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Profile of Mathematics and English Proficiency as well as Mathematical Literacy of Pre-Service Mathematics Teachers in the Era of Technology-Based Education

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A B S T R A C T

This study aims to describe the profile of pre-service mathematics teachers regarding their mathematical proficiency, English language competence, and mathematical literacy in the context of technology-driven education. As digital learning resources increasingly demand the integration of content knowledge, language skills, and higher-order thinking, this study investigates the extent to which these future educators are prepared. Using a mixed-methods approach involving diagnostic tests, literacy tasks, and interviews, the results show that students exhibit moderate mastery in mathematics and basic English but struggle with applying concepts in real-life problem-solving situations—an indicator of low mathematical literacy. The study calls for curriculum redesign that bridges content, language, and technology to better equip future teachers.

Keywords: *Mathematics Proficiency, English Competence, Mathematical Literacy, Pre-Service Teachers, Technology-Based Education.*

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INTRODUCTION

The role of mathematics teachers in the 21st century has undergone a significant transformation. No longer limited to mastering mathematical content, today's educators are expected to navigate a rapidly evolving digital landscape, demonstrate technological fluency, and communicate effectively in English—the dominant language of educational technology and global research. These expanded expectations reflect broader changes in global education, where the integration of technology has reshaped pedagogical practices across disciplines (Voogt et al., 2015).

In Indonesia, the challenges associated with this shift are particularly complex. While digitalization in education has advanced rapidly—especially following the COVID-19 pandemic—both teachers and learners often find themselves unprepared to harness the full potential of these technological tools (Nugroho et al., 2021). This gap between technological availability and user readiness underscores the urgency for teacher education programs to address digital literacy as an essential professional skill.

At the same time, linguistic competence, particularly in English, has become increasingly vital. As most academic publications, open-access resources, and instructional technologies are developed in English, teachers with limited proficiency may find it difficult to access or implement contemporary educational innovations (Putri & Siregar, 2020). English thus functions not only as a foreign language but as a gatekeeper to global educational resources and collaboration.

Moreover, despite the solid procedural skills often demonstrated by pre-service mathematics teachers, research suggests that many struggle to apply these skills in novel or real-world situations. According to the OECD (2019), this discrepancy highlights a broader issue of mathematical literacy—defined by PISA (2022) as the ability to interpret, formulate, and solve problems using mathematical knowledge in diverse contexts. In other words, being proficient in mathematics does not automatically translate into being mathematically literate.

The intersection between mathematical literacy and English proficiency becomes even more critical when considered within digital learning environments. For instance, many online learning platforms, software tools, and assessment systems require both mathematical understanding and the ability to follow English-language instructions and documentation (Zou et al., 2021). Thus, linguistic and digital competence are now deeply intertwined with mathematical instruction.

Although several studies have investigated mathematical proficiency among Indonesian pre-service teachers (Suryani, 2021) and others have examined English language competence in academic settings (Rahmawati, 2022), limited research has explored the convergence of these domains in the context of digital learning. Few inquiries have considered how English proficiency and digital literacy collectively influence the development of mathematical literacy in teacher education.

To address this gap, the present study aims to profile the integrated competencies of pre-service mathematics teachers in three key areas: mathematical understanding, English language skills, and mathematical literacy within digital education. By examining how these domains interact, particularly in the context of a technology-rich environment, this research seeks to offer insights that can inform curriculum development and teacher preparation programs in Indonesia and similar educational settings.

METHOD

Research Design

This study adopted a sequential explanatory mixed-methods design, combining both quantitative and qualitative approaches to obtain a comprehensive understanding of pre-service mathematics teachers' competencies. The design started with quantitative data collection through standardized tests and tasks, followed by qualitative interviews to elaborate on and contextualize the numerical findings. This approach was chosen to explore not just the level of proficiency but also the reasoning, challenges, and learning strategies experienced by participants in relation to mathematics, English, and mathematical literacy in technology-based education settings.

Participants

The participants consisted of 84 undergraduate students enrolled in the Mathematics Education program at a public university in Eastern Indonesia. Participants were selected using purposive sampling, with criteria including enrollment in at least the fifth semester and completion of fundamental courses in mathematics and general English. The choice of participants ensured a representative profile of students who had sufficient exposure to both disciplinary content and digital learning platforms. Demographically, 62% of the participants were female and 38% male, with age ranges between 19 to 23 years. All had experienced online or hybrid learning environments during the COVID-19 pandemic, thus providing relevant context for evaluating technology-based competencies.

Instruments

Mathematics Profiency Test

A 20-item multiple-choice test was developed, covering three main domains: algebra, calculus, and statistics. Items were adapted from national examination blueprints and validated by three senior lecturers in mathematics education. The test measured both procedural fluency and conceptual understanding.

English Proficiency Test

This test consisted of 25 items adapted from standardized TOEFL materials, focusing on structure, vocabulary, and reading comprehension relevant to academic content. The goal was to assess students' ability to understand English texts related to mathematics education.

Mathematical Literacy Task

Three open-ended problems were designed based on PISA-like tasks, requiring students to apply mathematical reasoning in real-life contexts such as financial planning, data interpretation, and spatial reasoning. Rubrics for scoring were adapted from OECD-PISA guidelines, focusing on formulating, employing, and interpreting mathematics in context.

