



Cognitive Exploration of Mathematics Teachers in the Lesson Study Model Through Metacognitive Skills to Enhance Digital Competence in Independent Learning

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Abstract

This research aims to explore the cognition of mathematics teachers through the lesson study model focusing on metacognitive skills and digital competence. The background of this research is based on the urgency of improving learning evaluation. Although many studies have been conducted, however these studies have yet to specifically explore teachers' cognition before, during, and after the lesson. Therefore, this research focuses on the three stages of lesson study: plan, do, and see. This research method uses a qualitative approach to reveal the cognition of mathematics teachers. The study involves two subjects: a male model teacher and a female model teacher with ten observers. Data were collected using initial diagnostic tests, observations, and reflections with the students. The research results show that teachers have a good understanding in learning objectives, teaching strategies that align with student characteristics, and digital skills. The data for this research was collected using a four-step metacognitive skills method, namely: prediction, planning, monitoring, and evaluation. The objectives of this research are: 1) The formation of cognitive classifications of teachers in three stages: a) Plan, where teachers conduct initial analysis, understand student characteristics, and prepare lesson plans; b) Do, where teachers implement the prepared lesson plans using predetermined methods and strategies according to the material and student characteristics, and actively interact with students to collect learning data; and c) See, where teachers evaluate student learning outcomes, reflect on the learning process, identify successes and shortcomings in teaching, and improve teaching practices based on the reflection of the obtained data. 2) Lesson study has a positive impact by supporting the availability of data for researchers in the data collection process, as well as enhancing teachers' digital competence.

Keywords: Cognitive; Metacognitive Skills; Lesson Study; Digital Competence; Independent Learning.

Abstrak

Penelitian ini bertujuan menggali pemahaman kognitif guru matematika melalui model Lesson Study dengan fokus pada keterampilan metakognitif dan kompetensi digital. Latar belakang penelitian ini didasarkan pada urgensi evaluasi pembelajaran untuk perbaikan di pembelajaran berikutnya. Meskipun banyak penelitian telah dilakukan, belum ada yang secara khusus mengeksplorasi pemikiran guru sebelum, selama, dan setelah pembelajaran. Oleh karena itu, penelitian ini berfokus pada tiga tahap Lesson Study: Plan, Do, dan See. Metode penelitian melibatkan dua subjek: seorang guru model laki-laki dan seorang guru model perempuan dengan sepuluh observer. Data dikumpulkan melalui tes diagnostik awal, observasi, dan refleksi bersama peserta didik. Hasil penelitian menunjukkan bahwa guru-guru memiliki pemahaman yang baik tentang tujuan pembelajaran, strategi pengajaran yang sesuai dengan karakteristik peserta didik, dan keterampilan digital. Data penelitian ini menggunakan metode empat langkah keterampilan metakognitif yaitu: prediksi, perencanaan, monitoring, dan evaluasi. Tujuan penelitian ini adalah: 1) Terbentuknya klasifikasi kognitif pengajar di tiga zona waktu: a) Plan, di mana pengajar melakukan analisis awal, memahami karakteristik siswa, dan mempersiapkan rencana pembelajaran; b) Do, pengajar melaksanakan rencana pembelajaran yang telah disusun, menggunakan metode dan strategi yang sudah ditentukan sesuai dengan materi dan karakteristik siswa, dan pengajar aktif berinteraksi dengan siswa dalam mengumpulkan data pembelajaran; dan c) See, pengajar mengevaluasi hasil belajar siswa dan merenungi proses pembelajaran, mengidentifikasi keberhasilan dan kekurangan dalam mengajar, dan memperbaiki praktik mengajar berdasarkan refleksi data yang diperoleh. 2) Lesson Study memberikan dampak positif yaitu mendukung ketersediaan data bagi peneliti dalam proses terkumpulnya data riset, serta meningkatkan kompetensi digital pengajar.

Kata Kunci: Kognitif; Keterampilan Metakognitif; Lesson Study; Kompetensi Digital; Merdeka Belajar.

