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Needs Analysis For Developing Problem-Based Learning E-LKPD Integrating Local Wisdom to Improve Mathematical Connection Skills

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ABSTRACT (10 PT)

Mathematical connection skills constitute a core competency emphasised in the Independent Curriculum and by the National Council of Teachers of Mathematics (NCTM). Nevertheless, empirical classroom evidence reveals that these skills remain at a low level. This condition is paradoxical, given the increasing availability of digital infrastructure in schools, which has not been optimally integrated into mathematics learning practices. This study aims to identify the need to develop Problem-Based Learning (PBL)–based electronic student worksheets (E-LKPD) that integrate local wisdom, with a particular focus on uncovering the gap between technological availability and its pedagogical utilisation. This research adopts a Research and Development framework using the ADDIE model, limited to the needs analysis phase. Data were collected through teacher interviews, student and teacher questionnaires, and a mathematical connection skills test administered to 22 eighth-grade students at one of the junior high schools in Sumedang. The data were analysed using descriptive quantitative and qualitative techniques and validated through technical triangulation. The findings indicate that mathematics instruction continues to rely predominantly on textbooks and printed worksheets, despite the presence of adequate digital infrastructure. Both teachers and students expressed a strong need for interactive digital learning media that incorporate local wisdom within a PBL framework. Furthermore, students' mathematical connection skills were found to be low, with an average score of 57.5 and only 27.3% achieving the minimum mastery criterion. These results underscore a significant discrepancy between infrastructure readiness and classroom practice, highlighting the urgency of developing PBL-based E-LKPD to foster students' mathematical connection skills.

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1. INTRODUCTION

The Merdeka Curriculum, aligned with the standards of the National Council of Teachers of Mathematics, emphasises five fundamental mathematical competencies: problem-living, reasoning and proof, communication, connections, and representation [1]. Among these, mathematical connection skills play a pivotal role in fostering meaningful learning, as they enable students to relate different mathematical representations, link concepts across topics, and apply mathematics to real-world situations. Mathematical connection skills are the ability to find relationships between concept representations and procedures, understand mathematical topics, and apply mathematical concepts in other fields and everyday life [2]. Strong mathematical connections support meaningful conceptual understanding and aid in problem-solving tasks through the interconnection of mathematical concepts and between mathematics and other disciplines [3]. Furthermore, Boaler [4] highlights that connected knowledge structures support flexible problem solving and adaptive reasoning. In real-life contexts, mathematical problem-solving often involves modelling processes that require integrating multiple concepts simultaneously [5]. In addition, real-world problems often require mathematical modelling in their solution, thereby requiring students to connect various relevant concepts [6]. Therefore, the development of mathematical connection skills is essential for enhancing students' higher-order thinking and mathematical literacy.

Despite its importance, empirical studies indicate that students' mathematical connection skills remain low, particularly in developing countries such as Indonesia. Various studies in Indonesia show that students' mathematical connection skills are still low [7], [8], [9]. Several esearch consistently report students' difficulties in linking mathematical concepts and applying them in different contexts [10], [11]. These challenges are often attributed to fragmented conceptual understanding, limited prior knowledge integration, and the dominance of teacher-centred instructional practices [12]

At the same time, the integration of digital technology in mathematics education remains suboptimal. However, technology has been widely recognised as a powerful tool for enhancing visualisation, conceptual understanding, problem-solving, and interactive learning [13], [14]. Technology can be an effective tool for creating deeper interactions between students and learning materials, but its effectiveness is greatly influenced by teachers' perceptions, attitudes, and competencies, as well as students' readiness to use it [15], [16], [17], [18]. In addition, existing student worksheets (LKPD) are predominantly paper-based, limiting opportunities for interactive, student-centred learning. This condition leads to passive learning environments, reduces students' engagement and motivation (Wijaya et al., 2020), and makes the learning process rather boring [19].

