

Inventa: Journal of Science, Technology, and Innovation
Vol 2 No 2 December 2026, Hal 37-53
ISSN: 3123-3147 (Print) ISSN: 3123-3155 (Electronic)
Open Access: https://scriptaintelektual.com/inventa

Development of Interactive Problem-Based Electronic Worksheets for Microsoft Office Using Liveworksheets and Wordwall at SMA Negeri 1 Taraju

Agung Muhaemin[1]*, Milah Nurkamilah[2], Sarmidi[3]
[1-3] Universitas Muhammadiyah Tasikmalaya, Indonesia
Email: agung502mhn@gmail.com[1]

Article Info :
Received:
06-10-2026
Revised:
10-11-2026
Accepted:
18-11-2026

Abstract

This study aimed to develop and evaluate interactive problem-based electronic student worksheets integrating Liveworksheets and Wordwall for Microsoft Office instruction at SMA Negeri 1 Taraju. A research and development design employing the ADDIE model was implemented with 36 Grade X students during the 2026/2027 academic year. Data were collected through classroom observations, teacher interviews, expert validation questionnaires, student practicality questionnaires, and cognitive pre-tests and post-tests comprising 15 multiple-choice questions. Data analysis employed descriptive statistics, percentage-based feasibility and practicality assessments, and normalized gain analysis. The developed worksheets incorporated contextual problem-solving activities involving Microsoft Word, Excel, and PowerPoint integration through Paste Special and Paste Link functions, supported by interactive exercises and gamified reinforcement. Media and subject-matter validation scores reached 82.00% and 95.56%, respectively, producing an average feasibility score of 88.78%. Student practicality reached 87.00%, indicating very practical instructional materials. Mean cognitive achievement increased from 73.70 to 88.89, while classical learning mastery improved from 52.78% to 100.00%. The reported normalized gain was 0.59, indicating moderate improvement. The findings demonstrate that the developed worksheets were feasible, practical, and associated with improved cognitive achievement, although causal effectiveness requires further comparative investigation.

Keywords: *Electronic student worksheets, Liveworksheets, Microsoft Office, Problem-based learning, Wordwall.*

©2026 Authors.. This work is licensed under a Creative Commons Attribution-Non Commercial 4.0 International License.
(https://creativecommons.org/licenses/by-nc/4.0/)

INTRODUCTION

The increasing integration of digital technologies into educational systems has intensified the need for instructional approaches that extend beyond technological accessibility toward the development of applicable digital competencies, independent problem-solving abilities, and meaningful student engagement. Contemporary educational transformation requires learning environments that enable students to interact with digital information, manipulate technological tools, and apply conceptual knowledge to authentic academic and professional tasks rather than merely reproduce procedural instructions. Within Indonesian secondary education, the Merdeka Curriculum establishes an instructional framework that emphasizes active learning, technological literacy, and the development of competencies relevant to increasingly interconnected digital environments. Informatics education at the senior secondary level consequently occupies a strategic position because students are expected to develop practical proficiency in productivity applications, including Microsoft Word, Microsoft Excel, and Microsoft PowerPoint, while understanding how information can be transferred and integrated across different software environments. Recent developments in educational technology indicate that interactive digital platforms and gamified learning environments offer opportunities to strengthen student participation, although their educational value depends substantially on instructional design, the relevance of learning activities, and alignment between technological features and intended competencies (Gui et al., 2023; Zeng et al., 2024). Research examining gamification in secondary education further emphasizes the importance of connecting interactive technological experiences with cognitive learning objectives rather than treating engagement as an independent indicator of educational effectiveness (Baltabayeva et al., 2026). Evidence from digital learning research also suggests that game-based instructional approaches can

support computational thinking and related cognitive processes when learners participate in structured activities requiring interpretation, decision-making, and problem solving (Ma et al., 2023). Nevertheless, technological integration does not automatically resolve persistent instructional limitations, particularly where classroom activities remain dominated by verbal explanations, teacher demonstrations, and static materials that provide insufficient opportunities for independent experimentation. Preliminary observations and interviews with the Informatics teacher at SMA Negeri 1 Taraju identified such limitations in teaching the integration of Microsoft Office applications, particularly students' difficulties in independently applying procedures for linking spreadsheet data with documents and presentations. These circumstances establish a specific instructional problem in which the availability of digital applications has not been adequately translated into interactive learning experiences that systematically develop students' practical understanding and application skills.

Contemporary scholarship on interactive digital education demonstrates a progressive movement from evaluating the general attractiveness of technological media toward examining the relationships among instructional architecture, learner participation, cognitive engagement, and measurable educational outcomes. One substantial body of research concerns gamification and digital educational games, with quantitative syntheses indicating generally favorable relationships between game-based instructional interventions and academic achievement while simultaneously identifying variations associated with educational settings, learning objectives, and game-design characteristics (Diaz & Estoque-Loñez, 2024; Ren et al., 2024). Research on gamification also distinguishes motivational outcomes from cognitive outcomes, suggesting that improvements in learner autonomy, relatedness, and intrinsic motivation should not automatically be interpreted as equivalent improvements in demonstrated competence (Li et al., 2024). Investigations involving language education and digitally supported design instruction extend this discussion by emphasizing the pedagogical significance of contextualized tasks, feedback mechanisms, and technology-mediated participation across different disciplinary environments (Chan & Lo, 2024; Cal y Mayor-Peña et al., 2024). Another interconnected research direction examines digital student worksheets as structured instructional instruments that organize learning tasks, guide individual exploration, and connect conceptual understanding with practical problem-solving processes. Research on differentiated digital worksheets indicates that their educational contribution is associated not merely with electronic presentation but also with the organization of meaningful activities that encourage learners to interpret information and construct responses to disciplinary problems (Qalfin et al., 2024). A recent synthesis of problem-based digital worksheet applications similarly positions authentic problems, guided investigation, and structured learning activities as central features supporting the development of problem-solving abilities (Sanca et al., 2026). These research directions reveal considerable conceptual compatibility between problem-based instructional design and interactive gamification, particularly where digital worksheets provide the organizational structure for investigating problems while game-based activities reinforce knowledge and sustain participation. The emerging state of the art therefore supports an integrated understanding of educational technology in which pedagogical sequencing, interactive task completion, feedback, and learner-centered assessment are examined as complementary instructional components rather than isolated technological interventions.

