Al-Ishlah: Jurnal Pendidikan
Vol.17, 4 (December, 2025), pp. 7967-7978
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v17i4.8658

Needs Analysis for a STEM-Based Interactive E-Worksheet Using Heyzine and Problem-Based Learning in Elementary Mathematics

Mutiara Rachmadini [1], Neza Agusdianita [2], Agus Susanta[3], Ade Gusti Ningsih[4]

[1] Universitas Bengkulu, Bengkulu, Indonesia; mutiararchmdni225@gmail.com
[2] Universitas Bengkulu, Bengkulu, Indonesia; nezaagusdianita@unib.ac.id
[3] Universitas Bengkulu, Bengkulu, Indonesia; agussusanta@unib.ac.id
[4] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; adegusti.2023@student.uny.ac.id

ARTICLE INFO

Keywords:

STEM education;
Heyzine;
problem-based learning;
e-worksheets;
problem-solving

Article history:

Received 2025-09-25
Revised 2025-10-18
Accepted 2025-12-31

ABSTRACT

Mathematics instruction in Indonesian elementary schools often relies on conventional, text-heavy worksheets that lack interactivity and contextual relevance. These limitations hinder students' engagement, problem-solving development, and alignment with 21st-century competencies and Profil Pelajar Pancasila (P3). This study aims to identify the needs of teachers and students for a STEM-based, interactive E-Worksheet using Heyzine integrated with Problem-Based Learning (PBL). An exploratory sequential mixed-methods design was employed as the initial phase of a broader design-based research cycle. Quantitative data were collected from 22 fifth-grade teachers and 110 students across 11 public elementary schools in Bengkulu City through validated questionnaires. Qualitative insights were obtained from semi-structured interviews with five teachers. Data were analyzed using descriptive statistics and thematic coding. Findings reveal that less than half of students (47.27%) found existing worksheets clear and engaging. Teachers rated the current modules at 40–45% across core indicators, citing weak integration of STEM-PBL principles, low interactivity, and insufficient alignment with P3 values. Both students and teachers emphasized the need for multimedia-rich, contextually relevant materials that support inquiry and collaboration. The study highlights a significant gap between curricular goals and actual classroom practices. It underscores the urgency of developing interactive, multimodal digital worksheets using platforms like Heyzine to enhance student engagement, problem-solving skills, and teacher readiness for digital pedagogy.

Corresponding Author:
Neza Agusdianita
Pendidikan Dasar, Universitas Bengkulu, Bengkulu, Indonesia; nezaagusdianita@unib.ac.id

1. INTRODUCTION

Instructional media have long been acknowledged as essential in enhancing the effectiveness of the learning process (Lubis, Febriani, Yana, Azhar, & Darajat, 2023). Beyond functioning as a conduit for information delivery, media play a crucial role in stimulating learners' interest, facilitating comprehension, and promoting active participation. The increasing integration of digital technology in education has transformed conventional media into interactive, multimodal, and student-centered platforms (Kerimbayev, Umirzakova, Shadiev, & Jotsov, 2023). This transformation is particularly significant in mathematics education, where abstract and symbolic representations often pose cognitive challenges for young learners. Through digital media, such concepts can be represented more concretely, enabling a deeper and more meaningful understanding of mathematical ideas.

Mathematics education constitutes the foundation for developing logical reasoning, analytical thinking, and problem-solving competencies across educational levels (Yang, 2024). At the elementary stage, mathematical instruction extends beyond computational fluency to emphasize the application of concepts to real-world situations (Sujatha & Vinayakan, 2023). However, empirical observations consistently reveal persistent difficulties among students in translating abstract concepts into practical contexts. For instance, the Indonesian national curriculum requires elementary learners to determine the area of various two-dimensional shapes and their combinations (Jayathirtha, 2018). Yet, data from 76 Bengkulu Public Elementary School indicate that the average mathematics score of fifth-grade students remains at 49.82 well below the minimum mastery criterion of 65—revealing a notable discrepancy between curricular expectations and learning outcomes. This performance gap highlights the need for innovative instructional media that enhance engagement, reduce learning anxiety, and cultivate problem-solving abilities.

