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Knowledge of Content and Students Rules in Planning Mathematical Literacy Lesson: A Case Study of Preservice Teacher from Bachelor of Mathematics

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ABSTRACT: Knowledge of Content and Student (KCS) is a crucial component of teachers' pedagogical content knowledge because it enables teachers to anticipate students' characteristics and use this knowledge to make appropriate instructional decisions. In the context of mathematics literacy, teachers are expected not only to understand mathematical content but also to anticipate how students engage with contextual mathematical problems. This study aims to explore the KCS of a pre-service mathematics teacher from bachelor of mathematics in planning integrated mathematics literacy instruction. A qualitative case study design was used. Data were collected through observations of lesson plans, questionnaires, and semi-structured interviews and analyzed using methodological triangulation. The findings indicate that the participant developed knowledge about students by identifying their prior knowledge, anticipating learning difficulties, and considering students' interests and motivations before making instructional decisions. These forms of pedagogical anticipation informed the selection of contextual learning tasks, instructional approaches, grouping strategies, and various activities. However, the participants tended to interpret students' readiness for mathematics literacy learning through the lens of prerequisite mathematical knowledge, while explicit anticipation of students' mathematics literacy processes received relatively less attention. This study demonstrates that planning mathematics literacy lessons requires teachers not only to identify prerequisite mathematical knowledge but also to anticipate students' readiness throughout the entire mathematics literacy process. These findings contribute to an understanding of how KCS are applied in mathematics literacy lesson planning and provide implications for strengthening pre-service mathematics teacher education.

KEYWORDS: Knowledge of content and students, mathematical literacy, lesson planning, preservice mathematics teacher

INTRODUCTION

The ability to interpret quantitative information, evaluate data-based arguments, and make reasoned decisions is no longer optional for 21st-century students; it is a prerequisite for fully participating in daily life—from reading statistics in the media to managing personal finances. These competencies are encompassed by the concept of mathematical literacy. The OECD defines mathematical literacy as a person's ability to formulate, apply, and interpret mathematics in various real-life contexts

(2012). This definition emphasizes that mathematical literacy goes beyond mastery of computational procedures; it requires students to recognize the mathematical structures underlying concrete situations, select appropriate problem-solving strategies, and then translate the results back into their original language and context. These three processes—formulating, applying, and interpreting—are interdependent, and a weakness at any stage typically causes the entire contextual problem-solving process to fail, even if students master the necessary calculations.

Empirical data shows that this gap is evident in Indonesia. Results from PISA 2022 indicate that the majority of Indonesian students perform below the minimum proficiency level expected in solving contextual math problems. This pattern is typically not merely a reflection of weak mastery of basic mathematical concepts; it also indicates that students struggle to bridge real-world situations with relevant mathematical representations—or, conversely, struggle to translate mathematical results back into their contextual meaning. In other words, the problem often lies precisely at the points of transition between the real world and the world of mathematics, not merely in the arithmetic operations themselves. These findings suggest that improving students' mathematical literacy requires not only curriculum reform but also well-designed instruction that enables students to develop the processes of formulating, applying, and interpreting mathematics. Reforming curriculum documents alone is clearly insufficient as long as

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teachers in the classroom lack the mindset and repertoire of instructional decisions necessary to guide students through these three processes.

This is where the teacher's role becomes decisive. Teachers play a central role in designing such learning experiences. Designing mathematics literacy lessons requires teachers to understand both the mathematical content and students' ways of thinking about it—two aspects that are often treated separately in teacher training, even though they are most useful when integrated during lesson planning. This perspective is reflected in Knowledge of Content and Students (KCS), one of the domains of Mathematical Knowledge for Teaching proposed by Ball et al. (2008). KCS refers to a teacher's ability to integrate mathematical knowledge with students' prior understanding, potential misconceptions, learning difficulties, and learning needs when making instructional decisions. In practice, it is KCS that enables a teacher to predict which representations will confuse students, which contexts will feel unfamiliar, or which step in a word problem is most likely to be a stumbling block for students, long before the lesson is actually taught. In the context of mathematical literacy, KCS enables teachers to anticipate students' readiness to tackle literacy-oriented tasks and to design learning activities that support students in developing mathematical literacy.