Despite the expanding evidence supporting interactive digital learning, several limitations remain relevant to the development of instructional materials for application-oriented Informatics education. First, the generalizability of favorable gamification outcomes remains constrained by variation in educational contexts, learner characteristics, instructional content, and the configuration of game elements, making it inappropriate to assume that an intervention effective in one subject will generate equivalent outcomes in another. Meta-analytical investigations have demonstrated that the educational effects of gamification are influenced by intervention characteristics and learning conditions, indicating that technology-mediated engagement and actual academic achievement require differentiated evaluation rather than being treated as interchangeable constructs (Zeng et al., 2024; Xu et al., 2025). Second, research on student engagement suggests that interactive and gamified experiences may encourage participation without necessarily establishing whether learners have acquired the practical competencies required to complete authentic tasks independently (Ramírez Ruiz et al., 2024). Third, existing discussions of digital learning platforms emphasize the instructional value of using platform-generated information to inform pedagogical decisions, yet evidence

concerning digital platform utilization does not independently establish the effectiveness of a particular combination of learning applications for a specific curricular competency (Hase & Kuhl, 2024). Fourth, investigations into self-regulated learning within problem-based instructional environments highlight the complexity of learner strategies and the importance of instructional support, suggesting that presenting students with a problem does not necessarily guarantee productive independent investigation (Tempelaar et al., 2024). These limitations become particularly relevant when considering the transferability of findings from gamified learning, science-oriented digital worksheets, and problem-based instructional research to the practical integration of Microsoft Office applications at the senior secondary level. The literature considered provides substantial support for individual pedagogical mechanisms, but it offers a less direct evidentiary basis for evaluating a deliberately sequenced combination of Liveworksheets-based practical investigation and Wordwall-based gamified reinforcement in teaching data integration across Word, Excel, and PowerPoint. The research gap addressed in the present study is therefore a contextual and instructional-design gap concerning the development and evaluation of an integrated learning product for a specific practical Informatics competency, rather than an unsupported assertion that interactive worksheets or the combination of digital learning platforms have never been investigated.

The unresolved instructional-design problem has implications for both the interpretation of educational technology research and the practical quality of secondary-level Informatics instruction. From a scientific standpoint, the absence of context-specific evaluation limits understanding of how established pedagogical principles can be operationalized into coherent learning products that connect authentic problem identification, guided technological practice, feedback, and competency assessment. Digital learning environments frequently incorporate multimedia features, immediate responses, and motivational elements, yet the educational significance of these characteristics depends on whether they contribute to the cognitive activities required by the learning objectives rather than functioning primarily as sources of entertainment. Research comparing motivational and competency-related outcomes provides a substantive justification for evaluating learning materials through several distinct dimensions, including expert-assessed instructional quality, student-perceived usability, and demonstrated learning achievement (Li et al., 2024). Investigations of digital educational games further indicate that the effectiveness of technological enrichment depends on the contribution of instructional elements to content learning, reinforcing the need to design game-based activities around substantive educational tasks (Gui et al., 2023). For teachers, insufficiently structured digital resources may preserve dependence on repeated demonstrations, reduce opportunities for differentiated learning, and restrict the time available for students to investigate procedural errors through independent practice. For students, these limitations may weaken their ability to transfer knowledge from recognizing software functions to applying those functions in the preparation of integrated academic documents and presentations. The instructional difficulties observed at SMA Negeri 1 Taraju consequently require a learning intervention that addresses not only student interest but also the systematic organization of practical activities, accessibility of instructional resources, and adequacy of assessment procedures. A structured product-development approach is particularly relevant because it enables the characteristics of the learning materials to be examined before their classroom implementation and allows student responses to be considered alongside cognitive achievement. The scientific urgency lies in establishing evidence concerning the feasibility, practicality, and educational performance of a contextually designed interactive learning product, while the practical urgency concerns the provision of instructional materials that enable teachers to support application-oriented learning without relying exclusively on conventional demonstrations.

The present study is positioned at the intersection of problem-based instructional development, interactive electronic worksheets, and gamified learning reinforcement, with its proposed contribution located in the pedagogical integration of these components for a specific secondary-school Informatics application. Unlike research primarily concerned with the aggregate effects of gamification or the comparative performance of educational game elements, the study focuses on developing a coherent instructional product in which each digital platform performs a distinct function within an organized learning sequence. Evidence concerning game-element combinations suggests that the educational implications of gamification depend partly on how instructional and motivational features are configured, supporting the need for pedagogically justified rather than arbitrary technological integration (Xu et al., 2025). The proposed product employs Liveworksheets as the

principal environment for presenting contextual problems, providing procedural guidance, and organizing interactive practice, while Wordwall functions as a supplementary reinforcement environment through interactive matching activities and immediate feedback. This configuration is intended to support the five instructional stages of problem-based learning, beginning with the identification of a practical problem and progressing through collaborative investigation, the development of solutions, and the evaluation of learning processes. The instructional content is specifically directed toward integrating Microsoft Excel tables and charts into Microsoft Word documents and Microsoft PowerPoint presentations through the Paste Special and Paste Link functions, thereby distinguishing the learning product from digital materials emphasizing conceptual recognition without corresponding software-based application. The study also incorporates the ADDIE development model to organize instructional needs analysis, product design, development, implementation, and evaluation within a systematic research and development procedure. Its proposed novelty consequently consists of a context-specific instructional configuration that combines problem-based electronic worksheets, differentiated platform functions, and practical cross-application Microsoft Office integration within a single learning product. This contribution should be interpreted as an applied pedagogical and product-development innovation rather than the introduction of a new learning theory or a claim of universal technological originality. The evaluation framework further distinguishes the study from interventions examined primarily through engagement or achievement alone by incorporating expert validation, student practicality assessments, and cognitive pre-test and post-test measurements as complementary indicators of instructional product quality.