Conventional learning resources, particularly printed worksheets, remain the predominant medium for guiding classroom instruction (Hazaveh & Wanless, 2021). However, such resources frequently promote rote learning and fail to sustain students' motivation, particularly among digital-native learners. Although Rockinson-Szapkiw, Courduff, Carter, & Bennett (2013) found no significant differences in cognitive achievement between students using electronic and print textbooks, digital worksheets possess affordances that extend beyond mere content delivery. Electronic worksheets (E-Worksheets) enable interactive, multimedia-supported learning experiences accessible through computers, tablets, or smartphones (Maharani & Marhamah, 2024). Platforms such as Heyzine Flipbook facilitate the integration of multimedia elements including videos, animations, sound, hyperlinks, and interactive quizzes that enhance motivation and foster independent, flexible learning (Hartoyo, Dewi, Saragih, Isdianto, & Khairina, 2024). Empirical findings further demonstrate that E-Worksheets improve instructional clarity, promote systematic learning, and support learner autonomy compared to traditional formats (Agustin, Masita, & Pranoto, 2024). Accordingly, the development of E-Worksheets represents a strategic response to the need for engaging, technology-enhanced mathematics instruction

Recent pedagogical paradigms underscore the importance of interdisciplinary learning and authentic problem-solving in cultivating 21st-century competencies. The STEM (Science, Technology, Engineering, and Mathematics) framework integrates disciplinary knowledge to foster inquiry, exploration, and design-based learning that bridges theory and practice. In mathematics education, STEM-oriented approaches contextualize abstract concepts within real-world applications, thus enhancing creativity, collaboration, and critical thinking. Complementarily, the Problem-Based Learning (PBL) model emphasizes active engagement through the resolution of contextualized problems. By encouraging learners to identify issues, construct hypotheses, test solutions, and reflect on outcomes, PBL strengthens metacognitive regulation and higher-order reasoning. A growing body of evidence supports the efficacy of PBL in improving motivation, engagement, and problem-solving competence, suggesting strong pedagogical synergy when integrated with STEM-oriented strategies.

Nevertheless, the integration of STEM and PBL approaches in elementary mathematics remains limited. Field observations in several public elementary schools in Bengkulu revealed that existing instructional modules are predominantly conventional, emphasizing procedural drills and rote memorization with minimal incorporation of authentic or interdisciplinary tasks. Such practices constrain students' opportunities for creative and critical inquiry. Empirical studies by Susanta (2025) and Martaningsih (2022) affirm the potential of integrated approaches: the former demonstrated that STEAM-Inquiry Learning (STEAMIL) modules enhanced students' mathematical literacy, while the latter confirmed the effectiveness of a STEM–PBL module in improving problem-solving skills among fourth-grade learners. These findings underscore the promise of integrating both frameworks, yet also highlight a paucity of research utilizing digital, multimodal platforms to implement them.

While several studies have independently developed STEM or PBL modules, few have combined both approaches through a digital, multimodal platform such as Heyzine, particularly within the context of elementary mathematics education. This research seeks to address that gap by exploring the design of a STEM–PBL E-Worksheet that leverages Heyzine's interactive and multimodal affordances. Integrating these frameworks is expected to support conceptual understanding, real-world problem-solving, and learner engagement more effectively than traditional media.

Prior to development, a systematic needs analysis is imperative to ensure that the instructional design aligns with pedagogical goals, teacher expectations, and learner needs. Accordingly, this study aims to:

1. Identify the teacher and student needs in developing a STEM–PBL Heyzine-based E-Worksheet for elementary mathematics learning; and
2. Examine the barriers to the current use of worksheets in mathematics instruction.

By addressing these objectives, this study contributes to the growing discourse on digital and interdisciplinary learning design, providing empirical and practical insights for advancing mathematics education at the elementary level.

This study aims to perform a needs analysis for the development of a STEM-oriented E-Student Worksheet using Heyzine integrated with PBL to foster problem-solving skills in elementary mathematics. By identifying specific gaps, expectations, and requirements of stakeholders, the study seeks to establish a solid foundation for the subsequent design and validation of innovative learning resources. Ultimately, this research contributes to advancing the discourse on technology-enhanced mathematics education and provides practical insights for improving instructional practices in elementary schools.

2. METHODS

2.1 Research Design

This study employed an exploratory sequential mixed-methods design, constituting the needs analysis phase of a broader design-based research (DBR) cycle aimed at developing a STEM-oriented Electronic Student Worksheet (E-Worksheet) using Heyzine integrated with the Problem-Based Learning (PBL) model. The exploratory sequential approach was selected to capture in-depth qualitative insights from teachers and students, which subsequently informed the quantitative instrument development and interpretation. This design aligns with Ponce and Pagán-Maldonado (2015), who emphasize methodological triangulation as a means of enhancing validity and reliability through the integration of qualitative and quantitative data.

