Mathematical literacy and ICT integration research in particular real-world problem-solving in education

Emily Warrender June 16, 2025

Professor Goto Joji, an expert in mathematics education, emphasizes the need for university-level mathematics education to develop essential skills in probability, statistics, and functional reasoning, highlighting its relevance to real-world problem-solving and everyday life

Developing mathematical literacy for real-world problem-solving

In today's increasingly digital society, mathematical literacy has become more essential, and the mathematical competencies required in the workforce are becoming broader and more advanced. As a result, mathematics education at university level must aim not only to produce specialists but also to cultivate the mathematical skills relevant to each field for those who will use mathematics in their professions. Recently, the importance of mathematical literacy has been widely recognized even among students outside STEM (Science, Technology, Engineering, Mathematics) fields. There is also a growing awareness of the need to master basic mathematical skills such as probability, statistics and functional reasoning as a basis for data science.

However, there are problems in the development and practice of mathematical literacy education, including isolated lessons that attract only superficial interest, the inability to apply learned examples to new situations, and the tendency to acquire only context-dependent knowledge. In addition, students themselves often lack the awareness that mathematics can be applied to real-world problems.

I specialize in mathematics education and information education, and from the perspective of fostering competence and literacy in university education. I have been involved in research on lesson design that enhances students' intrinsic motivation and promotes autonomy, as well as theoretical research on quantitative literacy concepts and instructional research related to the development of mathematical literacy. Previous research on mathematical problem- solving has shown that students, regardless of their educational level, tend to have narrow and negative views of mathematics. In order to shake up such views of mathematics and transform them into broader, more flexible and positive ones, I believe it is important to provide students with opportunities to re-examine their views and ideas about mathematics by exposing them to different aspects of mathematics through learning experiences that they have not had before. Through my teaching practice, mainly with first-year university students majoring in Humanities and Social Sciences, I have verified the pedagogical effects of promoting mathematical literacy, and, as a result, changes in students' 'views of mathematics' and 'perceptions of the usefulness of mathematics' have been observed. For example, comparisons between the pre and post- questionnaires show an increase in the percentage of students reporting that they 'like' mathematics and perceive mathematics as 'useful for solving real-world problems'. This suggests that students' perceptions of mathematics are shifting from the traditional view of mathematics as a "textbook-based, abstract subject" to a view of mathematics as a "socially and personally meaningful resource related to everyday life and society".

However, challenges remain. One is "context specificity", where learners can only apply mathematical knowledge in familiar contexts. Knowledge also tends to be fragmented and not systematically organized. Educational support is needed to build a comprehensive knowledge system for application. Consider the process of applying functions to solve real-world problems: it begins with clarifying the goal of the problem and then understanding the relationships in the phenomenon (linear, curved, periodic, continuous, discrete, etc.) that reveal the structure of the problem. By combining these characteristics with a conceptual understanding of functions, students get the idea that the phenomenon can be expressed as a function. This marks a semi-formalized transition from a real-world context to a mathematical representation. The next step is to identify and apply the most appropriate function. Finally, students explain their reasoning, check and compare the results, and feed back to the real-world situation. This process suggests that mastery of conceptual and procedural knowledge alone is not enough. Students also need to learn how and when to apply mathematical knowledge in different real-world contexts.

Future challenges and prospects

ICT is highly effective in supporting the learning of mathematical literacy for problem-solving. ICT tools can help to visualize concepts, organize and analyze data and test hypotheses, enabling learners to explore content in greater depth. For example, dynamic graphs of functional changes or spreadsheet-based statistical experiments provide an intuitive understanding not possible with traditional paper materials. In addition, ICT bridges the gap between data science – interpreting phenomena using data – and mathematics, which involves reasoning based on evidence. Learners are expected to develop mathematical reasoning and critical thinking skills through the use of data.

More recently, advanced tools such as generative AI have also gained attention. For educators, generative AI can streamline the creation of contextualized content, problem setting, lesson design and exercise generation. For students, dialogue with AI allows them to explore how mathematics can be used in different contexts and deepen their understanding. For example, using AI-generated scenarios as the basis for data analysis and modelling activities can help link contextual knowledge with mathematical concepts.

The future development of mathematical literacy requires a strong theoretical and practical foundation. This includes organizing the relationships between contextual, conceptual and procedural knowledge and building pedagogical models based on empirical research. Careful consideration needs to be given to the possibilities and limitations of integrating generative AI into education. While AI can provide individualized learning opportunities, it also requires a redefinition of the role of the teacher – from knowledge provider to learning facilitator.

Investment in educational infrastructure is also essential. This includes expanding access to high-quality online resources, developing interdisciplinary numeracy programs and overhauling teacher training. Designing inquiry-based curricula capable of addressing complex societal issues requires interdisciplinary collaboration. The integration of ICT and mathematical literacy provides a basis for improving real-world problem-solving skills. As the educational environment evolves with technological advances, practices that enable meaningful, contextualized mathematics learning are expected to deepen.

Finally, based on previous research and practice, the following policy recommendations are proposed: First, explicitly include the development of mathematical literacy in curriculum design, including for non-STEM students, to promote reasoning. Second, restructure teacher education and training programs to develop teachers who can also act as digital literacy coaches and AI-integrated lesson designers, providing hands-on ICT and interdisciplinary learning opportunities. Third, increase investment in education infrastructure. In addition to expanding access to accessible digital materials, open data and classroom ICT equipment, it is essential to promote the development and dissemination of exploratory, cross-disciplinary learning materials through innovative teaching methods and collaborative efforts. The integration of mathematical literacy and ICT into education policies and systems will contribute significantly to the development of citizens who are able to engage flexibly and critically in society.

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