The present study aims to develop and evaluate interactive problem-based electronic student worksheets integrating Liveworksheets and Wordwall for Microsoft Office instruction among Grade X students at SMA Negeri 1 Taraju. The development process is organized through the Analysis, Design, Development, Implementation, and Evaluation stages of the ADDIE model to ensure systematic alignment between instructional needs, curriculum-related competencies, technological features, and learning activities. The instructional product is designed to facilitate practical understanding of cross-application data integration involving Microsoft Word, Microsoft Excel, and Microsoft PowerPoint, particularly through the application of Paste Special and Paste Link functions in contextual problem-solving activities. The study specifically seeks to examine the feasibility of the developed worksheets through media and subject-matter expert validation, determine their practicality through structured student responses, and assess changes in students' cognitive learning outcomes through pre-test and post-test measurements and normalized gain analysis. These objectives are operationalized within a classroom-based research and development design involving 36 students from class X 8 during the 2026/2027 academic year, with the evaluation focused on the instructional product and its implementation in the participating class. The anticipated scientific contribution is the provision of context-specific evidence concerning the development and evaluation of a pedagogically integrated digital worksheet model that combines structured problem-based practice with gamified reinforcement for application-oriented Informatics instruction. The methodological contribution concerns the coordinated examination of product feasibility, user practicality, and learning achievement within a systematic instructional development framework, while recognizing that a single-group implementation cannot independently establish causal superiority over alternative teaching approaches. The practical contribution is the development of a structured digital learning resource that can assist teachers in organizing interactive Microsoft Office activities and provide a basis for subsequent refinement, adaptation, and more rigorous comparative evaluation in related educational settings.

RESEARCH METHODS

This study employed a research and development (R&D) design using the ADDIE model, comprising five sequential stages: Analysis, Design, Development, Implementation, and Evaluation. The research was conducted at SMA Negeri 1 Taraju, Tasikmalaya Regency, Indonesia, during the first semester of the 2026/2027 academic year, involving all 36 students enrolled in class X 8 through a census sampling approach. The object of development was an interactive problem-based electronic student worksheet designed to support the integration of Microsoft Word, Microsoft Excel, and Microsoft PowerPoint, particularly through the Paste Special and Paste Link functions. The Analysis stage involved preliminary classroom observations, interviews with the Informatics teacher,

identification of instructional difficulties, and examination of Phase E learning outcomes under the Merdeka Curriculum to establish the instructional requirements of the proposed product. The Design stage involved organizing learning activities according to the five stages of problem-based learning, preparing contextual problems concerning the integration of spreadsheet data into documents and presentations, designing the interactive worksheet structure, and planning digital assessment instruments. During Development, the researchers constructed the electronic worksheets using Liveworksheets, developed gamified reinforcement activities through Wordwall, and prepared pre-test, post-test, and student response instruments using Google Forms. The instructional product was subsequently evaluated by two expert validators, Dani Rohpandi, M.Kom., as the media expert and Elis Siska, S.Kom., as the subject-matter expert, whose assessments and qualitative recommendations informed product revisions before classroom implementation. The Implementation stage involved the use of the revised worksheets in classroom and computer-laboratory activities, combining collaborative problem-solving exercises on laptops with smartphone-accessible assessments and interactive reinforcement activities. The Evaluation stage examined three dimensions of instructional product quality: feasibility based on expert validation, practicality based on student responses, and effectiveness in terms of changes in cognitive learning achievement following implementation.

Data were collected using classroom observation forms, structured interview guidelines, expert validation questionnaires, student practicality questionnaires, and cognitive achievement tests administered before and after the instructional intervention. Expert validation addressed the technical and instructional suitability of the electronic worksheets through separate media and subject-matter assessments, while qualitative comments from the validators were examined descriptively and used to identify aspects requiring revision. Feasibility percentages were obtained by dividing the scores awarded by each validator by the corresponding maximum possible scores and multiplying the resulting ratios by 100; the overall feasibility percentage was determined from the arithmetic mean of the two individual validation percentages. Product practicality was assessed through responses from all 36 participating students using a five-point Likert-scale questionnaire covering usability, visual attractiveness, and perceived learning usefulness. The questionnaire responses were summarized descriptively through mean scores and percentage-based interpretations to determine the practicality of the developed learning materials. Cognitive learning achievement was measured using 15 multiple-choice questions administered as a pre-test before implementation and as a post-test following the learning activities, with the evaluation directed toward students' understanding and application of Microsoft Office integration procedures. The resulting scores were analyzed using descriptive statistics, including mean achievement, highest and lowest scores, the number of students meeting the minimum mastery criterion of 75, and the corresponding percentage of classical learning mastery. Changes in achievement were additionally evaluated using normalized gain (N-Gain) analysis, calculated from pre-test and post-test performance relative to the maximum attainable score and interpreted using the gain categories adopted in the study. The pre-test–post-test assessment was conducted within a single participating class without a separately documented control group; consequently, the analysis was restricted to describing observed learning improvements rather than establishing causal superiority over alternative instructional approaches. Methodological rigor was supported by the documented sequence of instructional development, expert-based product assessment, revision informed by validator feedback, consistent administration of the specified assessment instruments, and explicit quantitative procedures for evaluating feasibility, practicality, and learning achievement.

RESULTS AND DISCUSSION

Development of Interactive Problem-Based Electronic Worksheets Using Liveworksheets and Wordwall

The development of interactive problem-based electronic student worksheets was conducted through the five stages of the ADDIE model, namely Analysis, Design, Development, Implementation, and Evaluation, with instructional activities directed toward the integration of Microsoft Office applications. The development process addressed the instructional difficulties identified at SMA Negeri 1 Taraju, particularly the limited availability of interactive learning materials and students' dependence on teacher demonstrations when performing practical software operations. The resulting instructional design positioned electronic worksheets as structured

environments for investigating practical problems rather than repositories of digital learning content, consistent with the emphasis on guided problem solving in digital worksheet development (Sanca et al., 2026). This orientation established a connection between the identified classroom needs, the selection of digital platforms, and the competencies associated with integrating numerical information into documents and presentations.