2.2 Research Site and Participants

The study was conducted in a sub-district of Bengkulu City, involving 11 public elementary schools:

1 Public Elementary School 101 Bengkulu City
2 Public Elementary School 104 Bengkulu City

3 Public Elementary School 106 Bengkulu City
4 Public Elementary School 16 Bengkulu City
5 Public Elementary School 56 Bengkulu City
6 Public Elementary School 66 Bengkulu City
7 Public Elementary School 74 Bengkulu City
8 Public Elementary School 76 Bengkulu City
9 Public Elementary School 78 Bengkulu City
10 Public Elementary School 79 Bengkulu City
11 Public Elementary School 84 Bengkulu City

A total sampling strategy was applied for teachers, involving two participants from each school (the fifth-grade classroom teacher and/or the mathematics subject teacher), yielding 22 respondents for the questionnaire. From this group, five teachers were selected randomly for in-depth interviews. For students, a proportional random sampling technique was used, selecting approximately 10 fifth-grade students from each school, for a total of 110 participants. Replacement lists were prepared to address potential non-response, and participation was conditional upon parental consent. This sampling ensured sufficient representativeness for quantitative analysis while allowing qualitative depth to contextualize the findings.

2.3 Data Collection Procedures

Data were collected in two sequential phases. The quantitative phase (May 2025) consisted of questionnaire administration, both in printed and Google Form formats, each requiring approximately 25–30 minutes. The qualitative phase (June 2025) involved semi-structured interviews conducted face-to-face or online, depending on availability. Ethical clearance was obtained prior to data collection, with informed consent from teachers and parents. Participation was voluntary, confidentiality was assured, and respondents were informed of their right to withdraw at any time.

Table 1. Summary of Instruments Used in the Study

Instrument	Respondents	Dimensions/Focus	Scale
Teacher Questionnaire	22 teachers	a) Current worksheet use, b) Problem-solving challenges, c) STEM–PBL integration needs, d) Expectations for Heyzine-based features	5-point Likert
Student Questionnaire	110 students	a) Mathematics learning perception, b) Problem-solving difficulties, c) Experiences with printed vs. digital worksheets, d) Preferred digital features	5-point Likert
Semi-Structured Interview Guide	5 teachers	a) Instructional challenges, b) readiness for digital adoption, c) expectations for Heyzine E-Worksheet	Open-ended

The validity of the developed instrument was established through expert validation, conducted under the guidance and supervision of the academic advisor. This validation process ensured that each component of the instrument aligned with the theoretical framework and met the standards of construct and content validity. The expert review also provided critical feedback to refine the indicators, wording, and measurement scale to enhance clarity, relevance, and consistency with the research objectives.

2.4 Data Analysis

Quantitative data were analyzed using descriptive statistics (means, standard deviations, percentages), alongside cross-tabulations to compare teacher and student perspectives. Qualitative data from interviews and open-ended responses were analyzed thematically, involving iterative coding, categorization, and interpretation of recurring patterns, such as barriers in problem-solving instruction, digital readiness, and expectations for STEM–PBL integration.

3. FINDINGS AND DISCUSSION

3.1 Descriptive Statistics of Student and Teacher Questionnaire Results

Table 1 summarizes the descriptive statistics of the two principal variables: the implementation of learning through student worksheets and the relevance of instructional modules as perceived by teachers. For student worksheet implementation, eight valid items were analyzed, yielding scores that ranged narrowly between 47.00 and 49.00 (range = 2.00), with a mean of 48.25 and a standard deviation of 0.71. This small variation indicates a high level of score homogeneity, implying a relatively uniform perception among students regarding the use of worksheets. The skewness (–0.404) and kurtosis (–0.229) values fall within the acceptable range of ±2, signifying a near-normal data distribution.

In contrast, the teacher questionnaire assessing module relevance consisted of thirteen valid items, with responses ranging between 3.60 and 4.40 (range = 0.80). The mean score of 4.17 (SD = 0.35) suggests moderately high teacher evaluations of module components. Both skewness (0.362) and kurtosis (0.168) values also lie within the normality threshold, indicating symmetrical and mesokurtic distributions. Overall, both sets of descriptive statistics demonstrate adequate psychometric quality, validating their use for subsequent inferential or thematic analyses.

Table 2. Descriptive Statistics of Worksheet Implementation and Module Relevance

Statistic	Implementation of Learning through Worksheet (Students)	Module Relevance Based on Teacher Questionnaire (Teachers)
Number of Items	8	13
Number of Respondents	110	22
Range	2.00	0.80
Minimum	47.00	3.60
Maximum	49.00	4.40
Mean	48.25	4.17
Standard Error of Mean	0.25	0.13
Standard Deviation	0.71	0.35
Variance	0.50	0.12
Skewness	–0.404	0.362
Kurtosis	–0.229	0.168

The analysis is based on eight valid cases with scores ranging from 47.00 to 49.00, yielding a narrow range of 2.00. The mean score is 48.25, with a standard deviation of 0.71, indicating high homogeneity and minimal dispersion. The skewness (-0.404) and kurtosis (-0.229) values suggest a marginally left-skewed and platykurtic distribution; nevertheless, both values remain within the acceptable threshold of ±2, signifying that the data approximate a normal distribution.