Introduction

Improvements must match the rapid growth of technology in the quality of education. Enhancing quality can be achieved by evaluating the learning that has taken place to determine whether the outcomes align with the intended goals. The evaluation conducted in learning can provide information on which areas need improvement (Sawaluddin, 2021). The activities that need to be carried out in the evaluation process must encompass the aspects of remembering, understanding, applying, analyzing, evaluating, and creating. "Six cognitive aspects of students in learning include aspects of remembering, understanding, applying, analyzing, evaluating, and creating" (Susanto et al., 2020), because it is from these six cognitive aspects that the learners' abilities can be captured.

The digitalization of independent learning in this research is defined as integrating digital technology in the learning process that allows teachers and students to access a broader and more diverse range of learning resources. In the

context of digital platforms, teachers can develop essential metacognitive skills in identifying, analyzing, and evaluating effective learning methods. These digital platforms enhance their digital competence and enrich students' learning experiences by providing interactive and adaptive content. Thus, digitalization in Independent Learning aims to create an inclusive and responsive educational environment for individual needs, facilitating learners' independent and sustainable intellectual growth.

Considering the perspectives above, it is imperative to investigate the cognitive processes of educators before, during, and after the instructional phases. That activity is essential since knowledge of personal thinking and awareness regarding one's ability to solve a problem will increase the likelihood of success in addressing a problem or undertaking a task (Hidajat et al., 2018). In the field of education, many experts have indeed engaged in evaluation activities, such as the problem-solving figure Polya, who approaches problem-solving through four activities: understanding, planning, solving, and reviewing (Schoenfeld, 2014). These activities continue to be carried out; however, no researchers have yet investigated what educators think about when preparing teaching materials, what goes through their minds during the teaching process, and what thoughts arise after the lesson. Research we have previously conducted on recognizing knowledge of personal thinking awareness regarding problem-solving abilities, known as metacognition (Hidajat et al., 2020), it provides initial information that the results of an activity can be predicted earlier. In further research to deepen metacognition, Hidajat formulated four metacognitive skills: prediction skills, planning skills, monitoring skills, and evaluation skills (Hidajat et al., 2021). This research illustrates the second prediction, which is commonly called follow-up activities for implementation or for conducting subsequent activities to improve the percentage of results.

This research builds upon the gaps identified in previous studies, addressing the unexplored cognitive processes of educators before, during, and after the teaching process to enhance the quality of competencies required for the successful implementation of the Independent Learning initiative (Fuadi & Aswita, 2021). Lesson study is a highly effective learning model for exploring data, as the "do" stage is the data collection phase (Purba, Suyanti, & Juwitaningsih, 2021), which can serve as an initial diagnostic for making predictions as a preliminary step in metacognitive skill activities (Veenman et al., 2004).

This research has two objectives: 1) To understand and classify the cognitive processes of teachers before, during, and after the learning process; and 2) To evaluate the effectiveness of lesson study in supporting data collection and

enhancing the digital competence of teachers. The structure of the problem-solving approach involves several stages. 1) Preparing instruments for assessing metacognitive skills at three data collection points: before learning, during learning, and after learning; 2) Conducting learning sessions using the lesson study model; 3) Collecting data at three stages of the lesson study process: data before learning (Plan), data during learning (Do), and data after learning (See); and 4) Involving various participants, including students, teacher education students, teachers, and school principals.

State of the art and novelty. Based on previous research, the focus has still been on the implementation of Lesson Study (LS) to improve teacher competence (Farida, 2016; Murtisal et al., 2016; Susanto et al., 2016), and many researchers still discuss the influence of metacognition on problem-solving and enhancing learning motivation (Anggo et al., 2014; Hasbullah et al., 2017; Lata & Bala, 2018; Tachie & Molepo, 2019). This research explores the cognition of teachers using the Lesson Study model through metacognitive skills and digital competence to enhance self-learning competence, this is a new study and has not been discussed before. This research emphasizes what teachers think at three different times: before, during, and after learning. If this data is later collected, it will undoubtedly provide new capital for future research, because these data findings will later build a new strategy on how and what should be done before, during, and after learning. If all these points are met, it could become a new policy that is recommended to be implemented in the recapitulation of the education curriculum, where at the very least, a teacher will make changes in their teaching practices.

Method

The acquisition of research data up to the evaluation stage to draw conclusions as answers to the research objectives using procedures on metacognitive skills through the implementation of lesson study in learning. The researchers conducted a thorough examination of the subjects regarding their cognition, did, wrote, and said during the research activities.

