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Developing a Problem Based Learning Student Worksheet Assisted by Kahoot! To Foster the Mathematical Literacy of Grade X Students

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Abstract: This study responds to the persistently low mathematical literacy of Indonesian secondary students and the limited availability of contextual, interactive teaching materials at SMAN 1 Seluma, Bengkulu. The purpose of the research was to develop a Student Worksheet (LKS) based on Problem Based Learning assisted by Kahoot! on the topic of Systems of Linear Equations in Three Variables (SLETV) and to describe its validity and practicality for fostering the mathematical literacy of grade X students. The study employed a research and development design following the ADDIE model, comprising analysis, design, development, implementation, and evaluation. Participants consisted of three expert validators (content, media, and language), two mathematics teachers, 12 students in a limited trial, and 74 students in a field trial, all selected through purposive sampling. Data were collected through observation sheets, interview guidelines, expert validation sheets, and teacher and student response questionnaires, and were analysed using quantitative descriptive techniques by converting scores into validity and practicality categories. The worksheet obtained average validation scores of 3.82 from the content expert, 3.78 from the media expert, and 3.78 from the language expert, all within the highly valid category. Practicality reached 96% from teacher responses and 96% from student responses, both categorised as highly practical. The developed worksheet is therefore declared valid and practical and is appropriate for use as teaching material to foster students' mathematical literacy.

Keywords: *Mathematical literacy; problem-based learning; Kahoot!; student worksheet; ADDIE model*

Abstrak: Studi ini menanggapi rendahnya literasi matematika siswa sekolah menengah Indonesia dan terbatasnya ketersediaan bahan ajar kontekstual dan interaktif di SMAN 1 Seluma, Bengkulu. Tujuan penelitian ini adalah untuk mengembangkan Lembar Kerja Siswa (LKS) berbasis Pembelajaran Berbasis Masalah yang dibantu oleh Kahoot! pada topik Sistem Persamaan Linear Tiga Variabel (SLETV) dan untuk mendeskripsikan validitas dan kepraktisannya dalam meningkatkan literasi matematika siswa kelas X. Studi ini menggunakan desain penelitian dan pengembangan mengikuti model ADDIE, yang terdiri dari analisis, desain, pengembangan, implementasi, dan evaluasi. Partisipan terdiri dari tiga validator ahli (konten, media, dan bahasa), dua guru matematika, 12 siswa dalam uji coba terbatas, dan 74 siswa dalam uji coba lapangan, semuanya dipilih melalui pengambilan sampel bertujuan. Data dikumpulkan melalui lembar observasi, pedoman wawancara, lembar validasi ahli, dan kuesioner tanggapan guru dan siswa, dan dianalisis menggunakan teknik deskriptif kuantitatif dengan mengkonversi skor ke dalam kategori validitas dan kepraktisan. Lembar kerja tersebut memperoleh skor validasi rata-rata 3,82 dari ahli konten, 3,78 dari ahli media, dan 3,78 dari ahli bahasa, semuanya dalam kategori sangat valid. Kepraktisan mencapai 96% dari tanggapan guru dan 96% dari tanggapan siswa, keduanya dikategorikan sebagai sangat praktis. Oleh karena itu, lembar kerja yang dikembangkan dinyatakan valid dan praktis serta sesuai untuk digunakan sebagai bahan ajar untuk meningkatkan literasi matematika siswa.

Kata kunci: Literasi matematika; pembelajaran berbasis masalah; Kahoot!; lembar kerja siswa; model ADDIE

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Introduction

Mathematical literacy has become a central goal of school mathematics worldwide because it describes what learners can actually do with mathematics beyond the classroom. The OECD (2023) defines mathematical literacy as an individual's capacity to reason mathematically and to formulate, employ, and interpret mathematics in a variety of real-world contexts in order to solve problems and make well-founded decisions. Burkhardt et al. (2024) argue that a literacy-oriented curriculum must therefore privilege reasoning and non-routine problem solving rather than the reproduction of procedures, while Koh et al. (2025) show that assessment practices still lag behind this ambition in many systems. In Indonesia, the *Kurikulum Merdeka* has adopted the same orientation by positioning literacy and numeracy as cross-cutting competencies that every subject is expected to cultivate (Kemendikbudristek, 2023).