A growing body of research highlights the effectiveness of digital learning materials, particularly electronic student worksheets (E-LKPD), in improving learning outcomes. Studies show that E-LKPD can serve as a learning aid to clarify learning messages, increase learning activities, and achieve learning objectives more optimally [20], [21], [22], [23]. Moreover, Problem-Based Learning (PBL) has been widely acknowledged as an effective pedagogical approach for promoting higher-order thinking skills and meaningful learning

[24]. Problem-Based Learning (PBL)-based E-LKPD has been proven to be valid, practical, and effective in improving students' mathematical abilities in several learning contexts [25], [26], [27].

In parallel, integrating local wisdom through ethnomathematics has been shown to increase the relevance of learning, strengthen cultural identity, and enhance conceptual understanding [28], [29]. Furthermore, integrating local wisdom into the problem context can make learning more relevant to students' real lives, foster a love of local culture, and strengthen conceptual understanding by grounding it in a familiar context [30]. Local wisdom is seen as a set of social and cultural values that shape students' character and identity, integrated with learning technology [31]. Although LKPD is generally capable of improving student skills [32] and ethnomathematics is effective for learning [33], there has been no integration of the two in the form of locally based PBL e-LKPD specifically aimed at improving mathematical connection skills. Research on PBL e-LKPD generally focuses on problem-solving skills without local cultural context [34], whereas ethnomathematics remains largely limited to printed worksheets.

This fragmented approach reveals a significant research gap: the lack of integrated digital learning resources that combine PBL, local wisdom (ethnomathematics), and the development of mathematical connection skills within a unified instructional design. Addressing this gap is crucial for responding to contemporary educational demands that require contextual, technology-enhanced, and student-centred learning environments.

Considering the theoretical importance, empirical challenges, and identified research gap, this study aims to analyse the need to develop Problem-Based Learning (PBL)–based E-LKPD integrated with local wisdom to enhance students' mathematical connection skills. Specifically, this study seeks to identify the discrepancy between the availability of digital infrastructure and its actual use in classroom practices, and to examine teachers' and students' readiness. It serves as a foundation for designing innovative, contextually relevant, and technology-enhanced mathematics learning materials.

2. METHOD

This research method is a research and development study aimed at producing a product in the form of an E-LKPD based on Problem-Based Learning with a theme of local wisdom that is valid, practical, and effective. This research uses an ADDIE-based development model. ADDIE (Analysis – Design – Develop – Implement – Evaluate) has a development process that includes repeated testing by experts, individual research subjects, and small- and large-scale field tests, along with revisions to refine the final product [35]. However, this research is only at the analysis stage, focusing on the needs for developing a PBL-based E-LKPD with a local wisdom theme. The basis of the needs analysis focuses on collecting and analysing the needs of teachers, students, and learning conditions in the field [36].

The techniques used to analyse the needs of teachers and students were interviews and questionnaires. Meanwhile, written tests were used to assess mathematical connection skills. The data obtained at this stage of analysis provided a solid basis for designing and refining E-LKPDs that are in line with the actual learning context and the learning outcomes of the Merdeka curriculum.

The interview guidelines used for teachers included the curriculum, learning activities, school facilities, and perceptions of local wisdom. The questionnaire indicators used for students included the types of teaching media used, variations in learning models, and the integration of local wisdom. Meanwhile, the indicators of students' mathematical connection abilities in this study refer to the NCTM [1] connection standards, namely (1) recognising and using the connections between mathematical ideas, (2) relating and applying mathematics to other disciplines, and (3) relating and applying mathematics to everyday life [37].

The research subjects were mathematics teachers at four public junior high schools in in Sumedang. The teachers interviewed had at least 2 years of experience teaching mathematics. The test was administered to 22 eighth-grade students at the researcher's school.

The questionnaire data were analysed descriptively by presenting the distribution of responses in percentage form to illustrate the tendencies of teachers and students regarding the development of PBL-based E-LKPD with a local wisdom theme. The test data were analysed using descriptive statistics, followed by qualitative analysis of several students' responses.

Data from tests, questionnaires, and interviews collected in a single study can be analysed using a triangulation approach to assess the validity of the findings. This approach utilises various data collection techniques to ensure that the analysis results more accurately reflect empirical conditions, thereby strengthening the validity and reliability of the research findings. Through triangulation, researchers can confirm interview and observation findings with questionnaire data, resulting in a more complete understanding of the issues under study.