In contrast, the module relevance based on teacher responses comprises thirteen valid cases with a considerably broader range (3727.00–4455.00). The mean score of 4056.00 with a standard deviation of 205.30 reflects moderate variability among teachers' evaluations. Skewness (0.362) and kurtosis (0.168)

values fall within the normality threshold, suggesting that the distribution of responses is approximately symmetrical and mesokurtic. Overall, these descriptive results indicate that both variables demonstrate acceptable statistical properties and are suitable for subsequent parametric analyses.

3.2 Student Perceptions of Mathematics Learning through student worksheets SD Negeri Kota Bengkulu

The findings from the student questionnaire on the implementation of mathematics learning through student worksheets reveal relatively low levels of effectiveness across all indicators, with none exceeding 50% of positive responses. Table 1 presents the distribution of students' responses regarding the implementation of mathematics learning through student worksheets.

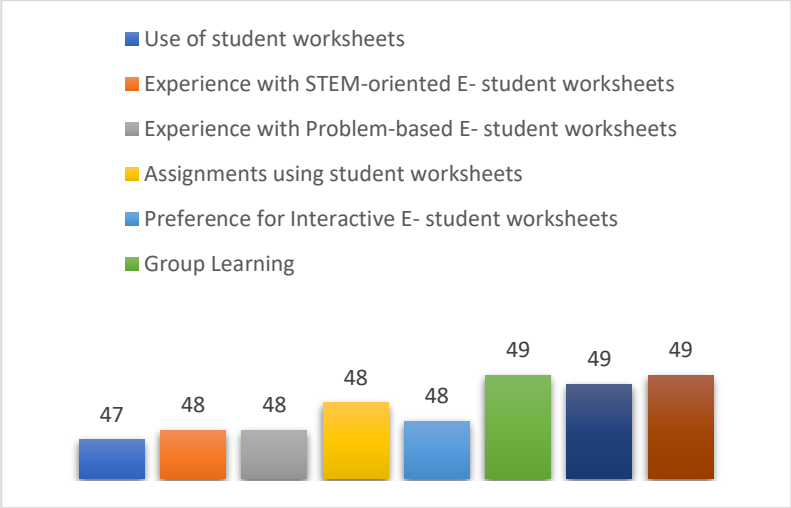

Figure 1. Students' Questionnaire Results on the Implementation of Learning through Student Worksheets

Findings from the student questionnaire (Table 2) reveal consistently low levels of perceived effectiveness across all indicators, with none exceeding 50% of positive responses. The lowest proportion was found in the clarity of student worksheets (47.27%), indicating that many students experienced difficulties in understanding instructional materials. Exposure to STEM- or problem-based formats was also limited (47.58%), suggesting that such innovative approaches have yet to be fully integrated into mathematics classrooms in SD Negeri schools across Bengkulu.

Similarly, only 48.48% of students reported that assignments regularly involved worksheet use, implying that these tools were not systematically utilized for both learning and assessment. Interest in interactive worksheets was also low (47.88%), pointing to a lack of design elements—such as interactivity or gamification that could enhance engagement. The group learning indicator achieved the highest response rate (49.39%), reflecting students' appreciation for collaborative approaches, although their implementation remains sporadic.

From the student perspective, learners described the module as text-heavy and visually unappealing. One student remarked, *"The module is too monotonous, with too much text,"* reflecting a general sense of fatigue and disengagement when interacting with lengthy written content. This feedback indicates that visual appeal and multimodal elements such as pictures, animations, and interactive features are essential to maintain attention and motivation. Overall, these findings suggest that student worksheets, though commonly employed, are not yet optimized to promote active and meaningful learning. A visual representation of student perceptions (see Figure 1) demonstrates a consistent pattern of low engagement across all indicators.

3.3 Analysis of Module Relevance Based on Teacher Questionnaire

The analysis of teacher responses regarding the relevance of the instructional module is presented in Table 2. Data obtained from 22 teachers indicate that the overall level of implementation remains low, with achievement percentages ranging only between 37% and 45%. This finding suggests a considerable gap between the expected quality of teaching modules and the actual conditions encountered in schools.