Empirical evidence indicates that the ambition has not yet translated into outcomes. In PISA 2022, Indonesian students reached a mean mathematics score of 366 against an OECD average of 472 (OECD, 2023), a gap that reflects difficulty in interpreting contextual problems rather than a lack of procedural fluency alone. Studies conducted in Indonesian classrooms point to similar patterns: Mulyani and Haerudin (2021) documented systematic errors when students translated word problems on systems of linear equations into mathematical models, and Sudi (2022) found that literacy-oriented approaches improved performance precisely where conventional instruction had failed. Zendrato et al. (2025) further reported that problem-based instruction supported by interactive digital media raised students' mathematical reasoning substantially, strengthening the case for contextual and digitally supported learning materials.

Preliminary observation at SMAN 1 Seluma, a public senior secondary school in Bengkulu Province, revealed conditions consistent with this national picture. Worksheets in use were dominated by procedural exercises that gave students few opportunities to explore ideas or reason at a higher level; the mean mathematical literacy score in the observed classes reached only 60 out of 100, and most students struggled with context-based items. Teachers reported difficulty providing timely feedback because assessment was still carried out manually, and the limited availability of projectors constrained the use of technology-supported media. Systems of Linear Equations in Three Variables (SLETV) proved particularly demanding, since it requires students to model a situation, choose an appropriate solution strategy, and interpret the result against the original context.

Problem Based Learning (PBL) offers a pedagogical response that aligns closely with these demands. Its syntax—orienting students to a problem, organising them for study, guiding investigation, developing and presenting results, and analysing and evaluating the problem-solving process (Tiara et al., 2024)—mirrors the formulate–employ–interpret cycle that defines mathematical literacy. Worksheets built on this syntax have been shown to improve learning outcomes and problem-solving performance in Indonesian schools (Alboihaqi et al., 2024; Gustami et al., 2024; Yani et al., 2023), and Izzati et al. (2025) demonstrated specifically in the Bengkulu context that PBL-based, literacy-oriented worksheets improved junior secondary students' problem solving. Kosasih et al. (2025) reported comparable gains for contextually grounded worksheet designs.

Digital game-based assessment provides a complementary mechanism. Kahoot! delivers immediate feedback within a low-stakes competitive format, and a substantial evidence base links its use to increased motivation and engagement (Licorish et al., 2018; Plump & LaRosa, 2017; Wang & Tahir, 2020). In mathematics specifically, Lubis and Ulfah (2024) and Aprihartha et al. (2024) found that Kahoot!-based formative assessment supported students in applying concepts and communicating solutions, while Jarrah et al. (2025) and Pehlivan and Arabacioglu (2023) reported gains in both motivation and achievement. Purwadi (2022) and Juliani et al. (2025) documented similar effects on conceptual understanding and interest in Indonesian classrooms, and national policy has explicitly encouraged such platforms as part of the digitalisation of learning (Kemendikdasmen, 2025).

What remains underdeveloped is the integration of these two elements into a single teaching artefact. Existing PBL worksheet studies rarely embed a digital formative assessment component, while Kahoot! studies typically treat the platform as a standalone activity detached from the instructional sequence and seldom target mathematical literacy as the outcome of interest (Mukti & Yustitia, 2025; Setyaningrum et al., 2023). Work at senior secondary

level on SLETV, and in under-resourced districts such as Seluma, is scarcer still. This study addresses that gap by developing a Student Worksheet (LKS) in which Kahoot! is positioned deliberately at the fifth PBL stage as an interactive formative assessment. Two questions guide the research: (1) how valid is the developed worksheet according to content, media, and language experts, and (2) how practical is it according to teacher and student responses? The study contributes a documented, expert-validated design that other teachers can adapt, and it offers empirical evidence on where in the PBL sequence gamified assessment can most usefully be placed.

METHOD

Research design

This study used a research and development (R&D) design aimed at producing a Student Worksheet (LKS) based on Problem Based Learning and assisted by Kahoot! for mathematics instruction at grade X of SMAN 1 Seluma. Qualitative data informed the needs analysis, product design, and expert validation, while quantitative data were used to measure the validity and practicality of the product. The development procedure followed the ADDIE model (Branch, 2009), which comprises five stages: analysis, design, development, implementation, and evaluation (Figure 1). ADDIE was selected because its iterative structure permits revision at every stage rather than only at the end, which suits the development of classroom materials that must be adjusted repeatedly in response to expert and user feedback. The study also adopted a descriptive-evaluative paradigm, describing and appraising product quality against defined criteria so that the evaluation results feed directly into product refinement.