The research data is descriptive and then described to obtain a natural picture of educators' metacognitive skills before, during, and after teaching. The research approach used to achieve the objectives of this study is qualitative research, characterized by four features: (1) it focuses on processes, understanding, and meaning; (2) the researcher is the primary instrument in data collection and analysis; (3) the research process is conducted inductively; and (4) the data

presentation is in descriptive form, consisting of words and images (Merriam & Tisdell, 2016; Rijali, 2018; Yoon & Uliassi, 2022). The characteristics of the qualitative approach in this research are as follows: First, this research design is natural. The data source is the model lesson study teacher who has prepared the material to be taught, and there was no special treatment given to the research subjects before the interviews. Secondly, the main instrument in this research is the researcher, who acts as the interviewer. Thirdly, this research places greater emphasis on "what is thought" and "why it is thought" by the research subjects than the products they produce (Risnanosanti, 2016; Vitantri & Asriningsih, 2016). The research does not formulate a hypothesis before data collection. Thus, the data processing is not just testing a hypothesis but making the data processing inductive. Fourth, the data collected from this research consists of information provided by the research subjects, specifically regarding metacognitive skills in the material presented.

The subjects of this research are teachers who are capable and prepared in the lesson study model. The selection of subjects is carried out through the plan meeting as an initial step in the lesson study, where all researchers and teachers are present at the school where the research takes place. This research was conducted at the Veteran Vocational High School in Sukoharjo Regency. The data collection of this research was done through observations, written materials, and interviews conducted with research subjects through model lesson study teachers. The data analysis technique in this study was conducted using an interactive model (Ary et al., 2018; Creswel, 2017). Miles proposed three stages of qualitative data analysis, which include data condensation, data presentation, and conclusion drawing (Miles et al., 2014).

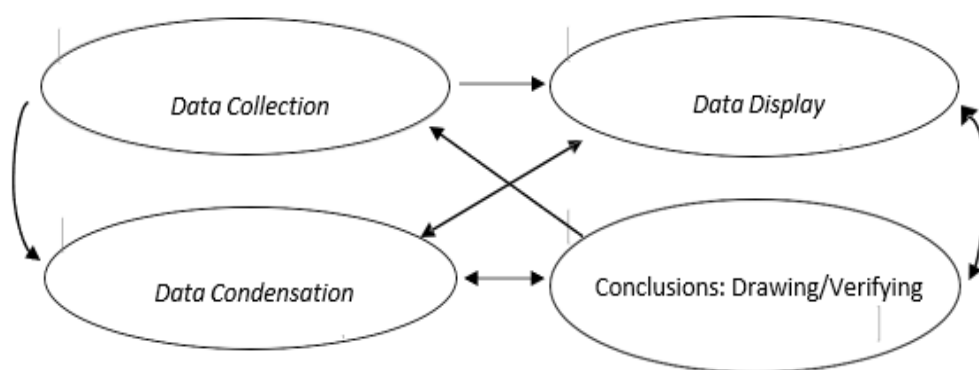


Figure 1: Components of Interactive Model Data Analysis

In more detail, data analysis is carried out with the following steps: 1) Data review: Data review is conducted by creating transcripts from observations, interviews, and documentation. Observation data includes researcher notes and

subjects' answers to instrument questions; 2) Data condensation: the process of selecting, focusing, simplifying, abstracting, and transforming data from researcher notes, interview transcripts, documents, and other empirical materials. Data condensation is carried out on interview data that has undergone credibility testing and is deemed credible; 3) Data presentation: The reduced data is organized and arranged in relational patterns so that it is easy to understand, presented with descriptions in the form of words, charts, and inter-category relationships. The researcher organizes the relevant data to become meaningful information; 4) Data interpretation: interpreting the obtained data to draw conclusions; and 5) Conclusion drawing: The final stage of data processing activities is drawing conclusions based on the findings from data analysis.

The validation results of each instrument used are as follows: 1) Observation: Validation is conducted through data triangulation by repeatedly observing the model teacher's activities and comparing the observation results with interview and documentation data. Interview; 2) Validation through member check by asking subjects to confirm the accuracy of the interview transcripts; and 3) Documentation: Validation is conducted by cross-checking with other data to ensure the consistency of the obtained information.