Preliminary analysis identified a discrepancy between the practical competencies expected in Grade X Informatics education and the learning experiences available through conventional instructional resources. Classroom observations and interviews with the Informatics teacher indicated that learning activities were predominantly supported by lectures, demonstrations, printed materials, and passive PDF modules, which provided limited opportunities for students to independently investigate software integration procedures. These conditions were relevant to the development of interactive learning materials because the effectiveness of digital instructional environments depends on the organization of meaningful tasks and the extent to which learners can actively manipulate information (Qalfin et al., 2024). The analysis consequently informed the selection of practical activities requiring students to establish relationships among Microsoft Excel, Microsoft Word, and Microsoft PowerPoint rather than merely identify the functions of individual application tools.

The instructional design incorporated five stages of problem-based learning, beginning with orientation toward a contextual problem and continuing through the organization of learning activities, individual or collaborative investigation, development and presentation of solutions, and evaluation of the problem-solving process. The central problem involved preparing documents and presentation materials that required numerical information from spreadsheets to be linked appropriately through the Paste Special and Paste Link functions. This organization established a practical relationship between the instructional content and the cognitive demands of identifying problems, selecting applicable procedures, and evaluating the resulting digital outputs. Research on self-regulated learning in problem-based environments indicates that structured instructional support is relevant to students' management of learning activities, particularly when tasks require sustained investigation and decision-making (Tempelaar et al., 2024).

The development stage produced interactive electronic worksheets using Liveworksheets, reinforcement activities using Wordwall, and digital assessment instruments administered through Google Forms. Liveworksheets accommodated instructional guidance and practical learning activities, whereas Wordwall provided matching-pairs exercises supported by immediate feedback and leaderboard features. The allocation of distinct instructional functions to these platforms reflected a deliberate separation between guided procedural practice and gamified reinforcement, consistent with research emphasizing the relationship between digital game design and educational objectives (Gui et al., 2023). The instructional components were organized to support the acquisition and reinforcement of Microsoft Office integration skills without positioning gamification as a substitute for practical application. The Google Forms interfaces developed for administering the pre-test, post-test, and student practicality questionnaire are presented in Figure 1.



(a) Google Forms pre-test (b) Google Forms post-test (c) Student practicality questionnaire

Figure 1. Google Forms interfaces used for the evaluation instruments

Table 1 presents the documented relationship between the ADDIE stages, development activities, and resulting instructional components.

Table 1. Development Stages and Instructional Components of The Interactive Electronic Worksheets

ADDIE stage	Documented development activities	Instructional components or outputs
Analysis	Classroom observations, teacher interviews, examination of Phase E learning outcomes	Identification of instructional needs and Microsoft Office integration difficulties
Design	Planning contextual problems, organizing five PBL stages, designing platform interfaces and assessments	Structured problem-based learning activities and digital assessment plans
Development	Constructing Liveworksheets materials, Wordwall quizzes, and Google Forms instruments; conducting expert validation and revision	Interactive electronic worksheets, gamified reinforcement activities, and assessment instruments
Implementation	Applying revised materials through group activities, laptop-based practice, and smartphone-accessible activities	Classroom implementation involving 36 Grade X students
Evaluation	Assessing feasibility, practicality, and cognitive achievement	Expert validation data, student responses, and pre-test–post-test data

The development structure presented in Table 1 demonstrates that the electronic worksheets were produced through an instructional sequence linking identified learning needs with product construction, classroom implementation, and evaluation. Each stage contributed a distinct methodological function, particularly by separating the identification of instructional requirements from the assessment of the developed product. This structure is relevant to contemporary digital instructional design because educational applications require alignment between technological affordances, learning objectives, and the instructional decisions governing their implementation (Hase & Kuhl, 2024). The documented development activities also provide a basis for evaluating the product as an integrated learning resource rather than assessing Liveworksheets and Wordwall as unrelated technological interventions.

The Liveworksheets interface incorporated group identification fields, instructions for use, curriculum learning outcomes, and contextual exercises involving the integration of spreadsheet tables and charts into documents and presentations. These components were intended to support procedural clarity while allowing students to complete practical activities within an interactive digital environment. The combination of instructional guidance and task-based exploration is consistent with research indicating that digitally structured learning activities can support the development of disciplinary competencies when their content and organization correspond to intended learning outcomes (Qalfin et al., 2024). The developed interface consequently reflected an instructional emphasis on the application of Microsoft Office functions rather than the passive presentation of technological information. The main Liveworksheets interface, including group identification fields, instructional guidance, curriculum learning outcomes, and contextual Microsoft Office integration activities, is presented in Figure 2.

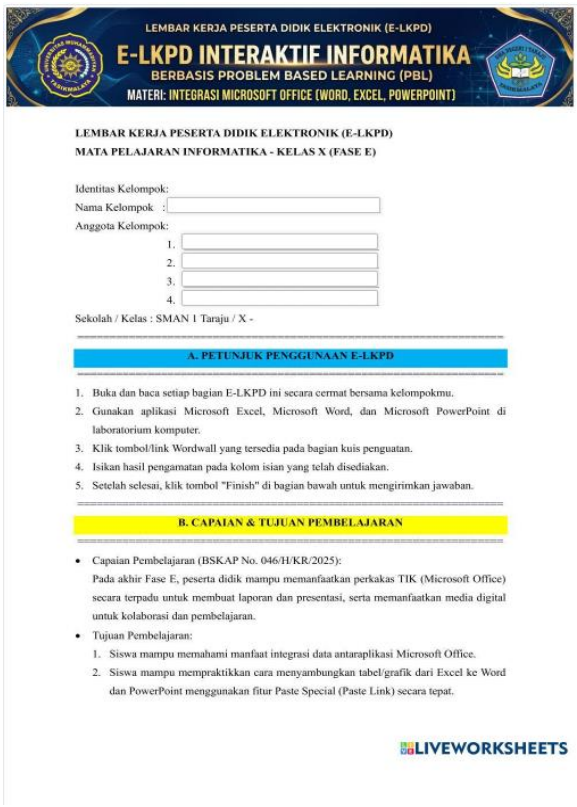


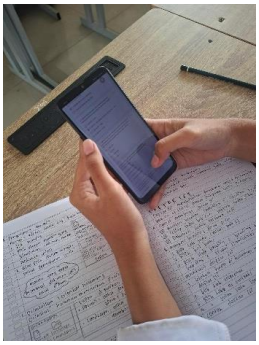
Figure 2. Main Liveworksheets interface of the interactive electronic worksheets