Figure 1. The ADDIE development model (adapted from Branch, 2009)

Setting and participants

The research was conducted at SMAN 1 Seluma, Seluma Regency, Bengkulu Province, during the even semester of the 2025/2026 academic year, with data collection carried out over two months (April–May 2026). Participants were selected through purposive sampling on the basis of grade level, learner characteristics, and the school's readiness to support the research. They comprised three expert validators—a mathematics education lecturer at Universitas Muhammadiyah Bengkulu (content), a mathematics teacher at SMAN 1 Seluma (media), and a supervisor of Indonesian language for the Regional Education Office of Area VI Tais (language)—together with two mathematics teachers acting as practitioner validators, 12 grade X students in the limited trial, and 74 grade X students in the field trial.

Instruments

Three sets of instruments were used. Expert validation sheets assessed content feasibility, presentation, graphic design, language, and the integration of mathematical literacy indicators, using a four-point Likert scale with space for qualitative comments. Teacher and student response questionnaires measured practicality across three aspects—attractiveness and motivation, content and mathematical literacy, and language and readability—using a five-point Likert scale. Observation and interview guidelines captured qualitative evidence on student engagement, collaboration, and difficulties encountered during implementation, and were used to triangulate the questionnaire findings.

Development procedure

At the *analysis* stage, classroom observation and teacher interviews established the need for contextual, interactive material on SLETV, together with an audit of learner characteristics, curriculum requirements, and available facilities. At the *design* stage, the worksheet structure was mapped onto the five PBL stages and drafted in Microsoft Word 2019, with layout, colour, typography, and illustration developed in Canva; the Kahoot! quiz was authored and linked through a QR code. At the *development* stage, the draft was submitted to the three experts, revised in line with their recommendations, and then trialled with 12 students. At the *implementation* stage, the revised worksheet was used with 74 students across regular mathematics lessons, and teacher and student responses were collected. The *evaluation* stage was formative throughout, with

each preceding stage reviewed and refined before the next began.

Data analysis

Validity was analysed by computing the mean validator score using V = Σx / n, where V is the mean validity score, Σx is the total score awarded, and n is the number of validators. Scores were interpreted against four categories adapted from Akbar (2013): 3.26–4.00 (highly valid), 2.51–3.25 (valid), 1.76–2.50 (less valid), and 1.00–1.75 (invalid). Practicality was analysed as a percentage using P = (Σx / (N × S_max)) × 100%, where P is the practicality percentage, Σx is the total score obtained, N is the number of respondents, and S_max is the ideal maximum score. Percentages were interpreted as 85.01–100% (highly practical), 70.01–85.00% (practical), 50.01–70.00% (less practical), and ≤50.00% (impractical). The product was deemed successful when it achieved a mean validation score of at least 3.25 and a practicality percentage of at least 85%. Qualitative data from observation, interviews, and open-ended comments were reduced, categorised, and triangulated against the quantitative results to guide revision.

RESULTS AND DISCUSSION

Analysis and design

The needs analysis confirmed that mathematics instruction on SLETV at SMAN 1 Seluma remained largely teacher-centred, relying on exposition and routine textbook exercises. Students received information more often than they engaged in problem solving, discussion, or connecting mathematical concepts to everyday situations, and consequently their critical thinking and mathematical literacy had limited opportunity to develop. This pattern is consistent with the interpretive difficulties documented by Mulyani and Haerudin (2021) and with the broader diagnosis offered by OECD (2023) and NCTM (2020), both of which locate the problem in instruction that stops at procedural mastery.

The design stage produced a worksheet organised around the five PBL stages. The cover, identity page, learning outcomes, graduate profile dimensions, learning objectives, and usage instructions preceded the core activity sequence: an orientation problem concerning the price of stationery at the school cooperative; group organisation and task division; guided investigation in which students construct and solve the three-variable system using elimination, substitution, or a combination of the two; presentation of group results; and analysis and evaluation of the solution process. A discussion table, a Kahoot!-assisted formative assessment section with quiz instructions and a QR-coded access link, a scoring rubric covering the full modelling cycle, and a reflection page completed the structure. Positioning the Kahoot! quiz at the fifth stage was a deliberate design decision rather than a convenience: it allows the quiz to assess understanding after the entire problem-solving cycle has been completed, gives students immediate feedback at the point where they are reviewing their own reasoning, and sustains engagement through to the close of the lesson.

Validity of the developed worksheet

Expert validation results are presented in Table 1.