Results

This is the research results:

Table 1. Answers on Metacognitive Skills of Two Subjects during Planning

Stages of Metacognitive Skills During Plan	Answer Subject 1 (S1)	Answer Subject 2 (S2)
<p>Prediction: How do you predict students will interact with the material during the lesson, and what do you expect students to demonstrate their understanding?</p>	Students engage in learning through an open-ended approach and enthusiastically respond to the material because it is new to them.	Students engage in learning through an open-ended approach and enthusiastically respond to the material because it is new to them.
<p>Planning: How do you plan the steps to achieve learning objectives and address potential difficulties that students may encounter?</p>	The plan includes initial diagnostic tests, communication with teachers regarding the characteristics of the students, observation, the creation of teaching modules according to the characteristics of the students, and the implementation of student-centered learning strategies.	The plan includes diagnostic tests, the development of a learning design with strategies that suit the characteristics of the students, the implementation of student-centered learning, and reflection together with the students.
<p>Monitoring: How will you monitor students' understanding during the lesson, and what indicators will you use to assess whether students understand the material?</p>	Monitoring students' understanding by frequently interacting, asking questions, and providing exercises. Also, offering scaffolding will encourage students to be more enthusiastic about learning.	Continue interacting with the students, asking about their understanding, and applying scaffolding as needed
<p>Evaluation: How would you assess the effectiveness of your lesson plan, and what criteria would you use to evaluate the lesson?</p>	Discuss with the field supervisor, mentor teacher, and colleagues to evaluate the effectiveness of the lesson plan.	Reflection will be conducted with the supervising teacher, field supervisor, and fellow students to evaluate the learning experience.

Table 2. Responses of Two Subjects' Metacognitive Skills During Do

Stages of Metacognitive Skills During Do	Answer Subject 1 (S1)	Answer Subject 2 (S2)
<p>Prediction: How do you predict students will interact with the material during the lesson, and what do you expect students to demonstrate their understanding?</p>	Students will be enthusiastic and eager to learn, actively asking questions, answering, and working on problems competitively.	Students actively ask questions related to the material and are able to answer the questions posed by the teacher.
<p>Planning: How do you ensure that students are actively engaged in lessons and plan adjustments to teaching methods if students encounter difficulties?</p>	The plan includes initial diagnostic tests, communication with teachers, observations, teaching modules made to the characteristics of the students, and student-centered learning strategies.	The plan includes diagnostic tests, learning designs made to the characteristics of the students, student-centered implementation, and reflection with the students.
<p>Monitoring: How do you monitor student engagement during lessons, and what do you do to ensure students stay focused and motivated?</p>	Always interact with the students, remind them to stay focused, move around, and provide scaffolding.	Engaging in two-way interaction during learning and applying scaffolding as needed for the students.
<p>Evaluation: How do you assess students' understanding of the material taught, and what do you do to determine whether your teaching methods are effective?</p>	Formative and summative assessments, student worksheets, and activities for answering questions.	Formative assessment and reflection by asking about the understanding of the material.

Table 3. Responses of Two Subjects' Metacognitive Skills During See

Stages of Metacognitive Skills During See	Answer Subject 1 (S1)	Answer Subject 2 (S2)
<p>Prediction: What is your prediction about students' learning outcomes compared to the actual results, and what have you learned from that prediction regarding students' responses to the lessons?</p>	The outcomes is not different from the initial predictions. If students are enthusiastic and motivated, the material can be easily understood, and the learning objectives can be achieved	The students appeared enthusiastic during the learning process, achieving optimal learning outcomes.
<p>Planning: How will you plan the next lesson based on this reflection, and what changes will you make to your teaching plan?</p>	Improving what is not suitable, learning strategies and methods, and enhancing knowledge about learner-centered strategies and approaches.	Applying better learning than before, seeking references, and discussing suitable learning strategies.
<p>Monitoring: How will you monitor changes in student understanding in the next lesson, and what indicators will you use to assess the improvement in student understanding?</p>	Questions to stimulate and initial appreciation to monitor changes.	Aperception and triggering questions for students.
<p>Evaluation: How do you assess the overall teaching and learning process, and what have you learned from this evaluation that can be applied in the future?</p>	I reflected with the students, supervising teachers, field supervisors, and colleagues after the teaching and learning process was completed. This learning experience serves as a foundation to enhance my competencies as a teacher.	I conducted a reflection activity with the students, the field supervisor, the mentor teacher, and other fellow students. The results of this reflection will help me provide a better learning experience in the future.