Wordwall was incorporated as a supplementary learning environment through a matching-pairs activity intended to reinforce knowledge acquired during the practical exercises. Its immediate feedback and leaderboard features introduced interactive assessment elements that differed from the procedural guidance delivered through Liveworksheets. Research on gamification indicates that game-based educational elements may support motivation and participation, although their effects on demonstrated competence can differ from their effects on learners' motivational experiences (Li et al., 2024). This distinction is relevant to the developed product because the Wordwall activities served a reinforcement function, while the application of Paste Special and Paste Link remained embedded in the practical learning tasks. The Wordwall matching-pairs activity developed to reinforce students' understanding through interactive exercises and immediate feedback is illustrated in Figure 3.



Figure 3. Wordwall quiz for reinforcing student learning

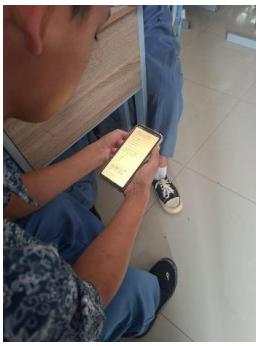
Classroom implementation involved 36 students from class X 8 who participated in collaborative learning activities using laptops and completed digital assessments and reinforcement exercises through smartphone-accessible platforms. The instructional arrangement combined group discussion, practical Microsoft Office integration exercises, interactive worksheet activities, and researcher guidance during classroom implementation. Studies examining gamified educational environments suggest that learner participation can be supported through combinations of interactive tasks and feedback mechanisms, although the quality of engagement depends on their instructional organization (Ramírez Ruiz et al., 2024). The documented implementation therefore demonstrated the operational integration of practical software activities and digital reinforcement within the participating class, without independently establishing the contribution of each platform to subsequent learning outcomes. The classroom implementation, including smartphone-based assessment, collaborative discussion, practical exercises, and instructional guidance, is documented in Figure 4.



(a) Pre-test on a smartphone



(b) Group discussion and laptop practice



(c) Interactive quiz and electronic worksheet activities



(d) Practical guidance from the researcher

Figure 4. Implementation of problem-based learning in the classroom

The resulting product represented an applied instructional development that combined problem-based learning procedures with complementary digital platforms for a specific Informatics competency. Its distinguishing characteristic was not the independent use of Liveworksheets or Wordwall, but the organization of guided practical activities and gamified reinforcement around the integration of Microsoft Office applications. Research examining combinations of game elements indicates that instructional configurations warrant particular attention because the educational contribution of gamification depends partly on how learning features are arranged and connected to instructional objectives (Xu et al., 2025). The documented development process provides a basis for subsequent assessment of expert-rated feasibility, student-perceived practicality, and cognitive achievement, while the available evidence does not establish the independent effectiveness of the individual platforms.

Feasibility and Practicality Evaluation of Interactive Problem-Based Electronic Worksheets

The feasibility evaluation of the developed interactive electronic worksheets was conducted to determine whether their instructional content, technological structure, and presentation characteristics were appropriate for implementation in Grade X Informatics education. Two expert validators

participated in the assessment, comprising a media specialist and a subject-matter specialist whose evaluations addressed different dimensions of instructional product quality. This evaluation approach is relevant to digital instructional development because the effectiveness of educational technology depends not only on the availability of interactive features but also on the alignment between instructional content, technological functionality, and pedagogical objectives (Cal y Mayor-Peña et al., 2024). The separation of media and subject-matter assessments provided complementary evidence concerning product suitability before examining students' experiences during classroom implementation.

Media validation was conducted by Dani Rohpandi, M.Kom., who assessed the developed instructional product and awarded 41 points from a maximum possible score of 50, corresponding to a feasibility percentage of 82.00%. This result was classified as very feasible according to the interpretation criteria adopted in the study, indicating that the evaluated media characteristics satisfied the established feasibility classification. The result is relevant to research on digitally supported learning because instructional interfaces must facilitate access to learning activities and enable students to interact with educational materials without unnecessarily complicating task completion (Hase & Kuhl, 2024). Nevertheless, the validation percentage represents an expert assessment of product suitability rather than an independent measurement of interface efficiency, cognitive load, or students' actual technological proficiency.

Subject-matter validation was undertaken by Elis Siska, S.Kom., who assigned 43 points from a maximum possible score of 45, producing a feasibility percentage of 95.56%. The evaluation was classified as very feasible, providing expert-based evidence concerning the instructional suitability of the developed Microsoft Office integration materials. The relatively high subject-matter validation score is consistent with the emphasis in problem-based digital worksheet development on connecting structured instructional activities with the competencies targeted through practical learning tasks (Sanca et al., 2026). The difference between the media and subject-matter percentages also indicates that the two evaluation domains should be interpreted separately, since favorable instructional content assessment does not necessarily imply an equivalent level of technological or interface-related suitability.

The feasibility results were summarized through the arithmetic mean of the individual expert validation percentages, producing a reported overall feasibility score of 88.78%. This calculation treated the media and subject-matter evaluations as equally weighted domains, although the two instruments had different maximum attainable scores. Such differentiation is relevant when interpreting educational product evaluations because the design characteristics of interactive learning environments and the quality of their instructional content represent related but analytically distinct dimensions (Li et al., 2024). The documented scores and percentage calculations are presented in Table 2, allowing the contribution of each expert assessment to the reported feasibility classification to be examined directly.