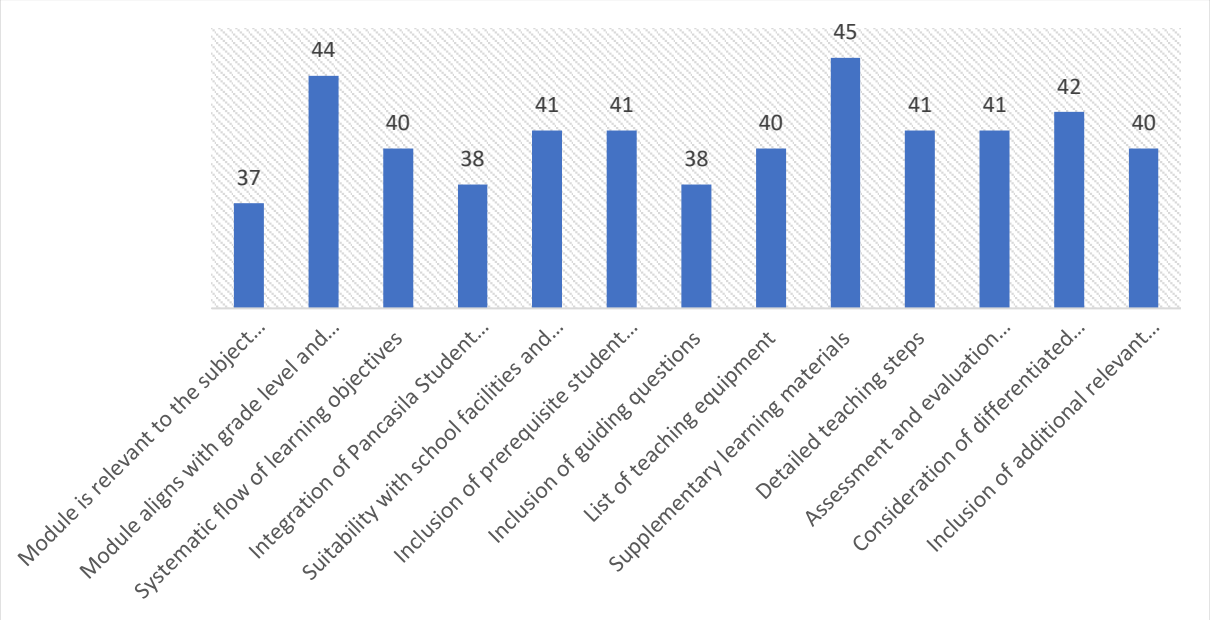

Figure 2. Evaluation Results of Mathematics Module Feasibility in Terms of Content, Curriculum Alignment, and Pedagogical Design

The results show that, in the general information aspect, only 37.27% of teachers considered the module relevant to the subject matter, while alignment with grade level and phase reached a slightly higher 43.64%. This indicates that the current module design has not yet achieved full consistency with curriculum requirements and student characteristics.

In terms of learning outcomes and objectives, the systematic flow of objectives was rated at 40%, while integration of the Pancasila Student Profile (P3) dimensions was even lower, at 38.18%. These findings highlight the module's limitations in fostering critical, creative, and collaborative learning, as mandated by the curriculum. For the design aspect, both the suitability of the module with facilities and the inclusion of prerequisite competencies reached 40.91%. These moderate figures suggest that while some structural alignment exists, the module does not adequately support students' readiness to learn nor does it fully address the realities of school infrastructure.

The lesson detail aspect achieved relatively higher scores, with supplementary learning materials obtaining the highest response (44.55%), followed by differentiated learning at 41.82%. However, indicators such as guiding questions (38.18%), teaching equipment lists (40%), and assessment procedures (40.91%) remain below expectations. This reveals that while certain supporting features are present, the depth and comprehensiveness of the module remain insufficient.

Similarly, teachers emphasized that the current module lacks contextual relevance to students' everyday lives. As one teacher stated, *"The module is not very engaging; perhaps the material feels too distant from what exists in our local context."* This comment underscores the necessity of designing learning

materials that integrate authentic, locally grounded examples to strengthen students' conceptual understanding and connection to real-world phenomena.

Overall, these qualitative insights reinforce the quantitative findings presented earlier, highlighting that both teachers and students perceive the existing module as insufficiently engaging and overly text-based. The integration of STEM-oriented and Problem-Based Learning (PBL) principles, supported by interactive digital media such as Heyzine, is therefore considered crucial to enhance motivation, contextual relevance, and learning outcomes.