Although the KCS framework is well-established theoretically, its application in the context of mathematical literacy has not been empirically mapped in detail, particularly at the planning stage. Previous studies have examined teachers' Pedagogical Content Knowledge (PCK) in mathematics literacy instruction (Rahayu et al., 2022), but the focus has largely been on what happens inside the classroom: how teachers present material, manage discussions, or respond directly to students' answers. However, limited attention has been paid to how Knowledge of Content and Students (KCS) is applied in lesson planning, particularly how pre-service mathematics teachers develop knowledge about their students and translate it into instructional decisions. Existing research primarily focuses on teachers' classroom practices or their general understanding of mathematical literacy, while little is known about the pedagogical reasoning that underpins lesson planning before instruction begins. In fact, critical decisions—such as selecting problem contexts, determining the sequence of tasks, and deciding when students should work in groups or independently—are largely made before teachers enter the classroom, rather than being improvised on the spot. Understanding this process is crucial because lesson planning provides insights into how teachers anticipate students' prior knowledge, learning difficulties, and learning needs when designing mathematics literacy lessons.

This gap is particularly important to examine among pre-service teachers from the Bachelor of Mathematics. This group generally possesses strong mastery of mathematical content but may not yet have sufficient teaching experience to develop an intuition for how real students react to contextual problems—making it an ideal case for observing how KCS is formed and used in the early stages of a teaching career. Therefore, this study explores how Knowledge of Content and students is reflected in the lesson planning of a pre-service teacher from the Bachelor of Mathematics. Using a qualitative case study approach, this study analyzes lesson plan documents, questionnaire responses, and semi-structured interview data to examine how participants develop knowledge about students and translate that knowledge into instructional decisions when planning mathematics literacy lessons.

METHODOLOGY

Research Design

This study employs a qualitative case study design to explore how a pre-service teacher in a Bachelor of Mathematics program identifies and uses students' prior knowledge when planning integrated mathematics literacy instruction. A case study was chosen because it allows for an in-depth understanding of a specific case within its educational context, enabling the researcher to examine the subject's pedagogical reasoning using multiple sources of evidence.

Research Subject

Research Subject M is an Indonesian preservice teacher from bachelor of mathematics. M was purposively selected because their lesson plans, questionnaire responses, and interview data provided the most comprehensive information regarding the planning of mathematics literacy instruction among all subjects involved in the larger study. Furthermore, the subject demonstrated a systematic lesson-planning process, making this case particularly well-suited to examining how Content and Student Knowledge (KCS) manifest in instructional planning.

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Data Collection

Data were collected from three sources: lesson planning documents, questionnaires, and semi-structured interviews. The lesson-planning documents included teaching modules, student worksheets, presentation slides, and assessment instruments that the participants prepared to teach matrix multiplication. The questionnaire was designed to explore the participants' pedagogical considerations underlying the lesson plans, while the semi-structured interviews were conducted to clarify and confirm the findings obtained from the documents and questionnaire.

Data Analysis

Data were analyzed using thematic analysis in three stages: data reduction, data display, and conclusion drawing. Data from the lesson-planning documents and questionnaires were first analyzed to identify evidence related to Content Knowledge and Student Knowledge in planning mathematics literacy instruction. These findings were then compared with interview data using methodological triangulation to verify the consistency of the subjects' responses and to construct valid interpretations. The analysis focused on how the subjects identified students' prior knowledge, interpreted students' learning characteristics, and translated this information into instructional decisions during lesson planning.

RESULTS

This section describes how Subject M's KCS manifested in the process of planning mathematics literacy lessons on the topic of matrix multiplication. Analysis of interview data and lesson-planning documents revealed three forms of pedagogical anticipation engaged in by the participant before teaching: anticipation of students' prior knowledge, anticipation of students' learning difficulties, and anticipation of students' interests and motivation. These three forms are discussed sequentially in the following subsections.

Anticipating Students' Prior Knowledge

For M, assessing students' prior knowledge is a mandatory step before designing a mathematics literacy lesson. The reason is simple: without adequate mastery of mathematical concepts and procedures, students will struggle to solve contextual problems involving matrix multiplication. To assess this prior knowledge, the participant relies on a cognitive diagnostic assessment administered before instruction begins. This assessment targets students' readiness with basic matrix concepts, matrix operations, and algebraic manipulations. Beyond test results, the participant also takes students' cultural backgrounds into account when designing contextual activities, assuming that familiar contexts will make it easier for students to understand mathematical problems.