Table 2. Expert Validation Results for Interactive Problem-Based Electronic Worksheets

No.	Validator	Evaluation domain	Obtained score	Maximum score	Feasibility (%)	Classification
1	Dani Rohpandi, M.Kom.	Media expert	41	50	82.00	Very feasible
2	Elis Siska, S.Kom.	Subject-matter expert	43	45	95.56	Very feasible
	Mean of validation percentages	Overall feasibility	84	95	88.78	Very feasible

The results in Table 2 indicate that both expert assessments met the study's classification of very feasible, although the subject-matter evaluation exceeded the media evaluation by 13.56 percentage points. The reported mean of 88.78% was obtained by averaging the two validation percentages rather than dividing the combined obtained score by the combined maximum score, which is an important distinction when interpreting the aggregate evaluation. The numerical

difference suggests that instructional content received a more favorable assessment than the media characteristics, but the available data do not identify the specific questionnaire items responsible for this discrepancy. Research on educational technology design emphasizes that the instructional usefulness of digital resources emerges from the relationship between pedagogical organization and technological implementation, supporting the interpretation of feasibility as a multidimensional construct rather than a single measure of instructional effectiveness (Cal y Mayor-Peña et al., 2024).

Student practicality was evaluated after classroom implementation through a five-point Likert-scale questionnaire completed by the 36 participating students. The instrument examined three documented dimensions of user experience, namely usability, visual attractiveness, and perceived learning usefulness, which represent complementary aspects of students' interaction with the developed electronic worksheets. The overall practicality score was 87.00%, corresponding to a mean questionnaire score of 4.35 and classified as very practical according to the study's criteria. Research examining gamified learning environments indicates that the perceived accessibility and attractiveness of instructional activities can contribute to positive learning experiences, although favorable user responses should be distinguished from independently demonstrated cognitive achievement (Ramírez Ruiz et al., 2024). The practicality evaluation consequently provides evidence concerning students' reported experiences with the instructional product rather than a direct measurement of learning effectiveness.

The practicality indicators demonstrated differences that are relevant to interpreting the product's instructional characteristics, with usability receiving a mean score of 4.28 or 85.60%, visual attractiveness receiving 4.35 or 87.00%, and perceived learning usefulness receiving 4.42 or 88.40%. The highest percentage was associated with perceived learning usefulness, suggesting that students evaluated the instructional relevance of the electronic worksheets more favorably than their operational ease of use. This pattern is consistent with research distinguishing different dimensions of gamified educational experiences, particularly the relationship between motivational perceptions, instructional engagement, and competence-related outcomes (Li et al., 2024). The difference between the highest and lowest indicator percentages was 2.80 percentage points, indicating relatively limited variation across the three reported practicality dimensions without establishing statistical equivalence among them. Table 3 presents the documented questionnaire results and their corresponding practicality classifications.

Table 3. Student Practicality Assessment of Interactive Electronic Worksheets (N = 36)

No.	Practicality indicator	Mean item score (5-point scale)	Percentage (%)	Classification
1	Usability	4.28	85.60	Very practical
2	Visual attractiveness	4.35	87.00	Very practical
3	Perceived learning usefulness	4.42	88.40	Very practical
	Overall mean	4.35	87.00	Very practical

The findings presented in Table 3 demonstrate that the developed electronic worksheets received favorable student evaluations across the three assessed practicality indicators. The relatively higher score for perceived learning usefulness suggests that participants recognized the relevance of the instructional activities to their learning needs, while the slightly lower usability score identifies an aspect that may warrant further examination during future product refinement. Research on gamified instructional design indicates that technological attractiveness and positive learner perceptions should be interpreted alongside the educational purpose of the activities rather than treated as sufficient evidence of knowledge acquisition (Chan & Lo, 2024). The practicality results support the conclusion that the product was positively received by the participating students, although the questionnaire data do not establish whether the perceived usefulness of particular platform features was directly associated with individual learning performance.

The combined feasibility and practicality evaluations provide two complementary forms of evidence concerning the quality of the developed instructional product. Expert validation addressed the suitability of its media and instructional content, whereas student responses characterized the

usability, attractiveness, and perceived educational usefulness of the product during its implementation in the participating classroom. Research synthesizing gamification outcomes emphasizes that favorable motivational and experiential indicators should not be interpreted as equivalent to demonstrated improvements in competence, reinforcing the need to examine these dimensions independently (Li et al., 2024; Diaz & Estoque-Loñez, 2024). The interpretation of the findings is also constrained by the involvement of one media validator, one subject-matter validator, and students from a single class, with no documented inter-rater reliability assessment or broader comparative evaluation. These results establish expert-rated feasibility and student-perceived practicality under the conditions of the present implementation, while evidence concerning cognitive learning outcomes requires separate examination through the pre-test, post-test, and normalized gain data.

Effectiveness of Interactive Problem-Based Electronic Worksheets in Improving Students' Cognitive Learning Outcomes

The effectiveness of the developed interactive problem-based electronic worksheets was evaluated by comparing students' cognitive achievement before and after the instructional implementation. The assessment involved 36 Grade X students at SMA Negeri 1 Taraju, who completed a pre-test and post-test consisting of 15 multiple-choice questions related to Microsoft Office integration competencies. The evaluation focused on changes in cognitive achievement associated with instructional activities combining guided practical exercises through Liveworksheets and gamified reinforcement through Wordwall. Previous meta-analytical investigations have demonstrated that digital educational games and technology-supported instructional interventions can contribute to learning achievement, although their effects vary according to instructional design, subject characteristics, and learning conditions (Gui et al., 2023; Ren et al., 2024). The present analysis consequently examined observed achievement differences within the participating class without attributing these changes exclusively to individual digital platforms or assuming causal superiority over alternative instructional approaches.

The pre-test results indicated that students entered the instructional implementation with a mean cognitive achievement score of 73.70, which was below the minimum mastery criterion of 75 established for the assessment. The highest recorded score was 100.00, whereas the lowest score was 26.67, indicating a substantial range of initial achievement among participants. Nineteen students, representing 52.78% of the class, satisfied the mastery criterion before the developed instructional product was implemented. The variation between the highest and lowest scores suggests that students possessed different levels of initial understanding of Microsoft Office integration procedures, although the available aggregate data do not permit identification of the specific competencies responsible for these differences. Research examining game-based learning and computational thinking emphasizes that instructional support should address the cognitive processes required by practical tasks rather than assume homogeneous learner proficiency (Ma et al., 2023).