Discussion

The findings of this study indicate a significant discrepancy between curriculum objectives and the practical implementation of mathematics instruction in elementary classrooms. Only 47.27% of students reported that the worksheets provided by teachers were accessible and engaging, while classroom activities were largely centered on textbook-based and procedural exercises. This instructional pattern restricts students' opportunities to develop conceptual understanding and to connect mathematical ideas with real-life contexts. The results point to a broader pedagogical tendency in which learning materials prioritize procedural fluency over conceptual exploration. This aligns with Mersin and Karabörk's (2021) assertion that the integration of technology in mathematics education frequently reinforces procedural practices rather than fostering deep and meaningful learning experiences.

From a theoretical standpoint, this misalignment contradicts constructivist principles, which posit that knowledge is actively constructed through interaction and contextual exploration. The dominance of rote and procedural exercises deprives learners of the opportunity to engage in authentic problem-solving, a cornerstone of both constructivism and Problem-Based Learning (PBL) frameworks. Moreover, the limited presence of inquiry-based tasks in the modules—only 40% of which addressed higher-order thinking—fails to realize the competencies mandated in BSKAP No. 046/H/KR/2025, such as critical thinking, creativity, and collaboration. Similar findings by Rahmawati and Isnarto (2022) underscore that many STEM-based instruments in Indonesian education remain structurally traditional, lacking explicit problem-solving dimensions.

The persistence of this gap suggests two intertwined causes: (a) teachers' continued reliance on traditional conceptions of teaching as transmission of information, and (b) inadequate professional development supporting inquiry-oriented and digital pedagogies. From a TPACK (Technological Pedagogical Content Knowledge) perspective, teachers' integration of technology remains confined to content delivery rather than as a transformative pedagogical tool. Strengthening teachers' TPACK competency is thus essential to ensure that digital resources enhance conceptual learning rather than merely digitize traditional content.

Another critical finding concerns the limited use of multimodal and interactive materials in mathematics instruction. Only 47.88% of students preferred interactive materials, and visual components appeared in just 44.55% of analyzed modules. This overreliance on static text not only limits cognitive engagement but also increases extraneous cognitive load by providing minimal visual scaffolding. According to Cognitive Load Theory (CLT), effective instructional design should reduce unnecessary cognitive effort while supporting the learner's working memory through visual and contextual cues. Text-heavy worksheets violate this principle by overwhelming learners with verbal information, thus impeding the construction of meaningful mental models (Çetin & Aydın, 2020).

Conversely, multimodal learning environments—incorporating text, imagery, audio, animation, and simulations—allow for dual coding and distributed cognition, which facilitate deeper conceptual processing (Gunawan & Yunita, 2025). The integration of such resources also aligns with constructivist learning theory, which emphasizes active knowledge building through multimodal representation and interaction. In this regard, digital publishing tools such as Heyzine can serve as effective platforms for

embedding hyperlinks, animations, and interactive assessments directly into student worksheets. As demonstrated by Taqwani et al. (2025) and Yuni et al. (2025), multimodal platforms not only enhance student engagement but also promote differentiated instruction by accommodating diverse learning preferences.

The study also identifies a weak integration of character education within mathematics learning. Only 38.18% of observed learning activities supported the P3 dimensions of creativity, collaboration, and ethics. This finding implies that the affective and moral goals of the curriculum are not yet embedded meaningfully into instructional materials. Qualitative feedback reinforces this conclusion: one student described the module as "too monotonous, with too much text," while a teacher noted that "the module is not very engaging; perhaps the material feels too distant from what exists in our local context."

From a contextual constructivist perspective, learning becomes meaningful when it connects with learners' sociocultural experiences. Modules that ignore local context fail to foster this relevance, thereby diminishing motivation and character development. Sukestiyarno et al. (2019) and Triono and Santoso (2024) emphasize that contextual and experiential approaches can bridge academic content with value formation, cultivating empathy, responsibility, and collaboration. Integrating P3 principles within STEM–PBL frameworks would therefore yield both cognitive and affective benefits—promoting reasoning while nurturing civic and moral awareness. This dual focus aligns with the national vision of producing students who are both competent and character-driven.

The fourth major finding pertains to teachers' low technological readiness (40.91%), reflecting systemic challenges in digital literacy and infrastructure (Andarwulan et al., 2021). Many teachers still rely on static PDFs or scanned worksheets, expressing limited confidence in creating or adapting interactive content. This lack of readiness constrains innovation and reinforces traditional practices. The TPACK framework again provides a useful analytical lens: although teachers possess basic content and pedagogical knowledge, their technological pedagogical integration remains minimal.