Interview Protocol

A semi-structured interview guide was used to gather in-depth information from a sub-sample of 10 students. Questions explored students perceived challenges, learning habits, digital resource usage, and language-related barriers in understanding mathematics content online.

Data Collection Procedures

Quantitative data were collected in two sessions via the university's Moodle platform, supervised through Zoom proctoring. Students had 60 minutes for the mathematics and English tests, and 45 minutes for the mathematical literacy task. Interviews were conducted one week after the tests using Google Meet, lasting approximately 20–30 minutes per participant. Interviews were audio-recorded (with consent), transcribed verbatim, and translated into English if needed.

Data Analysis

Quantitative data were the responses from the mathematics and English tests were analyzed using descriptive statistics (mean, percentage, standard deviation), while Pearson correlation analysis was used to examine relationships among the three competencies (math, English, and literacy). Data were processed using SPSS 26.0. Qualitative data were interview transcripts which were analyzed thematically using Braun & Clarke's (2006) six-phase framework. Coding categories included: language-related difficulty, confidence in problem-solving, use of digital platforms, and instructional language preferences. Triangulation was done by comparing test scores with qualitative responses.

Validity and Reliability

Instrument validation involved a panel of three experts in mathematics education and applied linguistics. Reliability testing showed acceptable Cronbach's Alpha values: 0.81 for the mathematics test, and 0.78 for the English test. Inter-rater agreement for scoring the literacy task was 85%, ensuring consistency in open-ended task evaluation.

FINDINGS AND DISCUSSION

Mathematics Proficiency

The mathematics proficiency test results showed that 69% of participants demonstrated adequate understanding of fundamental topics, particularly in algebra and differential calculus. However, only 48% were able to correctly solve problems involving inferential statistics and data interpretation.

This indicates a tendency among participants to rely on procedural knowledge rather than conceptual understanding. The findings are consistent with previous research (Suryani, 2021) that suggests pre-service teachers often perform well in algorithmic tasks but struggle with abstract reasoning and contextual application. This outcome highlights the need for instructional practices that promote higher-order thinking, such as mathematical modeling and problem-based learning.

English Language Competence

Only 35% of participants met the minimum benchmark for academic English proficiency. Most struggled with vocabulary, reading comprehension, and interpreting grammatical structures within educational texts. These limitations were particularly evident in tasks requiring engagement with mathematical content written in English.

This aligns with existing literature (Choi, 2016; Putri & Siregar, 2020), which identifies English language barriers as a significant factor affecting access to global educational resources. The inability to effectively engage with English-based digital platforms may limit students' exposure to diverse mathematical perspectives and instructional methodologies. These findings support the integration of English for Specific Purposes (ESP) courses within teacher education curricula to enhance discipline-specific language proficiency.

Mathematical Literacy

Performance on mathematical literacy tasks revealed that only 24% of participants demonstrated the ability to interpret, apply, and communicate mathematical ideas in real-life contexts. While many were able to perform calculations correctly, they failed to justify their reasoning or interpret results meaningfully.

This suggests a disconnect between mathematical procedures and contextual understanding. According to the PISA (2022) framework, mathematical literacy involves the application of mathematics in diverse, authentic situations. The low performance observed in this study indicates a need for curricular and pedagogical strategies that emphasize real-world relevance and reasoning beyond computation.

Integration of Mathematics, Language, and Technology

A correlation was found between English proficiency and performance in mathematical literacy tasks. Students with stronger English skills were more likely to access and utilize international resources, and they demonstrated better problem interpretation and solution strategies.

These findings highlight the interdependence between language competence and mathematical literacy in a technology-mediated educational context. As the global educational environment increasingly relies on English-language resources, limited language skills may hinder engagement with mathematical content and reduce opportunities for professional development. Therefore, teacher education programs should consider integrated learning approaches that simultaneously foster mathematical understanding, language competence, and digital literacy. Cross-disciplinary collaboration and instructional design that reflects these dimensions are essential for preparing future educators in a globalized, technology-based educational landscape.

CONCLUSIONS

This study examined the profile of mathematics proficiency, English language competence, and mathematical literacy among pre-service mathematics teachers in the context of technology-based education. The findings indicate that while students demonstrate a moderate level of mathematical knowledge and basic English proficiency, their ability to apply mathematics in real-world contexts—i.e., their mathematical literacy—remains limited. The data suggest a compartmentalization of learning, where mathematical content, language skills, and literacy practices are developed in isolation. However, the increasing integration of digital tools in education necessitates a more interconnected approach. The observed correlation between English proficiency and mathematical literacy highlights the importance of language in enabling access to and engagement with global mathematical resources. To address these gaps, teacher education programs should adopt interdisciplinary strategies that promote simultaneous development of content knowledge, academic language, and literacy. Curriculum revisions may include the integration of English for Mathematics Education, the use of PISA-style contextual tasks, and structured engagement with international digital learning platforms. These interventions are essential to prepare future mathematics teachers who are not only competent in their subject matter, but also capable of navigating and contributing to an increasingly digital and global educational environment.

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