3. RESULTS AND DISCUSSION

3.1. Analysis of Learning Implementation

Based on questionnaires, interviews, and observations of the mathematics learning process, a trend emerged regarding the teaching methods and materials most frequently used by teachers. The results of the student questionnaires showed that the learning pattern remained dominated by a teacher-centred approach and that teaching materials remained limited to textbooks. The following data on the teaching methods used by teachers are shown in Table 1.

Table 1. Student questionnaire analysis

No.	Aspects asked about	Percentage
1	Teaching media in the form of textbooks	63,6%
2	Use of electronic student worksheets	0%
3	Internet connection	100%
4	Use of varied learning models	12,2%
5	Integration of local wisdom	0%

The findings indicate that mathematics learning practices remain predominantly conventional, as reflected in the high reliance on textbooks (63.6%) and the complete absence of electronic worksheets (0%). This suggests that students' learning experiences remain largely teacher-directed and are minimally supported by interactive or technology-enhanced resources. Such conditions limit students' opportunities to actively construct knowledge, explore multiple representations, and develop deeper conceptual understanding. This condition is in line with studies reporting that learning practices in many schools still rely on printed teaching materials and teachers rarely use interactive e-worksheets, thus limiting students' opportunities to explore concepts independently and dynamically [38]. In fact, the use of media in mathematics learning has been proven to improve learning outcomes and motivation, and to make learning more enjoyable [39], [40], [41]. In addition, the provision of diverse teaching materials is a form of differentiated learning [42], [43], [44] that should be implemented in learning.

Interestingly, although all respondents reported full internet access (100%), this infrastructure has not been translated into meaningful pedagogical use. This discrepancy highlights a critical gap between technological availability and instructional practice, suggesting that access alone is insufficient without adequate teacher competence, pedagogical readiness, and institutional support. This is in accordance with the statement by Rismawati and colleagues [45], which states that the readiness of devices and networks does not automatically follow teachers' habits and abilities in integrating technology into learning. Moreover, the gap between infrastructure readiness and pedagogical integration aligns with findings by Zelkowski and colleagues [16], who emphasise that teachers' beliefs and competencies are key determinants of effective technology integration. Furthermore, the low percentage of students experiencing varied learning models (12.2%) indicates that instructional practices are still dominated by procedural approaches rather than inquiry- or problem-based learning. This may contribute to the underdevelopment of higher-order thinking skills, including mathematical connection skills, as students are not regularly engaged in activities that require conceptual integration and real-world application. The low variation in instructional models also supports previous evidence that traditional teaching approaches hinder the development of higher-order thinking skills. According to Cindy E. Hmelo-Silver [24], Problem-Based Learning (PBL) provides a more effective framework for fostering conceptual understanding and knowledge integration compared to conventional methods

Another significant finding is the complete absence of local wisdom integration (0%) in mathematics learning. This suggests that learning contexts remain abstract and disconnected from students' lived experiences, potentially reducing both relevance and engagement. The lack of contextualization may further hinder students' ability to form meaningful connections between mathematical concepts and real-life situations. In addition, the absence of local wisdom integration contrasts with findings from ethnomathematics research, which demonstrate that culturally contextualised learning enhances students' understanding and engagement. Ubiratan D'Ambrosio [28] argues that embedding cultural context in mathematics learning helps students connect abstract concepts with real-world practices. Empirical studies [46] further confirm that such approaches improve conceptual

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comprehension and support meaningful learning. In fact, local wisdom can also be implemented in mathematics learning as a source of problems [47], [48], [49], [50]. The integration of local wisdom in E LKPD is carried out by utilising the local community's cultural context, environment, and customs, as well as data sources and problem situations [51]. This local wisdom will make learning more contextually relevant, making it easier for students to understand and apply the material being studied [52], [53], [54], [55].