Table 4: Effectiveness of the Lesson Study in the Research Data Collection Process

Aspects of the Lesson Study	Effectiveness
The purpose of the lesson study	<ol style="list-style-type: none"> 1. Enhancing teachers' competencies in teaching. 2. Understanding students' metacognitive skills. 3. Strengthening professionalism and the teaching community. 4. Building more coherent instruction across classes. 5. Connecting individual teaching with the long-term vision shared by the school.
Measured Results	<ol style="list-style-type: none"> 1. Improvement of teachers' knowledge and confidence. 2. Norms and routines of professional learning. 3. Routines and learning tools. 4. Student learning outcomes.
Theoretical Perspective Used	<ol style="list-style-type: none"> 1. Knowledge integration environment. 2. Self-determination theory. 3. Self-efficacy theory. 4. Pedagogy of practice.
Phase Lesson Study	<ol style="list-style-type: none"> 1. Study. 2. Plan. 3. Do. 4. See.
Reflection Questions	<ol style="list-style-type: none"> 1. How effective is our work during each phase? 2. What worked well, and what needs improvement? 3. How can we improve the lesson study process in the future?

The research subjects were observed over one complete cycle of lesson study, which included the planning (Plan), implementation (Do), and reflection (See) stages, each lasting one week, resulting in a total observation duration of three weeks. The mathematics material provided includes algebra topics that are linear and quadratic equations and their applications in everyday life. In the planning stage, the teacher designs the lesson by considering the students' difficulties, develops an inclusive plan, and uses active learning strategies. In the Do stage, the teacher delivers the material using interactive methods, collaborates with students to solve mathematical problems, and provides detailed explanations. In the See stage, the teacher assesses students' answers through reflection and discussion, identifies the section of the lesson that needs improvement, and plans adjustments for the next lesson. Interview excerpts from the research subjects cover various stages: "I predict that students will be enthusiastic about learning because this material is very applicable in everyday life," at the Plan stage; "During the lesson, I saw students very actively asking questions and trying to understand the new

concepts", at the Do stage; and "Reflections show that students are able to understand the material better when given real-life examples," at the See stage.

Observation data includes field notes from each stage of the lesson study. At the planning stage, the records show that the subjects prepared teaching materials and anticipated student difficulties. At the Do stage, the records indicate active student participation and the teacher's use of scaffolding methods. At the See stage, reflections show that students were able to answer evaluation questions well. Research data also showed an increase in digital competence in independent learning through the use of digital platforms for uploading teaching materials, digital interaction, and digital evaluation tools. The digital platform Google Classroom helps teachers upload teaching materials and assign tasks, while digital communication applications are used for discussions and Q&A during lessons. Teachers also use digital evaluation tools to measure student progress, indicating that students engaged in digital learning can use technology to complete learning tasks.

Discussion

In Table 1, the responses of the two subjects regarding metacognitive skills during the planning phase showed that Subject 1 predicts that students will respond to the material enthusiastically due to the new learning approach for them, while Subject 2 states that the learners are able to understand the material and implement it in their daily lives. In the planning skills for the bachelor's degree, it involves initial diagnostic tests, communication with teachers, observation, and the creation of teaching modules according to the characteristics of the students, while the master's degree includes diagnostic tests, the preparation of learning designs, the implementation of student-centered learning, and reflection with the students. In the monitoring skills, S1 monitors student understanding by interacting, asking questions, and using scaffolding to enhance students' learning motivation, while S2 continues to interact with learners, inquiring about their understanding, and applying scaffolding as needed. In the evaluation skills of a bachelor's degree, the effectiveness of lesson plans is assessed through discussions with observers, while in a master's degree, reflection is conducted with observers to evaluate the learning process. From the description of the data, it provides an overview of how two subjects (S1 and S2) think and plan learning in the planning stage. S1 is more focused on student responses and strategies such as scaffolding, while S2 emphasizes student understanding and collaborative reflection. The implications of this data help us understand the role of metacognitive skills in planning and

evaluating learning. S1 highlights the importance of interaction and adaptation during the learning process, while S2 emphasizes the significance of student understanding and reflection as part of the evaluation.