The results of the diagnostic assessment showed that many students were still weak in prerequisite mathematical knowledge, particularly the algebraic operations required for matrix problems. From this, M concluded that mastery of these prerequisites would be crucial to students' success in following the matrix lessons integrated with mathematical literacy. However, it should be noted that, although this diagnostic assessment was intended to measure students' readiness for mathematics literacy learning, its content primarily tested prerequisite knowledge rather than explicitly assessing students' ability to formulate mathematical contexts, apply mathematical reasoning, or interpret calculation results.

M then translated this understanding of students' prior knowledge into several instructional decisions. The diagnostic results were used to group students by cognitive readiness and to design tasks with varying levels of difficulty. Participants also selected contextual problems considered relevant to students' daily lives and phrased them in easily understandable language. In other words, while anticipating students' prior knowledge is indeed a crucial foundation for lesson planning, the focus is primarily on prerequisite mathematical knowledge, whereas students' readiness for the mathematics literacy process itself has not been sufficiently addressed.

Anticipating Students' Learning Difficulties

M views the potential for learning difficulties as something that needs to be taken into account from the planning stage. Rather than assuming all students will face the same obstacles, M anticipates that students will struggle to understand matrix multiplication when the mathematical concepts are presented in unfamiliar or overly abstract contexts. This anticipation then shapes M's choices regarding the instructional model, context, and instructional material.

To understand where students' difficulties lie, M draws on three sources: classroom observations, previous teaching experience, and discussions with a mentor teacher. From these, M can identify concepts that students typically find difficult to grasp,

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while also recognizing that unfamiliar contexts can serve as additional barriers. In conclusion, learning activities need to be designed to minimize unnecessary contextual difficulties so that students can focus on the substance of the mathematics.

It was this foresight that led M to choose the Problem-Based Learning (PBL) model combined with the Culturally Responsive Teaching (CRT) approach. The Jember Fashion Carnaval (JFC) was selected as the learning context because it is closely tied to students' daily experiences. In an interview, M explained that a context related to students' cultural background would be easier for them to understand than examples from regions unfamiliar to them. For the same reason, M also crafted contextual problems in an accessible language.

In short, M anticipates learning difficulties primarily based on two factors: how familiar students are with the learning context and how strong their mastery of prerequisite mathematics is. These two considerations do indeed guide important decisions regarding teaching approaches, contextual situations, and instructional content. However, there is still limited evidence that M also anticipates students' difficulties in the process of mathematical literacy itself—for example, difficulties in formulating mathematical contexts, selecting appropriate mathematical models, or interpreting solutions. The instructor's primary focus is on helping students understand mathematical content, rather than diagnosing difficulties throughout the process of developing mathematical literacy.

Anticipating Students' Interests and Motivation

M believes that students' interests and motivation must also be considered when designing mathematics literacy lessons. According to M, students will be more engaged if learning activities align with their level of understanding and connect to meaningful aspects of their daily lives. This belief motivated the participant to design activities intended to elicit active participation throughout the lesson.

To understand students' interests and motivation, M again relied on classroom observations, teaching experience, and direct interaction with students during instruction. Based on this experience, M surmised that students with lower cognitive readiness risk losing confidence when faced with tasks that are too difficult, while students with higher readiness risk becoming bored if the tasks are too easy. Therefore, differences in students' readiness are a critical consideration when designing learning activities.

The participants put this understanding into practice through several concrete decisions. Based on the results of cognitive diagnostic assessments, students were grouped by readiness level and given contextual problems of varying complexity. M explained that this differentiation is intended to ensure that tasks remain proportionally challenging for each group—students with low readiness remain motivated because the tasks are still achievable, while students with high readiness continue to be challenged by more demanding problems. The context of the Jember Fashion Carnaval (JFC) was also incorporated to increase students' familiarity with the learning situation and to make the math problems more engaging.

Thus, M's efforts to anticipate students' interests and motivation rely heavily on two factors: students' cognitive readiness and their familiarity with the context used. These considerations guide decisions regarding task differentiation, grouping strategies, and the selection of contextual material. Nevertheless, these decisions rely more on the participants' pedagogical judgment and teaching experience than on a systematic identification of students' interests or motivational characteristics before instruction begins. In other words, students' interests and motivation are anticipated indirectly—through assumptions about their learning needs—rather than explicitly diagnosed during the planning process.