Table 1. Expert validation results for the developed worksheet

No.	Assessed aspect	Mean	Category
1	Content feasibility	3.84	Highly valid
2	Presentation feasibility	3.80	Highly valid
3	Mathematical literacy	3.84	Highly valid
	Mean, content expert	**3.82**	**Highly valid**
4	Worksheet size	4.00	Highly valid
5	Cover design	3.71	Highly valid
6	Interior design	3.78	Highly valid
	Mean, media expert	**3.78**	**Highly valid**
7	Straightforwardness	3.50	Highly valid
8	Communicativeness	4.00	Highly valid
9	Dialogic and interactive	3.50	Highly valid
10	Learner suitability	4.00	Highly valid
11	Language conventions	3.83	Highly valid
	Mean, language expert	**3.78**	**Highly valid**

All three experts placed the worksheet in the highly valid category. The content expert awarded a mean of 3.82, indicating that the SLETV material is aligned with the curriculum learning outcomes, conceptually accurate, and systematically presented, and that mathematical literacy indicators are genuinely embedded in the problem-solving activities rather than appended to them. The media expert awarded 3.78, with layout, typography, colour, and illustration judged appropriate for grade X learners and the QR code and Kahoot! integration judged to increase interactivity. The language expert also awarded 3.78, confirming that the language is straightforward, communicative, suited to learner

development, and consistent with Indonesian language conventions. The lowest sub-scores—3.50 for straightforwardness and 3.50 for dialogic quality—identified instruction wording as the weakest element, which is precisely where the subsequent limited trial produced converging evidence.

Validator recommendations led to seven substantive revisions: renaming the product from LKPD to LKS and adding the author's name to the cover; correcting the preface and specifying the PBL–Kahoot! basis of the worksheet; updating the table of contents to include the formative assessment section; renumbering and correcting the graduate profile dimensions and linking them explicitly to mathematical literacy; rewriting the orientation problem so that it more strongly prompts literacy and critical reasoning; retitling the evaluation section as Kahoot!-assisted formative assessment on SLETV and regenerating the quiz QR code; and simplifying the reflection from a table format to open questions. These revisions confirm the value of the iterative structure of ADDIE, since each concerned the alignment between the stated literacy aim and the operational features of the material.

Practicality: limited trial

The limited trial with 12 students yielded the results shown in Table 2.

Table 2. Student responses in the limited trial (n = 12)

No.	Assessed aspect	%	Category
1	Interest and motivation	94.4	Highly practical
2	Content and literacy	93.1	Highly practical
3	Language and readability	91.7	Highly practical
	Overall mean	**93.1**	**Highly practical**

Observation during the limited trial showed high levels of engagement, particularly during group discussion, the construction of mathematical models for the stationery problem, and the Kahoot! quiz. Interviews indicated that students found the worksheet attractive and easy to follow, valued its systematic steps, and appreciated being able to see their results immediately after answering. Students also raised a specific concern about the wording of some task instructions, noting that certain sentences admitted more than one interpretation. This feedback converged with the language expert's lower ratings for straightforwardness, and the instructions were rewritten to be more operational before the field trial. That students noticed the ambiguity at all is itself evidence that they were reading and using the worksheet closely rather than working around it.

Practicality: field trial

Teacher and student responses in the field trial are presented in Tables 3 and 4.

Table 3. Teacher responses to the practicality of the worksheet (n = 2)

No.	Assessed aspect	%	Category
1	Attractiveness	96.7	Highly practical
2	Content and literacy	88.3	Highly practical
3	Language and presentation	96.7	Highly practical
	Overall mean	**96.0**	**Highly practical**

Table 4. Student responses to the practicality of the worksheet (n = 74)

No.	Assessed aspect	%	Category
1	Interest and motivation	97.7	Highly practical
2	Content and literacy	95.4	Highly practical
3	Language and readability	93.5	Highly practical
	Overall mean	**96.0**	**Highly practical**

Both groups placed the worksheet in the highly practical category at 96%. Teachers rated attractiveness and language and presentation most highly (96.7% each), reporting that the worksheet was easy to use, clearly sequenced, and consistent with the PBL syntax. The lowest teacher rating, 88.3% for content and mathematical literacy, remains within the highly practical band but suggests that the literacy demands of the tasks require more instructional support than the presentational features do—an unsurprising finding given that literacy-oriented tasks ask teachers to manage open-ended reasoning rather than to check procedural answers. Students rated interest and motivation highest at 97.7%, followed by content and mathematical literacy at 95.4% and language and readability at 93.5%. The improvement in the language and readability rating from 91.7% in the limited trial to 93.5% in the field trial indicates that the instruction revisions had their intended effect.