The two subjects' responses indicate planning involving diagnostic testing, teacher communication, observation, and student-centered learning strategies. Compared to previous research that also explored the application of lesson study in enhancing 4C skills (critical thinking, collaboration, communication, and creativity) in learning, it resulted in teachers designing learning plans that are suitable for classroom conditions and improving their teaching practices (Fitriati, Rosli, Iksan, & Hidayat, 2023; Radifan & Dewanti, 2020). From Table 1, we see that both subjects have planned well and paid attention to the characteristics of the learners. This indicates progress in the use of metacognitive skills at the planning stage.

In Table 2, the answers regarding the metacognitive skills of the two subjects during Do indicate that S1 predicts that students will interact with the material enthusiastically and actively. They will ask questions, answer them, and work on problems competitively. Meanwhile, the master's program hopes that students will actively ask questions related to the material and be able to answer the questions posed by the teacher. The planning action for undergraduate programs involves initial diagnostic tests, communication with teachers, observations, teaching modules tailored to the characteristics of students, and student-centered learning strategies. Meanwhile, graduate programs include diagnostic tests, lesson designs according to student characteristics, student-centered implementation, and reflection together with the students. In the session, monitoring student engagement involves interacting, reminding them to stay focused, circulating, and providing scaffolding. Meanwhile, S2 engages in two-way interaction during the learning process and applies scaffolding as needed for the students. In the evaluation stage, the undergraduate program uses formative and summative assessments, student worksheets, and activities that involve answering questions to evaluate students' understanding of the material, while the graduate program conducts reflections by asking about their understanding of the material as part of the evaluation.

If we evaluate further from Table 2, we see that both subjects have planned well and paid attention to the characteristics of the learners. This indicates positive progress in using metacognitive skills at the Do stage. These findings differ from previous researchers who found that lesson studies can enhance 4C skills in learning (Putra & Nurlizawati, 2019; Yulianto, 2023).

Table 3, which contains the responses regarding the metacognitive skills of two subjects at the See stage in the context of the lesson study, reveals several relevant findings. At the prediction stage, Subject 1 stated that the students' learning outcomes were not significantly different from the initial predictions. If students are enthusiastic and motivated, the material can be easily understood and learning objectives are achieved, while S2 observes that learners appear enthusiastic during the lessons and reach optimal learning outcomes. In the planning stage, undergraduate students make improvements on aspects that are lacking, learn strategies and methods, and enhance their knowledge about student-centered approaches, while graduate students focus on implementing better learning than before and seek references as well as engage in discussions for suitable learning strategies. During monitoring, S1 will observe changes in students' understanding by using prompting questions and initial apperception, while S2 will utilize apperception and prompting questions with the learners to monitor students' understanding. At the end of the undergraduate evaluation, a reflection is conducted with the students and all observers after the teaching and learning process is completed, resulting in a learning experience that serves as a foundation for improving competencies as a teacher. Meanwhile, in the master's program, conducting reflection activities with students and all observers leads to a better learning experience for future preparations.

Previous researchers' findings indicate that implementing lesson studies using discovery learning and problem-based instruction methods can enhance student activity in the learning process (Sutiarso, 2014; Wulandari et al., 2015). Compared to this research based on both subjects, it shows that planning and monitoring have been carried out well, meaning there has been progress in using metacognitive skills at the See stage, with results aligning with expectations and demonstrating the accuracy of predictions.

Table 4: Assessing the effectiveness of a lesson study is conducted by measuring the increase in knowledge and confidence of the educators, norms and routines of professional learning, learning routines and tools, and student learning outcomes. The theoretical perspectives used are: knowledge integration environment, self-determination theory, self-efficacy theory, and practice pedagogy. The phases of the lesson study observed are: study, plan, do, and see. The reflection questions are: 1) How effective is our work in each phase? 2) What worked well and what needs improvement?; and 3) How can we enhance the lesson study process in the future? From this, it shows that the implementation of The Lesson Study in the data collection process of research is very effective in: 1) improving teachers' competencies in teaching; 2) understanding students' metacognitive skills; 3)

strengthening professionalism and the community of teachers; 4) building more coherent instruction across classes; and 5) connecting individual teaching with the long-term vision shared by the school.