Overall, this pattern shows a large gap between the learning conditions in the field and the demands of the Merdeka Curriculum, which emphasises contextual, student-centred, and problem-based learning, while also emphasising the urgency of developing Problem-Based Learning-based E-LKPD with a local wisdom theme, as recommended by various studies that show the effectiveness of PBL E-LKPD and ethnomathematics-based LKPD in increasing student motivation, problem solving, and mathematical connection skills. The learning analysis based on teacher respondents is shown in Table 2.

Table 2. Analysis of Teacher Interviews

No	Aspects Asked	Answer	
		Yes	**No**
1	Has your school implemented the Merdeka Curriculum?	100%	0%
2	If so, based on the information you received from the workshop/in-house training/technical training, do the current learning media meet the needs of mathematics learning?	25%	75%
3	Do you have access to computers/laptops at school?	100%	0%
4	Is there a stable internet connection available in the classroom?	100%	0%
5	Do you feel that there is a need for digital-based learning media (e-LKPD)?	100%	0%
6	Have you ever used various learning models when teaching?	50%	50%
7	Do you always integrate local wisdom into your teaching?	25%	75%
8	Do you think it is important to integrate elements of local wisdom into classroom learning?	100%	0%

The results of the teacher survey indicate a paradoxical condition in which schools are structurally well-prepared to support innovative learning, yet this readiness has not been translated into optimal classroom practices. All teachers reported the implementation of the Merdeka Curriculum, adequate access to digital devices, and stable internet connectivity. However, only a limited proportion found existing learning media adequate, and only 50% reported using varied instructional models.

This discrepancy suggests that the challenge in mathematics education is no longer primarily about infrastructure availability, but rather about pedagogical readiness and instructional transformation. The limited use of diverse learning models indicates that teaching practices remain partially anchored in conventional approaches, which are less effective in fostering higher-order thinking skills, including mathematical connection skills. Furthermore, the perceived inadequacy of existing learning media underscores the need for more interactive, adaptive, and student-centred resources that support meaningful learning processes.

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Based on these conditions, it means that the infrastructure in each school is supportive, but classroom practices are not yet optimal. Typically, this condition is caused by teachers who often feel they lack the technical and pedagogical training to design ICT-based learning, so that the use of technology remains superficial or rarely used [56], [57], [58]. This is in line with the results of research by Zelkowski and colleagues [16], which showed that teachers' pedagogical beliefs and competencies play a more determining role than access to technology in shaping teaching practices. Similarly, Ge Ge [59] argue that the lack of use of digital tools in mathematics education is often associated with limited pedagogical innovation rather than technical constraints. In addition, policies from the principal and management support are needed; without them, teachers are reluctant to innovate [60], [61], [62]. The persistence of partially teacher-centred practices also aligns with evidence suggesting that instructional transformation requires not only curriculum reform but also sustained professional development and institutional support. Studies indicate that without adequate training and leadership support, teachers tend to adopt technology in superficial ways or avoid it altogether [63]

The above conditions also illustrate the gap between the demands of the Merdeka Curriculum, which emphasises student-centred, problem-based, and contextual learning, and the realities in the field, which still tend to be teacher-centred and rely on conventional media. This is in line with the opinion of Susanti et al. [64], who stated that the use of interactive digital media in mathematics learning is low. In fact, digital-based learning media (e-LKPD) is needed in learning [65]

Another important finding is that all teachers acknowledged the importance of integrating local wisdom into classroom instruction. This reflects a strong conceptual understanding of culturally responsive pedagogy, though it has not yet been operationalised in instructional practice. This gap between belief and implementation highlights the need for concrete instructional designs that can facilitate the integration of cultural context into mathematics learning. Ubiratan D'Ambrosio [28] emphasises that integrating cultural context into mathematics learning enhances relevance and meaning-making. Empirical work by Rosa and Orey [29] further demonstrates that culturally contextualised instruction improves student engagement and conceptual understanding. The integration of culture in mathematics learning can introduce local cultural values, increase students' awareness of Indonesia's cultural wealth, and make learning more contextual and meaningful [66], [67]. However, as observed in this study, such integration often remains at the level of discourse rather than practice, indicating a persistent implementation gap.