DISCUSSION

The results indicate that the alignment between PBL syntax and the mathematical literacy cycle is not merely theoretical. Each stage of the worksheet exercised a distinct literacy competency. The orientation problem required students to identify relevant mathematical information within a contextual situation, which is the formulating phase

described by OECD (2023). Group organisation and guided investigation required them to translate that situation into a three-variable system and to select among elimination, substitution, and combined strategies—the employing phase—supported by the guiding questions in the worksheet, which functioned as scaffolding in the Vygotskian sense by providing graduated assistance that could be withdrawn as competence developed. Presentation of results exercised mathematical communication, an indicator rarely trained in conventional instruction, and the closing reflection required students to interpret their solutions against the original context. These observations are consistent with Tiara et al. (2024) on the operation of PBL syntax and with Izzati et al. (2025), who found comparable literacy gains from PBL-based worksheets in Bengkulu.

The placement of Kahoot! at the evaluation stage merits particular attention because it distinguishes this design from studies in which gamified quizzes are used as warm-ups or standalone activities. Positioned at the close of the problem-solving cycle, the quiz functioned as genuine formative assessment: it measured understanding after the full sequence had been completed, returned feedback at the moment students were already reflecting on their reasoning, and gave teachers diagnostic information for subsequent lessons. This aligns with Lase (2024) on the role of formative assessment in sustaining learning and with Lubis and Ulfah (2024) and Aprihartha et al. (2024) on Kahoot!'s capacity to support the application and communication of mathematical concepts. The motivational effects observed here—reflected in the 97.7% student rating for interest—are consistent with the broader literature (Jarrah et al., 2025; Pehlivan & Arabacioglu, 2023; Wang & Tahir, 2020), though the present study adds the qualification that these effects were obtained when the platform was embedded within an instructional sequence rather than used in isolation.

Three features appear to account for the product's high validity and practicality ratings. First, the contextual anchoring of the problem in a familiar setting—the school cooperative—lowered the barrier to modelling, in line with Kosasih et al. (2025). Second, the explicit scaffolding structure of guiding questions, discussion tables, and a rubric covering the full modelling cycle gave students a visible pathway through problems that would otherwise have appeared unstructured. Third, the QR-coded access to Kahoot! removed a practical obstacle in a school where projector availability is limited, since students could reach the quiz on their own devices. Taken together, these features suggest that the effectiveness of gamified assessment in mathematics depends substantially on its instructional placement, a proposition that follows from the present findings but requires experimental testing to confirm.

Several limitations qualify these conclusions. The material covers only SLETV, so generalisation to other mathematical topics is not warranted. Kahoot! depends on device availability and network stability, both of which constrain adoption in schools with weaker infrastructure. PBL requires comparatively long instructional time, which may not fit every timetable. No design preview was conducted with users during initial drafting, and Kahoot! was used exclusively for formative assessment rather than across the instructional sequence. Most importantly, validity and practicality do not establish effectiveness: the study did not include a control group or pre-test/post-test comparison, so the extent to which the worksheet actually improves measured mathematical literacy remains an open question.

CONCLUSION

The Student Worksheet based on Problem Based Learning and assisted by Kahoot! developed in this study meets both criteria set for the research. It is highly valid, with mean scores of 3.82 from the content expert, 3.78 from the media expert, and 3.78 from the language expert, all above the 3.25 threshold. It is also highly practical, with teacher responses at 96% and student responses at 96%, both above the 85% threshold. The worksheet is therefore appropriate for use as teaching material on Systems of Linear Equations in Three Variables for grade X students. The study's principal contribution lies in demonstrating how a gamified formative assessment can be integrated at a specific point in the PBL sequence—the analysis and evaluation stage—rather than being appended to a lesson, and in documenting a design that other teachers can adapt to comparable contexts. Future research should test the effectiveness of the worksheet experimentally against a control class, extend the design to other mathematical topics, and examine whether alternative placements of the digital assessment within the PBL sequence produce different learning outcomes.

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

[First author]: conceptualization, methodology, investigation, data curation, writing—original draft. [Second author]: supervision, validation, writing—review and editing. [Third author]: supervision, methodology, writing—review and editing.

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