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MATHEMATICS LEARNING PROCESS THROUGH GAME-BASED METHODS: A PEDAGOGICAL CONTENT KNOWLEDGE PERSPECTIVE

Reni Nuraeni[1], Al Jupri[2*], Elah Nurlaelah[3]
[1,2*,3]Departement of Mathematics Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia
*Correspondence: aljupri@upi.edu

ABSTRACT
Pedagogical Content Knowledge (PCK) is an essential competency for mathematics teachers, as it significantly influences the effectiveness of student learning. This study examines the implementation of game-based learning in mathematics instruction through the lens of PCK. The research was conducted through observations of a junior high school mathematics teacher in Bandung Regency. The primary objective of this study is to analyze the mathematics learning process using the game-based method, focusing on its alignment with PCK principles. Data were collected through classroom observations and unstructured interviews with both teachers and students. A qualitative descriptive approach was employed for data analysis. The findings reveal the following key points: (1) Teachers do not prepare lesson plans or teaching modules before conducting classroom instruction; (2) Teachers' content knowledge requires reinforcement; (3) The formulation of exercises remains simplistic, lacking a range of difficulty levels (easy, medium, difficult), and does not include higher-order thinking skills (HOTS) questions; and (4) There is insufficient reinforcement when students struggle to recall fundamental concepts, such as fractions.
Keywords: Mathematics Learning, Game method, Pedagogical Content Knowledge.

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PRELIMINARY

According to Republic of Indonesia Law Number 14 of 2005, Article 8, concerning teachers and lecturers, educators must possess a set of competencies, including pedagogical competence, professional competence, personality competence, and social competence. These competencies are fundamental in ensuring high-quality education. Competent teachers can effectively design and implement instructional strategies that enhance student learning outcomes.

Teachers have an essential role in realizing quality education (Nuraeni & Juandi, 2023). Continuous improvement of teacher competence is crucial, as it plays a significant role in achieving educational quality. Pedagogical competence and professional

competence, when integrated, form a specialized competency known as Pedagogical Content Knowledge (PCK) (Shulman, 1986). These two competencies are essential for educators, as they encompass both mastery of subject matter and the ability to deliver content effectively to students (Indriani, Hidayah, & Hidayah, 2021; Hadi & Kurniawati, 2022).

Lack of mastery of Pedagogical Content Knowledge in classroom learning practices will result in the learning process in the classroom being hampered. Among them will cause problems, namely teachers having difficulty in transforming material into effective teaching strategies, so that this will find failure when handling student misconceptions, as well as inappropriate delivery of material (Halim and Meerah, 2002).

Pedagogical competence refers to a teacher's ability to manage the learning process effectively (Kurniawan & Astuti, 2017; Murtiyasa & Atikah, 2021). This competency is equally important as subject matter expertise, as it enables educators to create engaging and structured learning experiences. The teacher's pedagogical ability can be seen during the learning process. The learning process is an activity that involves educators and students in achieving a learning goal (Wulandari et al, 2023). Pedagogical Content Knowledge (PCK) involves not only understanding the subject matter but also selecting appropriate teaching approaches, structuring content effectively, and employing strategies that facilitate deeper student comprehension. PCK integrates concept representation, pedagogical techniques, student cognition, and epistemological perspectives, enabling teachers to address student difficulties, misconceptions, and foster meaningful learning.

There are several approaches for teachers to develop PCK, including self-reflection after teaching, engaging in dialogues with students, participating in discussions with fellow educators, attending professional development programs (such as seminars, classroom action research, and courses), joining professional organizations, and contributing to academic publications (Hartati et al., 2019). These strategies ensure that teachers not only understand their subject matter but also grasp its objectives, historical development, and real-world significance.

With the advancement of technology, its presence in various aspects of life, including education, is undeniable. Technology serves not only as a field of knowledge but also as a valuable source of learning and information that facilitates the educational process (Surani, 2019). To adapt to these evolving conditions, teachers must develop technological skills in addition to their pedagogical and subject matter expertise (Vu, 2018).