In learning digitalization, the research subjects use software such as Google Classroom, Zoom, and Microsoft Office to support the learning process at every stage of the lesson study. They also use hardware such as laptops and projectors to help deliver the material effectively. The digital competencies possessed by both research subjects include using digital platforms to upload teaching materials, interact with students through digital communication applications, and use digital evaluation tools to measure student progress.

At the planning stage, the use of software assists in preparing teaching modules and diagnostic tests that are distributed digitally. The subject uses Google Classroom to upload teaching materials and Zoom for initial communication with students. In this stage, the teacher demonstrates skills in planning and predicting students' learning needs through digital tools. In the Do stage, hardware and software deliver material interactively and interact with students. For example, projectors and digital presentations are used to clarify the algebra concepts being taught. Teachers also use digital communication applications to monitor student interactions and provide immediate feedback. At the See stage, digital devices are used to reflect and evaluate learning. Teachers use digital evaluation tools, such as online quizzes and reflection forms in Google Classroom, to assess students' understanding and obtain feedback on the effectiveness of the learning process. These digital skills are closely related to their metacognitive skills in predicting, planning, monitoring, and evaluating learning, thereby supporting the improvement of learning competencies and providing a better learning experience for students.

The use of technology not only enhances teachers' digital competencies but also enriches the learning process by providing various tools to support metacognitive skills. Through the integration of software and hardware, both subjects of the study are able to provide more adaptive, interactive, and effective learning, thereby helping students achieve learning objectives more holistically. This findings shows how cognitive skills and digital competencies can collaborate to improve the quality of education and better prepare students to face future challenges.

Conclusion

Based on the results and discussion, it can be concluded that: 1) Before, during, and after the learning process, an educator has various preparations and reflections, namely: a) Before Learning (Plan): i) An educator conducts an initial analysis, understands the characteristics of the students, and prepares a lesson plan; ii) focuses on the students' conditions, learning styles, and the teacher's competencies; and iii) The main goal is to design a relevant and effective lesson plan. b) During Learning (Do): i) The educator implements the prepared lesson plan; ii) uses methods and strategies that are appropriate for the material and the characteristics of the students; and iii) actively interacts with the students and collects learning data. c) After Learning (Reflection): i) The educator evaluates the students' learning outcomes and reflects on the learning process; ii) identifies successes and shortcomings in teaching; and iii) improves teaching practices based on reflections and the data obtained. 2) Lesson study provides support for data availability, making it very effective for researchers in the process of collecting research data. The forms of effectiveness highlighted as follows: a) Lesson study as an effective method: i) Lesson study has proven effective in gathering research data because it actively involves teachers in planning, implementing, and reflecting on learning; ii) Teachers use observation, interviews, and documentation methods to collect relevant and accurate data. b) Improvement in learning outcomes: i) Lesson study has a positive impact on student learning outcomes because teaching becomes more focused and relevant; and ii) Students experience an increase in understanding and skills through better learning. c) Collaboration and reflection: i) Lesson study ensures that educators understand and improve the learning process before, during, and after instruction; and ii) With good reflection, educators can enhance the quality of teaching and student learning outcomes.

Suggestions for future research: 1) exploring the use of more diverse and advanced technologies, such as augmented reality or virtual reality-based learning devices, to see how these technologies can further enhance teachers' metacognitive skills and digital competencies; 2) conducting more in-depth research involving larger and more diverse samples to obtain more representative results and stronger generalizations; and 3) further research can examine the long-term impacts of using lesson study and metacognitive skills on teachers' professional development and students' learning outcomes.

Limitations in the Research Methodology Used: 1) Sample Size Limitation: This study involves a relatively small number of research subjects, so the results may not be generalizable to a larger population. A study with a larger sample size is needed to validate the results. 2) Subjectivity bias: The use of qualitative methods

with the researcher as the primary instrument can lead to subjectivity bias in data collection and analysis. Data triangulation and the use of multiple raters can help reduce this bias. 3) Time Limitation: The observation duration covering only one lesson study cycle may not be sufficient to capture deeper and more complex learning dynamics. Longitudinal research can provide more holistic insights, and 4) Variability in Implementation: Differences in the implementation of lesson studies and the use of technology among research subjects can affect the results. More consistent implementation standards and clearer guidelines can help reduce this variability.

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