Previous studies affirm that interactive and gamified tools can substantially enhance engagement and self-regulation (Zainuddin et al., 2020; Hung et al., 2022). Platforms like Heyzine lower the technological threshold by offering intuitive interfaces for embedding multimedia and formative assessments (Ah-Nam & Osman, 2017). Building teachers' digital competence through structured professional learning communities and digital pedagogy workshops is thus crucial. These programs should emphasize not only tool proficiency but also the design of learning experiences that embody inquiry, creativity, and reflection—core dimensions of both PBL and constructivism.

This study highlights the interconnection between constructivism, cognitive load theory (CLT), and the TPACK framework in guiding the development of effective digital learning environments. Constructivism emphasizes learners' active engagement in contextualized experiences, CLT stresses the importance of organizing information to reduce cognitive overload, and TPACK bridges these principles through the integration of technology, pedagogy, and content. Together, these frameworks provide a strong theoretical foundation for designing multimodal and inquiry-based mathematics instruction that promotes meaningful understanding and sustained learner engagement.

Practically, the findings underscore several critical implications. Curriculum developers should establish design standards for multimodal and problem-based learning (PBL) modules that align with national competencies and incorporate Profil Pelajar Pancasila (P3) values. These materials should combine interactive simulations, localized contexts, and character-based learning elements to enhance both cognitive and affective outcomes.

4. CONCLUSION

This study reveals that mathematics instruction in elementary schools in Bengkulu City remains dominated by procedural worksheets that do not adequately promote higher-order reasoning, collaboration, or authentic problem-solving. Both teacher and student feedback indicate that existing modules are text-heavy, minimally interactive, and insufficiently aligned with curriculum standards, including the values of Profil Pelajar Pancasila. The lack of multimodal resources and limited teacher digital readiness further restricts the potential for meaningful classroom innovation.

These findings highlight the urgent need to fund, train, and implement STEM–PBL–multimodal digital tools such as Heyzine to close the gap between curriculum standards and classroom realities. Curriculum developers, teacher education institutions, and policymakers must collaborate to ensure that learning materials are interactive, contextually relevant, and technologically integrated. Strengthening teacher digital competence through sustained professional development will be essential to realizing these reforms.

Future research should advance this agenda by developing and validating prototype digital modules, conducting pilot testing with control groups, and implementing longitudinal studies to track their sustained impact on students' problem-solving, creativity, and critical thinking. Through such systematic efforts, mathematics education can evolve toward an integrated, engaging, and future-ready paradigm.

REFERENCES

Ah-Nam, L., & Osman, K. (2017). Developing 21st-century skills through a constructivist-constructionist learning environment. *K-12 STEM Education, 3*(2), 205–216.

Agustin, R., Masita, E., & Pranoto, N. W. (2024). E-worksheet to improve critical thinking and scientific argumentation skills: A systematic literature review. *Jurnal Penelitian Pendidikan IPA, 10*(6), 277–283.

Anazifa, R. D., & Djukri. (2017). Project-based learning and problem-based learning: Are they effective to improve students' thinking skills? *Jurnal Pendidikan IPA Indonesia, 6*(2), 346–355.* https://doi.org/10.15294/jpii.v6i2.11100*

Andarwulan, T., Fajri, T. A. A., & Damayanti, G. (2021). Elementary teachers' readiness toward the online learning policy in the new normal era during COVID-19. *International Journal of Instruction, 14*(3), 771–786.* https://doi.org/10.29333/iji.2021.14345a*

Anwar, M. (2025). Effectiveness of STEM-oriented project-based learning modules in visual communication design to support science and technology skills in vocational education. *Jurnal Penelitian Pendidikan IPA, 11*(4), 339–345.* https://doi.org/10.29303/jppipa.v11i4.9999*

Aydogdu, M. Z., & Kesan, C. (2014). A research on geometry problem-solving strategies used by elementary mathematics teacher candidates. *Online Submission, 4*(1), 53–62.

Çetin, H., & Aydın, S. (2020). The effect of multiple representation-based instruction on mathematical achievement: A meta-analysis. *International Journal of Educational Research Review, 5*(1), 26–36.* https://doi.org/10.24331/ijere.648575*

Gunawan, G., & Yunita, F. (2025). Multimedia-assisted SAVI learning model and its impact on mathematical problem-solving ability: A quantitative study. *Journal of Instructional Mathematics, 6*(1), 14–24.

Hartoyo, I., Dewi, N. R., Saragih, B., Isdianto, E., & Khairina, Y. (2024). Interactive digital flipbooks: Enhancing engagement and accessibility in education for diverse learners in technology in ELT course at Universitas Negeri Medan. *Jurnal Sustainable, 7*(2), 342–355.