The integration of content knowledge, pedagogical knowledge, and technological knowledge forms the Technological Pedagogical Content Knowledge (TPACK) framework. TPACK is an extension of Pedagogical Content Knowledge (PCK), which was first introduced by Shulman in 1986 and later expanded to incorporate technology (Koehler et al., 2006; Chuang & Ho, 2011). This framework highlights the interplay between content knowledge (subject matter expertise), pedagogical knowledge (instructional methods), and technological knowledge (effective use of technology in teaching) to enhance the learning experience.

Many students think that mathematics lessons are challenging, boring, and confusing (Mahendra & Sukartono, 2023). The game-based method is one of the instructional strategies employed by teachers to engage students in the learning process. During classroom observations, a mathematics teacher implemented a paper airplane game to facilitate learning. At the beginning of the lesson, the teacher took attendance while informally checking on students' well-being. This approach was beneficial in assessing students' readiness for the lesson. Additionally, the teacher provided a brief review of the previous topic, specifically the different forms of fractions, to reinforce prior learning.

Reinforcement of Fraction material to students through game methods aims to improve students' understanding of Fractions. Learning with game methods will help students build understanding gradually through visual, manipulative, and social representations that are generally difficult to achieve with ordinary practice questions. Learning with this game method will create a fun atmosphere for students, and reduce learning pressure in class.

In the main instructional activity, the teacher incorporated the paper airplane game as an interactive learning strategy. The process involved the following steps: (1) the teacher launched a paper airplane toward the students, (2) the student who caught or was hit by the airplane was required to come to the front of the class, read the question written on the paper, and attempt to solve it on the board, (3) upon completing the solution, the student then threw the airplane to another classmate, continuing the cycle. This method fostered student participation, encouraged engagement, and provided an alternative approach to problem-solving in mathematics.

Research specifically examining how teachers' PCK knowledge is reflected in the application of game-based learning in mathematics is still rare, especially in local contexts such as Bandung Regency. The limitations of this research indicate the need to explore further the role of teachers' PCK in implementing innovative strategies that can improve

the quality of learning. The objective of this study was to examine the mathematics learning process through the lens of teacher PCK at a junior high school in Bandung Regency. The findings contribute to a deeper understanding of how instructional strategies, including game-based learning, align with pedagogical content knowledge in mathematics education.

METHODS

This study was conducted through classroom observations to examine the implementation of mathematics instruction. The observation focused on a single teacher at a junior high school in Bandung Regency. The observation was conducted in Grade VII, specifically in classes VII A and VII B. The number of students observed was 30 in class VII A and 26 in class VII B. The subject observed was Mathematics, focusing on the topic of Fractions. The observation took place from 07.20 to 10.00 AM WIB.

The data collection methods included classroom observations and unstructured interviews. Observations were conducted using the PCK instrument, adapted from Maher et al. (2015). This PCK instrument focuses on observing the learning process, content knowledge, pedagogical content knowledge, and TPACK.

Meanwhile, unstructured interviews were conducted incidentally with both teachers and students, without predetermined interview guidelines. However, all interview questions remained relevant to the learning process and were analyzed from the perspective of the teacher's Pedagogical Content Knowledge (PCK). The reason for choosing this unstructured interview is to explore the deepest meaning and experiences of teachers and students when learning mathematics in class. In addition, it creates a more natural and relaxed interview atmosphere and helps the interviewee feel comfortable and open because the purpose of this interview is to explore subjective meaning, emotions, personal experiences, and deeper perspectives. Although there are limitations to this unstructured interview, namely that it takes longer because the interview process tends to be long because there are many spontaneous questions outside the plan.

The collected data were analyzed using a qualitative descriptive approach, allowing for an in-depth examination of teaching practices and their alignment with PCK principles. Data analysis was carried out by processing qualitative data (observations and interviews) with the aim of describing phenomena based on findings in the field without using statistical techniques. The analysis was carried out through the processes of data reduction, categorization, data triangulation, and verification.