Overall, these findings demonstrate how M's KCS is reflected in lesson planning decisions. Before designing a mathematics literacy lesson, M actively explored students' prior knowledge, anticipated potential learning difficulties, and considered factors influencing students' interests and motivation. These three forms of pedagogical anticipation, in turn, guided the selection of learning approaches, contextual tasks, grouping strategies, and activity differentiation. Nevertheless, M's anticipation of students' needs still relies largely on prerequisite mathematical knowledge and general teaching experience. Students' readiness to engage in the process of mathematical literacy itself—formulating, applying, and interpreting mathematics in contextual situations—has received little explicit attention during the planning stage. In other words, M has already demonstrated an emerging integration of content knowledge and student-centered approaches, although their anticipation of students' own mathematical literacy processes remains relatively limited.

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DISCUSSION

The findings of this study indicate that lesson-planning decisions by pre-service teachers from bachelor of mathematics programs are consistently preceded by pedagogical anticipation of students' characteristics. Before determining instructional strategies, pre-service teachers strive to understand students' prior knowledge, anticipate potential learning difficulties, and consider factors that influence student engagement during learning. These considerations then inform the selection of contextual problems, instructional approaches, various tasks, and grouping strategies. These findings align with the case study by Lestari et al. (2019) on a prospective mathematics teacher designing a mathematics literacy lesson on the topic of relations and functions: in that study, knowledge of content and students also emerged as the foundation guiding the prospective teacher's decisions in developing instructional materials, rather than merely serving as standalone background information.

This pattern also aligns with the central concept of knowledge of content and students proposed by Ball et al. (2008), which emphasizes that effective teaching requires teachers to integrate mathematical content knowledge with knowledge of how students tend to think, respond, and learn specific mathematical ideas. Hill et al. (2008) expand on this idea by showing that KCS is topic-specific: teachers' knowledge about students is not universally applicable but is closely tied to the specific mathematical topic being taught. This is consistent with the findings of this study, as participants' knowledge about students was shaped specifically around the topics of matrices and algebraic operations—the planned lesson content—rather than as general knowledge about students' overall characteristics.

In this study, knowledge about students does not stop at the descriptive stage but serves as the basis for pedagogical decision-making. Preservice teachers interpret information from diagnostic assessments, classroom observations, prior teaching experiences, and students' cultural backgrounds to anticipate how students will respond to planned mathematics literacy lessons. This process can be understood through the "professional noticing" framework by Jacobs et al. (2010), which divides teachers' abilities into three sequential components: attending to information about students, interpreting it, and then deciding on a pedagogical response. These three components appear to occur sequentially in participants' planning practices, although the context differs from that of the original study by Jacobs et al., which observed classroom interactions directly rather than the planning stage prior to instruction. This process also aligns with what Jatisunda et al. (2025) refer to as "prospective analysis" within the framework of Didactical Design Research: in their case study of a prospective mathematics teacher, a prospective analysis of possible student responses and learning barriers was conducted before instruction began, serving as the basis for the didactic decisions made by that prospective teacher—a pattern structurally similar to the anticipatory process observed in the participants of this study.

Therefore, the findings of this study reinforce the view that knowledge of content and students should be understood not merely as a teacher's awareness of student characteristics, but as a process of pedagogical reasoning, in which knowledge about students is transformed into instructional decisions. This perspective emphasizes that anticipating students' needs is integral to lesson planning, particularly when teachers design learning experiences that connect mathematical ideas to real-world contexts.

Another finding indicates that preservice teacher from bachelor of mathematics interpret students' readiness for mathematical literacy primarily through the lens of prerequisite mathematical knowledge. Pre-service teachers recognize the importance of contextual learning and design lessons intended to support mathematical literacy, but the information they use to anticipate students' readiness largely stems from students' mastery of prerequisite mathematical concepts and procedures, particularly algebraic operations and basic matrix concepts. Attention given to explicitly diagnosing students' readiness to formulate contextual situations mathematically, use mathematical reasoning to solve contextual problems, or interpret mathematical results in real-world situations remains limited. This tendency to focus on procedural mastery is also evident in the study by Fuadiah et al. (2022), which designed a hypothetical learning pathway for the topic of systems of linear equations in two variables: the prospective analysis phase of that study indicated that students' learning obstacles in algebraic topics stem largely from their understanding of the meaning of symbols and the equals sign, rather than solely from an inability to perform calculations — a nuance relevant to the topic of matrix algebra in this study, as it indicates that "prerequisite algebraic knowledge" itself is not a single concept but encompasses a conceptual understanding of symbols that is not always captured through procedural assessment alone.

This trend is also evident on a broader scale. A survey by Lestari et al. (2023) on the readiness of secondary school mathematics teachers to teach literacy and numeracy under the Merdeka Curriculum found that teachers' readiness still needs strengthening, particularly in applying literacy and numeracy in instruction, rather than merely mastering mathematical concepts.

