indicates that interest in coding significantly influences students' ability to solve math problems. This process does not occur instantly, but rather through repeated stages of understanding, practice, and application of concepts (Singh et al., 2021).

In addition, there are also clusters related to "technology in learning," "learning media," and "simple videos and games." The presence of these elements demonstrates that the use of digital media and technology is a crucial supporting factor in creating engaging and interactive learning (Qatrunada et al., 2022). Media such as videos and simple games can facilitate students' visual and contextual understanding of concepts, making learning easier to understand and less boring (Abiltarova et al., 2022).

Interestingly, this visualization also shows a connection with aspects of the student learning experience, such as "fun learning" and "helps understand the lesson." This confirms that coding-based learning not only improves cognitive aspects but also provides an enjoyable learning experience. When students feel happy, they tend to be more active, motivated, and receptive to learning materials.

This network demonstrates that each component of learning is interconnected and inseparable. Interest in coding serves as a central link between technology, learning strategies, literacy skills, and the ultimate outcome of improved numeracy. Thus, the coding approach serves as an integrative bridge, connecting various aspects of learning holistically.

The narrative that can be drawn from this visualization is that the success of developing students' numeracy literacy through a coding approach depends heavily on teachers' ability to create engaging learning, utilize technology effectively, and build students' understanding in a gradual and contextual manner. Therefore, this approach is not only relevant to the needs of 21st-century education but also a strategic solution for improving the quality of learning in Madrasah Ibtidaiyah, particularly in East Jakarta.

This study found that the application of a coding approach to numeracy learning significantly improved students' numeracy literacy competencies in elementary school (Madrasah Ibtidaiyah) classes in East Jakarta. Students demonstrated improved understanding of numerical concepts, application of problem-solving strategies, and logical thinking when working on code-based assignments. Students' active engagement in the learning process also reflected a shift from traditional numeracy learning (solely through practice problems) to contextual, reflective, and interactive numeracy learning.

Supporting classroom assessment data showed that students' average achievement increased from 40% before the implementation of coding-based learning to 85% after its implementation.These findings are consistent with previous research showing that coding in mathematics learning can strengthen students' problem-solving and logical thinking skills (Weintrop et al., 2016; Robertson et al., 2020). Specifically, Weintrop et al. (2016) argued that in the journal Computers & Education asserted that coding provides a context for explicitly constructing and understanding numerical relations, allowing students not only to imitate mathematical procedures but also to understand the logic behind numerical operations. This aligns with the findings of this study, where students were better able to explain their thought processes when constructing code to solve numerical problems.

4. CONCLUSION

This study demonstrates that implementing a coding-based learning approach contributes to strengthening students' numeracy literacy in Madrasah Ibtidaiyah by enhancing their ability to understand and solve mathematical problems while fostering logical, critical, and systematic thinking skills. The successful implementation of this approach depends largely on students' interest and active participation throughout the learning process. Prior to the intervention, students' literacy and numeracy achievement at MIN 13 and MIN 18 in East Jakarta remained relatively low, indicating the need for more innovative and contextual learning strategies to address current educational challenges. The findings further indicate that implementing coding-based learning contributed to improvements in students' literacy and numeracy competencies, as reflected in their increased learning achievement following the intervention. These improvements were supported by teachers who had received training and mentoring, enabling them to design more interactive, systematic, and problem-solving-oriented learning experiences that actively engaged students in developing conceptual understanding. Theoretically, this study reinforces constructivist learning theory and the concept of computational thinking by demonstrating that knowledge is constructed through active learning experiences, logical reasoning, and problem-solving processes. Practically, the findings highlight the importance of providing teachers with continuous professional development and mentoring to support the effective integration of coding into numeracy instruction, thereby enhancing the quality of learning in Madrasah Ibtidaiyah.

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