RESULT AND DISCUSSION

The Paper Airplane Game method creates a fun and engaging atmosphere for students. All students remain focused throughout the lesson, as the teacher ensures that every student can follow the learning process effectively. A direct, game-based approach is considered effective, providing an interesting and easily comprehensible learning experience (Pratama et al., 2019; Pratama & Haryanto, 2017).

The use of the game method aligns with Vygotsky's learning theory, which states that games provide students with opportunities to interact, collaborate, and learn from one another. Language plays a crucial role in this theory, as students use it to communicate, plan, and express their thoughts. This method is also consistent with Piaget's learning theory, which emphasizes that students learn actively by exploring and interacting with their environment. The game encourages students to apply their knowledge and skills in engaging and challenging situations, fostering cooperative learning through social interaction and collaboration.

However, the Paper Airplane Game method has certain drawbacks. One major issue is the excessive time consumption, as paper airplanes often land on students who have already participated or fail to reach their intended target due to interference from classroom fans. According to Kalaka, Mustofa, and Dalai (2023), a game is a form of entertainment that can serve as a means to relieve boredom and occupy free time.

Additionally, the questions presented by the teacher are too basic, lacking variation in difficulty levels such as easy, medium, and difficult. The absence of story problems and higher-order thinking skills (HOTS) questions prevents students from developing problem-solving skills and adaptability in tackling various types of mathematical problems.

During the core activity, the teacher does not provide rewards or additional assessments for students who correctly answer questions. When students provide correct answers, the teacher does not document their performance to track progress or identify students who have successfully completed the problems accurately.

While explaining the concept of fractions, the teacher generally understands the material but encounters two key issues. The first is a misinterpretation of decimal numbers, as the teacher incorrectly states the number behind the decimal point as a whole number rather than individual digits. For example, the teacher reads 2.15 as "two point fifteen" instead of the correct pronunciation, "two point one five." The second issue arises in visual representations of fractions, where the teacher incorrectly divides and shades the fractional

areas. The following section presents an excerpt of the errors observed in the teacher's visual representation of fractions.

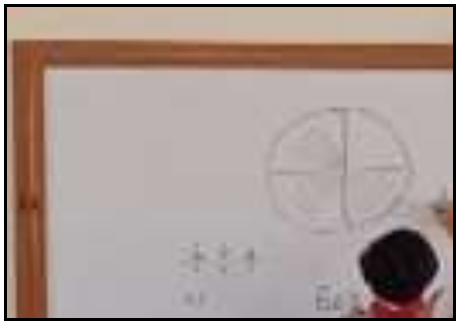

Figure 1. Teacher's Errors in Shading Sub-Division Areas.

One of the errors observed in the teacher's explanation of fractions was the incorrect shading of circular areas. The teacher failed to shade the entire designated area to properly represent a fraction. In Figure 1, unshaded portions remain, which makes it unclear where the fractional boundary lies. To accurately represent a fraction, the entire designated area should be shaded appropriately.

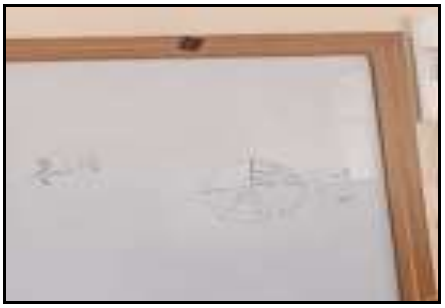

Figure 2: Teacher's Error in Dividing a Region

In Figure 2, a circle is divided into six sections, with four of them shaded. This image was created by a student while solving a problem presented through the Paper Airplane Game. The teacher failed to correct the student's mistake in representing the fraction, as the sections of the circle were not of equal size. A proper representation would require the circle to be divided into six equal parts. This issue was also observed in other classes, where students made the same mistake, and the teacher did not address it. Consequently, it can be concluded that the error originated from the teacher's initial explanation of the basic concept of fractions.