Following implementation, the mean post-test achievement score increased to 88.89, representing an absolute improvement of 15.19 points compared with the pre-test mean. The highest post-test score remained 100.00, whereas the lowest score increased from 26.67 to 76.67, indicating that the minimum observed achievement also improved after the instructional activities. All 36 participants obtained post-test scores meeting the minimum mastery criterion, increasing classical learning mastery from 52.78% to 100.00%. These changes indicate that the participating class demonstrated higher cognitive achievement after completing the instructional sequence, particularly in relation to the Microsoft Office competencies assessed by the achievement instrument. A meta-analysis examining gamification and academic performance similarly identifies potential educational benefits from interactive learning environments, although achievement changes must be interpreted with attention to the characteristics of the instructional intervention and research design (Zeng et al., 2024).

The magnitude of observed achievement development was examined using descriptive comparisons and the normalized gain indicator reported in the study. The reported mean N-Gain was 0.59, corresponding to the moderate improvement category adopted in the research, indicating progress relative to the remaining attainable achievement range. Normalized gain provides a complementary description of learning improvement because it relates the difference between pre-test

and post-test performance to the opportunity for improvement rather than relying exclusively on absolute score differences. Studies synthesizing the effects of gamified instruction suggest that achievement indicators should be interpreted in relation to educational objectives and the structure of instructional activities rather than treated as isolated evidence of technological effectiveness (Diaz & Estoque-Loñez, 2024). Table 4 presents the documented pre-test and post-test results, mastery indicators, and reported normalized gain used to evaluate cognitive achievement.

Table 4. Comparison of Students' Cognitive Learning Achievement Before and After Implementation

Evaluation indicator	Pre-test	Post-test	Change or interpretation
Number of participants	36	36	Same participating class
Mean achievement score	73.70	88.89	+15.19 points
Highest achievement score	100.00	100.00	No change
Lowest achievement score	26.67	76.67	+50.00 points
Students meeting mastery criterion (≥75)	19	36	+17 students
Classical learning mastery	52.78%	100.00%	+47.22 percentage points
Reported mean N-Gain	—	—	0.59 (moderate)

The results presented in Table 4 demonstrate improvement across the reported indicators of cognitive achievement, particularly the class mean, lowest observed score, and proportion of students satisfying the mastery criterion. The increase of 47.22 percentage points in classical learning mastery indicates that students who had not met the minimum criterion before implementation were no longer represented among those below the criterion in the post-test results. The reported mean N-Gain of 0.59 is retained as documented in the research, although it cannot be independently reconstructed as a mean of individual normalized gains because participant-level achievement scores were not provided. Research on gamified instructional environments emphasizes that the interpretation of performance improvement requires distinguishing measured academic outcomes from motivational responses and other indicators of learning experience (Li et al., 2024). The observed achievement differences establish a descriptive improvement within the participating class, while the absence of a comparison group and inferential statistical analysis limits conclusions regarding the intervention's independent causal effect.

The improvement in cognitive achievement can be interpreted in relation to the instructional organization of the developed electronic worksheets, which required students to engage with practical problems rather than rely exclusively on verbal explanations of software functions. Learning activities involved identifying relationships among spreadsheet information, word-processing documents, and presentation materials, followed by applying the Paste Special and Paste Link procedures to construct integrated outputs. These activities were designed to support knowledge application alongside conceptual recognition, corresponding to the intended progression from remembering and understanding software functions toward applying them in practical learning situations. Research concerning problem-based digital worksheets indicates that structured problem-solving tasks can provide opportunities for learners to connect conceptual knowledge with procedures required to address contextualized instructional problems (Sanca et al., 2026). The post-test results are consistent with this instructional rationale, although the available assessment data do not isolate the contribution of individual problem-based learning stages or establish whether students retained the competencies beyond the immediate evaluation period.

The integration of Liveworksheets and Wordwall introduced complementary instructional functions that may help explain the learning conditions associated with the observed achievement changes. Liveworksheets provided structured guidance for practical exercises involving Microsoft Office applications, while Wordwall supplied matching-pairs activities intended to reinforce knowledge through immediate feedback and interactive participation. Research examining gamified educational environments indicates that different combinations of game elements can influence learning outcomes, highlighting the relevance of aligning interactive features with instructional purposes rather than maximizing technological stimulation independently of learning objectives (Xu et al., 2025). Evidence from gamification research in secondary education also emphasizes the

relationship between educational game design and cognitive learning objectives, particularly when instructional activities are organized around identifiable levels of learning achievement (Baltabayeva et al., 2026). The present findings are compatible with the proposed complementarity of guided practice and gamified reinforcement, but the study design does not allow the separate effects of Liveworksheets, Wordwall, or their interaction to be quantified.

The achievement findings should also be considered alongside the student practicality evaluation because perceived instructional usefulness and measured cognitive performance represent distinct dimensions of educational product quality. The previously reported practicality score of 87.00% indicated favorable student perceptions of usability, visual attractiveness, and learning usefulness, while the cognitive assessment demonstrated higher achievement scores following classroom implementation. Research synthesizing gamification studies indicates that positive learner engagement and academic improvement may occur together, but their relationship cannot be established merely by observing favorable aggregate results from both measures (Ramírez Ruiz et al., 2024). Investigations of gamification in language education similarly emphasize the need to distinguish participation-oriented outcomes from the acquisition of disciplinary knowledge and competencies (Chan & Lo, 2024). The convergence of favorable practicality assessments and improved post-test performance provides complementary descriptive evidence for the educational utility of the developed product, without establishing a statistical relationship between individual student perceptions and achievement gains.