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The findings of this study reveal a consistent pattern at the individual level: participants were relatively confident in assessing students' readiness in procedural mastery, but had not yet fully addressed students' readiness in the broader process of mathematical literacy.

This trend is also evident in the PISA framework for mathematical literacy, which divides the mathematical literacy process into three activities: formulating, employing, and interpreting mathematics in real-world contexts (OECD, 2017). Preservice teachers' expectations regarding students' readiness largely stop at the "employ" aspect—mastery of the mathematical procedures and concepts needed to solve problems—and do not yet extend much to the "formulate" and "interpret" aspects, namely, students' ability to transform contextual situations into mathematical models and to reinterpret the results of calculations within their original context.

It is understandable that pre-service teachers rely on prerequisite mathematical knowledge as the primary basis for planning mathematics literacy lessons, since mathematics literacy requires students to apply the knowledge they have acquired. However, prerequisite mathematical knowledge alone may not be sufficient to fully describe students' readiness. Students who demonstrate adequate procedural knowledge may still struggle to translate contextual situations into mathematical representations, select appropriate models, or interpret solutions meaningfully. Schukajlow et al. (2023) provide empirical evidence for this condition: through experimental and qualitative studies of high school students working on open modeling problems, they found that identifying unknown quantities and formulating realistic numerical assumptions were the primary cognitive barriers to transforming real-world situations into mathematical models, and that students who actually knew the necessary assumptions could still fail to incorporate them into the mathematical models they constructed. In other words, students may have a solid grasp of algebraic and matrix operations, yet still struggle at the stage of constructing a model from a given contextual situation, because these difficulties stem from the modeling process itself—including the difficulty of recognizing incomplete information and making reasonable assumptions—rather than from a lack of procedural proficiency.

These findings have implications for mathematics teacher education, particularly in pre-service teacher preparation programs. In line with the recommendations of Lestari et al. (2023) which emphasize the need to strengthen teachers' readiness to apply literacy and numeracy—rather than merely equipping teachers with mastery of mathematical concepts—developing the capacity to design mathematics literacy lessons must involve not only preparing teachers to identify prerequisite mathematical knowledge, but also strengthening their ability to assess students' readiness throughout the mathematical literacy process, including during the formulation and interpretation stages. This type of diagnostic information can support more responsive lesson planning, as it allows teachers to anticipate not only what students know mathematically, but also how students engage with contextual mathematical problems. Thus, strengthening teachers' and students' content knowledge for mathematical literacy requires expanding teachers' pedagogical focus, from merely prerequisite mathematical knowledge to students' overall mathematical literacy process before instruction begins.

CONCLUSION

This study explores the Knowledge of Content and Student (KCS) of a preservice teacher from bachelor of mathematics in planning integrated mathematics literacy lessons. The findings indicate that pre-service mathematics teachers with a mathematics background develop knowledge about students by considering students' prior knowledge, anticipating learning difficulties, and taking into account students' interests and motivation before making instructional decisions. This pattern of pedagogical anticipation informs the selection of instructional approaches, contextual learning tasks, diverse activities, and grouping strategies, demonstrating that knowledge about students plays a crucial role in lesson planning.

Nevertheless, pre-service teachers' anticipation of students' readiness for mathematical literacy is primarily based on prerequisite mathematical knowledge, rather than on students' overall mathematical literacy processes. Pre-service mathematics teachers with a background in mathematics recognize the importance of contextual learning and design lessons intended to support mathematical literacy; however, the attention given to explicitly diagnosing students' abilities to formulate, apply, and interpret mathematics prior to instruction remains limited. These findings suggest that anticipating students' readiness for mathematical literacy must go beyond identifying prerequisite mathematical concepts and also include an understanding of how students engage with the overall process of mathematical literacy.

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This study contributes to the literature on knowledge of content and students by describing how pedagogical anticipation shapes lesson planning decisions in mathematics literacy instruction. These findings highlight the need for pre-service teacher education programs to strengthen pre-service teachers' capacity not only to identify prerequisite mathematical knowledge but also to assess students' mathematics literacy processes before designing instruction. Since this study examined a single subject, its findings are intended to provide an in-depth understanding of a single case, rather than broad generalizations. Future research could investigate similar phenomena among participants with different educational backgrounds or teaching contexts to enrich our understanding of Content Knowledge and Students in mathematics literacy lesson planning.

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