Based on the analysis of learning, informed by both student and teacher opinions, there is a gap between the demands of the independent curriculum and the conditions in the field. This condition underscores the urgent need for interactive learning media that combine technology, student-centred learning models, and local wisdom to improve mathematics learning objectives. This combination of findings indicates that the school context is very supportive and at the same time in great need of developing E-LKPD based on Problem-Based Learning with a theme of local wisdom, as this product will bridge the gap between the availability of infrastructure and curriculum demands with actual learning practices, and is supported by research results that show the effectiveness of PBL e-LKPD and ethnomathematics-based LKPD in increasing student motivation, problem solving, and mathematical connection skills [68].

3.2. Analysis of Mathematical Connection Abilities

One skill that junior high school students in Wado subdistrict still lack is mathematical connection skills. Mathematical connection skills refer to students' ability to connect mathematical concepts to real-life situations and to their relationships with the topics in mathematics [69]. According to the National Council of Teachers of Mathematics [70], poor mathematical connection skills can lead to a superficial, short-lived understanding of mathematics, as students find it difficult to see the connections between mathematical concepts and their applications in everyday life. Several studies also show that students' mathematical connection skills in various schools still need to be improved so that they can develop a deeper and more meaningful understanding of mathematics [7], [71]. This condition underscores the need to develop learning methods that enhance students' mathematical connection skills, enabling them to relate theory to practice effectively.

The data obtained is in the form of test results or scores of students' mathematical connection skills in answering essay-type test questions on Data and Diagrams, as shown in Table 3.

Table 3. Maximum Value, Minimum Value, Average

Number of Students	Maximum Score	Minimum Score	Average	Students Who Passed	Students Who Did Not Pass
22	90	25	57,5	6	16

Based on Table 3, the results of the mathematical connection ability test indicate that only 6 students (27.3%) have achieved the Minimum Passing Criteria (KKM), while 22 students (72.7%) have not. The school's KKM for grade VIII is 70. The maximum score achieved by students was 90, the minimum score was 25, and the average score was 57.5. This means students' mathematical connection skills remain relatively low. This is in line with several studies conducted in junior high schools showing that students' mathematical connection abilities in statistics tend to be low to moderate [72], [73], [74].

Furthermore, the students' answers were analysed further based on indicators of mathematical connection ability.

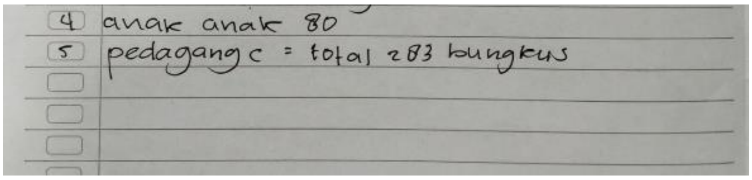

Figure 1. Students' answers to mathematical connection questions

Figure 1 shows that students are not yet able to relate mathematical concepts. This means that students are also unable to understand and explain the essence of the problems given. This occurs because of students' habit of doing routine problems [75]. In addition, the low level of students' mathematical connection skills is also influenced by weak conceptual understanding, a tendency to memorise formulas without understanding their meaning, low

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learning motivation, difficulty in converting story problems into mathematical models, and learning methods that lack variety [76], [77]. Thus, the student failed to meet all indicators of mathematical connection comprehension.

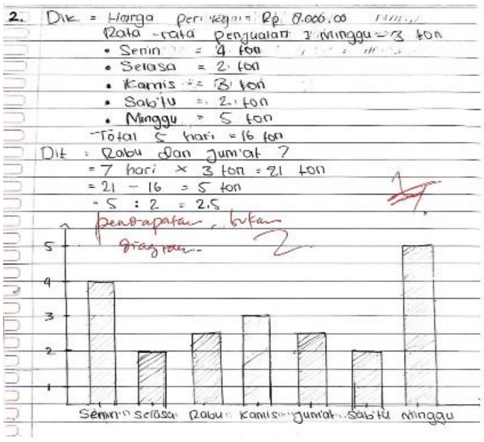

Figure 2. Students' answers indicate an inability to connect mathematics with other subjects.