Overall, the teacher demonstrated good pedagogical competence, particularly in delivering engaging lessons using games. The teacher effectively managed the classroom, ensuring students remained focused and actively participated in the learning process. Learning planning is done by first knowing the class conditions and adjusting them to the learning material that will be given to students (Jannah & Setyawan, 2022).

During the unstructured interviews with the teacher and students, it was revealed that mathematics lessons were frequently conducted through games to create a more enjoyable learning experience. During the observation, the teacher used the Paper Airplane Game, in which students solved fraction-related problems written on the airplanes after catching them.

Despite the teacher's competence in instructional delivery, certain shortcomings were noted. While the teacher demonstrated proficiency in preparing teaching materials, no teaching module for fractions was developed for the observed lesson. Instead, the teacher relied on a module from the previous session on whole numbers. This lack of preparation poses a significant issue, as the teacher did not have a structured lesson plan (RPP) outlining instructional strategies, models, and techniques for the lesson.

The teacher's Pedagogical Content Knowledge (PCK) is generally strong, as evidenced by the ability to deliver engaging and effective lessons. Mathematics instruction was conducted in a way that made learning enjoyable, helping students both understand the subject matter and remain motivated. Through games, students can develop a deeper understanding of mathematics (Ulfa & Rozalina, 2019).

At the beginning of the lesson, the teacher checked students' attendance and emotional state, offering encouragement to those who appeared unmotivated. This initial interaction helped foster a supportive learning environment. The teacher then reviewed the previously taught material on different types of fractions before introducing the new content.

During the core learning process, the teacher encouraged students to write their answers on the board, ensuring that all students had the opportunity to participate. However, when a student struggled to answer a question, the teacher immediately passed the question to another student without providing assistance or reinforcement. This practice missed an opportunity to guide students in recalling prior knowledge and building their problem-solving skills.

Furthermore, the teacher demonstrated an understanding of student characteristics and adapted instruction to their developmental stages. The approach aligns with John Dewey's Progressive Education Theory, which emphasizes learning based on students' needs. However, this was evident in the teacher's tendency to present only basic, repetitive problems without incorporating varying difficulty levels (easy, medium, and difficult). The absence of Higher-Order Thinking Skills (HOTS) questions was particularly concerning, as HOTS is essential in modern education (Sakinah & Prihantini, 2022). By integrating

HOTS, students develop skills in reasoning, decision-making, creative thinking, and solving non-routine problems (Anugrahana, 2018; Murray in Sakinah & Prihantini, 2022).

The following section presents an example of a paper airplane question designed by the teacher for this lesson (Figure 3).

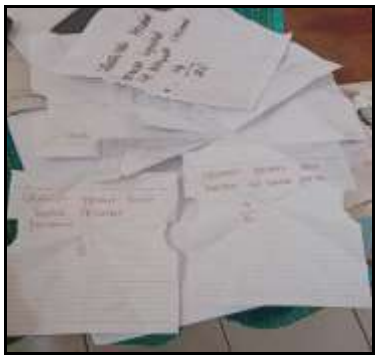

Figure 3. Questions Written on Paper Airplanes.

The teacher did not prepare a lesson plan (RPP) or teaching module for the session, preventing the observer from assessing whether the instructional activities aligned with planned objectives. Additionally, without a structured lesson plan, the observer could not evaluate whether the instructional strategies, methods, and techniques used in the classroom adhered to a coherent pedagogical framework.

CONCLUSION

Based on the analysis of classroom observations in junior high school mathematics, several issues remain that require attention, particularly for educators who play a crucial role in shaping the nation's progress. The identified problems include: (1) teachers do not prepare lesson plans or teaching modules before conducting lessons in the classroom; (2) teachers' content knowledge needs further improvement; (3) the questions presented are overly simplistic, lacking variation in difficulty levels (easy, medium, difficult), with routine question formats and an absence of higher-order thinking skills (HOTS) questions; and (4) insufficient reinforcement is provided to students when they struggle to recall fundamental concepts of fractions.