Hazaveh, P. K., & Wanless, L. (2021). Impact of online worksheets versus in-class printed worksheets

on students' learning outcomes and content mastery. In *2021 ASEE Virtual Annual Conference & Exposition*. ASEE.

Jayathirtha, G. (2018). An analysis of the national intended geometry curriculum. *Contemporary Education Dialogue, 15*(2), 143–163.* https://doi.org/10.1177/0973184918755284*

Kerimbayev, N., Umirzakova, Z., Shadiev, R., & Jotsov, V. (2023). A student-centered approach using modern technologies in distance learning: A systematic review of the literature. *Smart Learning Environments, 10*(1), 61.* https://doi.org/10.1186/s40561-023-00226-9*

Lubis, L. H., Febriani, B., Yana, R. F., Azhar, A., & Darajat, M. (2023). The use of learning media and its effect on improving the quality of student learning outcomes. *International Journal of Education, Social Studies, and Management (IJESSM), 3*(2), 7–14.

Maeti, N. W. S., Suweken, G., & Suparta, I. N. (2025). Developing e-module-based PJBL oriented with STEM on SPLDV material to improve problem-solving skills. *Indonesian Journal of Instruction, 6*(1), 22–33.

Maharani, P., & Marhamah, M. (2024). Development of e-student worksheet based on task-based learning through Liveworksheets.com for high school students. *Al-Ishlah: Jurnal Pendidikan, 16*(2), 1205–1217.* https://doi.org/10.35445/alishlah.v16i2.9999*

Mardiati, M., & Karmana, I. W. (2024). The effect of the team-assisted individualization learning model on students' science process skills and cognitive learning outcomes. *PAIDAGOGIA: Jurnal Inovasi Pendidikan dan Pembelajaran, 1*(1), 7–13.

Mersin, N., & Karabörk, M. A. (2021). The comparison of math textbooks in Turkey and Singapore in terms of technology integration. *International Journal of Curriculum and Instruction, 13*(1), 552–573.

Milla, D. (2025). The application of project-based learning with constructivism theory in enhancing creativity of elementary school students: A literature review. *Journal La Edusci, 6*(1), 17–27.* https://doi.org/10.37899/journallaedusci.v6i1.999*

Ponce, O. A., & Pagán-Maldonado, N. (2015). Mixed methods research in education: Capturing the complexity of the profession. *International Journal of Educational Excellence, 1*(1), 111–135.* https://doi.org/10.18562/IJEE.2015.0005*

Rockinson-Szapkiw, A. J., Courduff, J., Carter, K., & Bennett, D. (2013). Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning. *Computers & Education, 63*, 259–266.* https://doi.org/10.1016/j.compedu.2012.11.022*

Sujatha, S., & Vinayakan, K. (2023). Integrating math and real-world applications: A review of practical approaches to teaching. *International Journal of Computational Research and Development, 8*(2), 55–60.

Sukestiyarno, Y. L., Cahyono, A. N., & Pradnya, I. N. (2019). Integrating character education in mathematics learning in Indonesia and Denmark. *Journal of Physics: Conference Series, 1321*(3), 032014. IOP Publishing.* https://doi.org/10.1088/1742-6596/1321/3/032014*

Taqwani, R. A., Ratnaningsih, N., & Lestari, P. (2025). Development of Heyzine-based digibook to enhance students' computational thinking skills. *PRISMA, 14*(1), 128–138.

Triono, M., & Santoso, B. (2024). Character development through religious education via mathematics education in elementary schools. *Qalam: Jurnal Ilmu Kependidikan, 13*(1), 57–62.

Tu, J. C., Yang, C. H., Liang, C. Y., & Chen, H. Y. (2022). Exploring the impact of puzzle games for the elderly from experiential learning. *Thinking Skills and Creativity, 44*, 101107.* https://doi.org/10.1016/j.tsc.2022.101107*

Utaminingsih, S., Amalia, I., & Sumaji, S. (2024). Management of mathematics learning based on interactive digital worksheets to improve students' critical thinking ability. *Journal of Curriculum and Teaching, 13*(1), 159–169.* https://doi.org/10.5430/jct.v13n1p159*

Yang, W. (2024). Research on the implementation path of mathematical thinking cultivation in university mathematics education. *Journal of Modern Educational Theory and Practice, 1*(4), 45–56.

Yuni, R., Silaban, P. S. M. J., Thohiri, R., & Lubis, P. K. D. (2025). Effectiveness of using Heyzine Flipbook

Maker-based e-modules through a problem-based learning model. *Journal of Psychology and Instruction, 9*(1), 45–53.