Analysis of the answers in Figure 2 indicates that students demonstrated mathematical connection skills, even though not all indicators were met. Students rewrote key information from the question and organised it in a list, then correctly calculated the total sales and the difference. This shows a connection between data and basic mathematical operations. However, students did not complete an important instruction in the question: they were unable to find the income earned (economics) and instead drew a bar chart, indicating that connections to other fields of knowledge were not yet understood. These results are in line with several studies showing that students are often "less able" to connect mathematical topics with other topics found in everyday life [73], [74], [78].

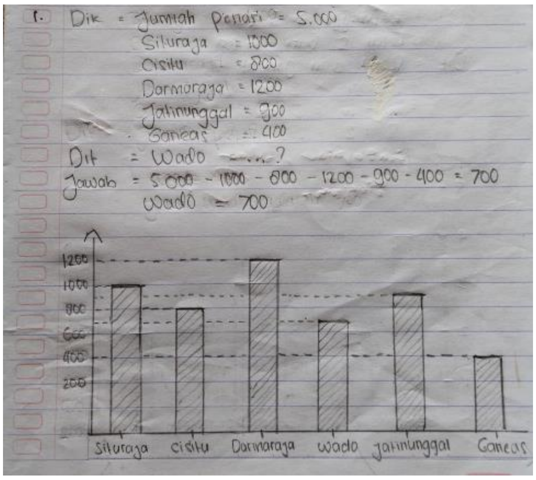

Figure 3. Answers with all three indicators met

Figure 3 indicates that students have mastered all indicators of mathematical connection skills. Students can connect contextual information to addition and subtraction operations to obtain unknown data. Students write down calculation operations in sequence. Students can connect calculation results to other representations, namely accurate bar charts, thereby demonstrating their ability to use various representations to describe the same situation. Students are also able to maintain consistency between the numbers in the calculation and the heights of the bars in the diagram, indicating that they have a very good understanding of the relationship between numerical data and visual representations in real-life contexts. These results are in line with [72], who found that students with strong connection skills are relatively adept at solving mathematical connection problems.

In general, students face obstacles when solving mathematical connection problems because they are not familiar with problems that differ from those given by teachers in class. Students also feel confused about where to start. So far, they have been solving problems given by teachers without understanding their meaning or what they are doing. This happens because students tend to memorise the formulas and steps for solving problems demonstrated by the teacher [72]. This means that the learning carried out does not provide students with opportunities to acquire knowledge or engage actively with the material. Thus, the results of this analysis further reinforce the urgent need to develop E-LKPD based on problem-based learning with a theme of local wisdom

4. CONCLUSION

This study demonstrates an urgent need to develop Problem-Based Learning (PBL)–based electronic student worksheets (E-LKPD) integrated with local wisdom to support mathematics learning within the Merdeka Curriculum. Empirical findings reveal a clear discrepancy between the availability of digital infrastructure and its limited pedagogical utilisation, as well as low students' mathematical connection skills, reflected in suboptimal achievement levels and limited ability to relate mathematical concepts across contexts. In addition, current learning practices remain dominated by conventional textbooks and printed worksheets, which contribute to low student engagement. From a practical perspective, these findings imply that teachers require interactive, technology-enhanced learning media that not only facilitate problem-based activities but also provide immediate feedback and contextual learning experiences. The integration of local wisdom into E-LKPD design can enhance students' motivation and engagement by situating mathematical problems within familiar cultural contexts, thereby supporting more meaningful learning processes.

However, this study is limited to the needs analysis stage within a Research and Development framework and involves a relatively small sample from a single school, which may restrict the generalizability of the findings. In addition, the study has not yet examined the effectiveness of the proposed learning media in improving students' mathematical connection skills.

Future studies should focus on developing and validating a prototype of PBL-based E-LKPD integrated with local wisdom, followed by rigorous testing of its effectiveness through experimental or quasi-experimental designs. Further research could also explore its impact on other higher-order mathematical competencies and investigate scalability across diverse educational settings to ensure broader applicability and sustainability.

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