Based on these findings, several recommendations are proposed: (1) Teachers should prepare lesson plans or teaching modules before conducting lessons to ensure a more structured and well-organized learning process, (2) Teachers should continuously enhance their content knowledge and technological pedagogical content knowledge (TPACK), for instance, by attending mathematics education seminars and engaging in in-depth discussions within teacher associations or with experts in mathematics and

mathematics education, (3) Teachers should incorporate questions with varying levels of difficulty (easy, medium, difficult) and include HOTS questions to develop students' problem-solving skills, (4) Teachers should provide reinforcement when students struggle with fundamental mathematical concepts, (5) Teachers should diversify instructional approaches to prevent monotony and disengagement while ensuring effective time management in the learning process.

The findings of this study provide a real picture of various problems in mathematics learning practices, especially at the junior high school level, including planning, content mastery, presentation of questions, and reinforcement of basic concepts for students. Therefore, these results are not only a reflection for teachers in improving the quality of their teaching practices, but can also be used as a basis for consideration in developing educational policies, especially in learning supervision, teacher training, and curriculum reinforcement. For further researchers, it can be studied further and in-depth, for example regarding the effectiveness of strategies for strengthening basic mathematical concepts through certain approaches.

REFERENCES

Anugrahana, A. (2018). Tinjauan Deskriptif Penerapan Higher Order Thinking dan Problem Based Learning pada Mata Kuliah Geometri Berdasarkan Kemampuan Matematika Mahasiswa. *Scholaria: Jurnal Pendidikan dan Kebudayaan*, *8*(2), 142–156. https://doi.org/10.24246/j.js.2018.v8.i2.p142-156

Chuang, H. H., & Ho, C. J. (2011). An investigation of early childhood teachers' technological pedagogical content knowledge (TPACK) in Taiwan. *Journal of Kirsehir Education Faculty*, *12(*2), 99–117. Retrieved from http://www.doaj.org/doaj?func=abstr act&id=782294&recNo=6&toc=1&uiL anguage=en

Hadi, F. R., & Kurniawati, R. P. (2022). Analisis Kemampuan TPACK Mahapeserta didik Calon Guru pada Mata Kuliah Pembelajaran Matematika SD. *Aksioma: Jurnal Program Studi Pendidikan Matematika, 11*(1), 734-742.

Halim, L., & Meerah, T. S. M. (2002). Science trainee teachers' pedagogical content knowledge and its influence on physics teaching. *Research in Science & Technological Education*, *20*(2), 215–225. https://doi.org/10.1080/0263514022000030462

Hartati, T., Heryanto, D., Annisa, N., Nuriyanti, R., Saputra, A. H., & Sutedi, R. (2019). Technological Pedagogical Content Knowledge (TPACK) dalam Rangka Peningkatan Kualitas Pembelajaran Mahasiswa PPG SD Prajabatan. *EDUTECH, 18*(2), 174-181.

Indriani, F., Hidayah, N., & Hidayah, Y. (2021). Pelatihan Pengembangan Subject Spesific Pedagogi Tematik Berbasis TPACK Bagi Guru SD Muhammadiyah di Wilayah Sleman Yogyakarta. *Prima Abdika: Jurnal Pengabdian Masyarakat, 1*(2), 65–72. https://doi.org/10.37478/abdika.v1i 2.979

Jannah, I., & Setyawan, A. (2022). Pemanfaatan Media Pembelajaran Papan Puzzle Pecahan untuk Meningkatkan Hasil Belajar Siswa SDN Bancaran 3 Bangkalan. *Jurnal Literasi Digital, 2*(2), 124–131. https://doi.org/https://doi.org/10.54065/jld.2.2.2022.191

Kalaka, Y., Mustofa, Y. A., & Dalai, H. (2023). Game Edukasi Pembelajaran Matematika untuk Anak-Anak Sekolah Dasar. *Jurnal Ilmiah Ilmu Komputer, 2*(1), 1-7.

Koehler, M. J., Mishra, P., Akcaoglu, M., & Rosenberg, J. M. (2006). *The Technological Pedagogical Content Knowledge Framework for Teachers and Teacher Educators*. In ICT Integrated Teacher Education: A Resource Book (pp. 2–7).

Kurniawan, A., & Astuti, A. P. (2017). Deskripsi Kompetensi Pedagogik Guru dan Calon Guru Kimia SMA Muhammadiyah 1 Semarang. *Seminar Nasional Pendidikan, Sains dan Teknologi, 1–7.*

Mahendra, F. J., & Sukartono, S. (2023). Application of Monopoly Game Media In Learning Mathematical Counting Operations Grade 3 MIM Talang. *Mathline: Jurnal Matematika dan Pendidikan Matematika, 8*(4), 1283-1304, http://doi.org/10.31943/mathline.v8i4.511

Maher, N., Muir, T., & Chick, H. (2015). Examining PCK in a Senior Secondary Mathematics Lesson. *International Group for the Psychology of Mathematics Education 39th Conference, Hobart, Autralia.*

Murtiyasa, B., & Atikah, M. D. (2021). Kemampuan TPACK Mahapeserta didik Calon Guru Matematika pada Mata Kuliah Praktikum Pembuatan Alat Peraga Matematika. *Aksioma: Jurnal Program Studi Pendidikan Matematika, 10*(4), 2577-2590.

Nuraeni, R., & Juandi, D. (2023). Assessing Technological Pedagogical Content Knowledge Proficiency Among Prospective Mathematics Teachers in Micro-Learning Courses. *Mosharafa: Jurnal Pendidikan Matematika, 12*(4), 843-852.

Pratama, L. D., Lestari, W., & Bahauddin, A. (2019). Game Edukasi: Apakah Membuat Belajar Lebih Menarik?. *At-Ta'lim: Jurnal Pendidikan, 5*(1), 39–50. https://doi.org/10.36835/attalim.v5i1.64

Pratama, U. N., & Haryanto, H. (2017). Pengembangan Game Edukasi Berbasis Android tentang Domain Teknologi Pendidikan. *Jurnal Inovasi Teknologi Pendidikan, 4*(2), 167–184. https://doi.org/10.21831/jitp.v4i2.12827

Sakinah, R. N., & Prihantini. (2022). Urgensi Penerapan Pembelajaran Berbasis HOTS di Sekolah Dasar. *Jurnal Pendidikan Tambusai, 6*(2), 9350-9356.

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher, 15*(2), 4–14. https://doi.org/10.3102/0013189X 015002004

Surani, D. (2019). *Studi Literatur: Peran Teknologi Pendidikan dalam Pendidikan 4.0*. Prosiding Seminar Nasional Pendidikan FKIP, 2(1), 456–469. https://jurnal.untirta.ac.id/index.p hp/psnp/article/view/5797

Ulfa, K., & Rozalina, L. (2019). Pengembangan Media Pembelajaran Monopoli pada Materi Sistem Pencernaan di SMP. *Bioilmi: Jurnal Pendidikan, 5*(1), 10–22. https://doi.org/10.19109/bioilmi.v5i1.3753

Vu, T. L. A. (2018). Building CDIO approach training programmes against challenges of industrial revolution 4.0 for engineering and technology development. *International Journal of Engineering Research and Technology, 11*(7), 1129–1148.

Wulandari, A. P., Salsabila, A. A., Cahyani, K., Nurazizah, T. S., & Ulfiah, Z. (2023). Pentingnya Media Pembelajaran dalam Proses Belajar Mengajar. *Jurnal Pendidikan, 05*(02), 3928–3936. https://jonedu.org/index.php/joe/article/download/1074/856/