Several methodological considerations qualify the interpretation of the effectiveness findings and define the extent to which they contribute to instructional development research. The study employed a single-class pre-test–post-test evaluation without a separately documented control group, random allocation, delayed retention assessment, or inferential statistical comparison, preventing definitive separation of the intervention effect from possible testing, maturation, and other implementation-related influences. The available results also consist of aggregate achievement indicators, limiting examination of individual learning trajectories, differences in initial proficiency, and the relative effectiveness of specific instructional components. Research on self-regulated learning emphasizes that learners may employ different strategies when completing problem-based activities, suggesting that aggregate achievement measures cannot independently explain the processes underlying individual improvement (Tempelaar et al., 2024). The reported outcomes nevertheless provide context-specific evidence that the developed interactive electronic worksheets were associated with improved cognitive achievement and complete attainment of the stated mastery criterion among participating students. Future comparative investigations involving broader student populations, documented instrument-quality assessments, and separate evaluations of instructional components would be necessary to determine whether the observed improvements can be attributed to the integrated intervention and generalized beyond the participating classroom.

CONCLUSION

This study developed interactive problem-based electronic student worksheets integrating Liveworksheets and Wordwall for Microsoft Office instruction among Grade X students at SMA Negeri 1 Taraju through the five stages of the ADDIE model. The developed instructional product combined structured problem-solving activities, guided practical exercises, and gamified reinforcement to support students' understanding and application of Microsoft Word, Microsoft Excel, and Microsoft PowerPoint integration procedures, particularly through Paste Special and Paste Link functions. Expert validation demonstrated that the product satisfied the established feasibility criteria, with media and subject-matter validation scores of 82.00% and 95.56%, respectively, producing an average feasibility score of 88.78% in the very feasible category. Student evaluations further indicated a high level of practicality, with an average score of 87.00%, reflecting favorable perceptions of usability, visual attractiveness, and instructional usefulness. Cognitive achievement increased from a mean pre-test score of 73.70 to a post-test score of 88.89, representing an improvement of 15.19 points, while classical learning mastery increased from 52.78% to 100.00% among the 36 participating students. The reported normalized gain of 0.59 indicated a moderate improvement in cognitive achievement, providing descriptive evidence of learning progress following implementation. These findings establish that the developed worksheets were feasible, practical, and associated with improved learning achievement under the instructional conditions examined.

The principal contribution of this research lies in the development and evaluation of an integrated digital instructional product that connects problem-based learning with complementary functions of Liveworksheets and Wordwall for application-oriented Informatics education. The instructional configuration extends the practical application of interactive electronic worksheets by incorporating contextual problems, collaborative investigation, software-based exercises, and gamified reinforcement within a structured learning sequence. The evaluation framework contributes methodologically by examining instructional product quality through three complementary dimensions: expert-rated feasibility, student-perceived practicality, and measured changes in cognitive achievement. The findings provide practical implications for Informatics teachers seeking to organize interactive learning activities that facilitate students' application of Microsoft Office integration procedures while reducing exclusive dependence on teacher-centered demonstrations. Interpretation of the effectiveness findings remains limited by the single-class implementation, the absence of a comparison group, and the lack of documented inferential statistical testing, preventing definitive causal attribution of achievement improvements to the developed instructional product. Further investigations should evaluate the product through comparative research designs, broader student populations, and additional assessments of learning retention and practical competency to establish the consistency and transferability of its educational outcomes. The study provides a context-specific foundation for developing and evaluating problem-based interactive digital learning materials that integrate practical technological competencies with structured instructional activities in secondary Informatics education.

REFERENCES

Alhamid, M. R. A., Widiyaningtyas, T., & Pratama, S. P. (2025). Pengembangan e-LKPD interaktif berbasis Liveworksheets sebagai sarana pembiasaan berpikir kritis peserta didik. Jurnal Pendidikan dan Pembelajaran Indonesia, 5(3), 1577–1588. https://doi.org/10.53299/jppi.v5i3.1794

Baltabayeva, N., Adikanova, S., Ponkina, E. V., & Nurkanova, R. (2026). Enhancing secondary education through gamification and Bloom's taxonomy: The BilimQuest portal. Frontiers in Education, 11, Article 1749909. https://doi.org/10.3389/feduc.2026.1749909

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. Medical Education, 20(6), 481–486. https://doi.org/10.1111/j.1365-2923.1986.tb01386.x

Cal y Mayor-Peña, F., Barrera-Animas, A. Y., Escobar-Castillejos, D., Noguez, J., & Escobar-Castillejos, D. (2024). Designing a gamified approach for digital design education aligned with Education 4.0. Frontiers in Education, 9, Article 1439879. https://doi.org/10.3389/feduc.2024.1439879

Chan, S., & Lo, N. (2024). Enhancing EFL/ESL instruction through gamification: A comprehensive review of empirical evidence. Frontiers in Education, 9, Article 1395155. https://doi.org/10.3389/feduc.2024.1395155

Diaz, A. F., & Estoque-Loñez, H. (2024). A meta-analysis on the effectiveness of gamification on student learning achievement. International Journal of Education in Mathematics, Science and Technology, 12(5), 1236–1253. https://doi.org/10.46328/ijemst.4185

Fauziah, N., et al. (2022). The use of digital game-based learning media to increase students learning motivation. Journal of Education Technology, 6(2), 210–217.

Fiorella, L., & Mayer, R. E. (2015). Learning as a generative activity: Eight learning strategies that promote understanding. Cambridge University Press. https://doi.org/10.1017/CBO9781107707085

Gui, Y., Cai, Z., Yang, Y., Kong, L., Fan, X., & Tai, R. H. (2023). Effectiveness of digital educational game and game design in STEM learning: A meta-analytic review. International Journal of STEM Education, 10, Article 36. https://doi.org/10.1186/s40594-023-00424-9

Hase, A., & Kuhl, P. (2024). Teachers' use of data from digital learning platforms for instructional design: A systematic review. Educational Technology Research and Development, 72, 1925–1945. https://doi.org/10.1007/s11423-024-10356-y

Hasugian, R., Siagian, G., & Silaban, W. (2024). Pengembangan media pembelajaran berbasis Powtoon untuk meningkatkan hasil belajar siswa pada materi sistem ekskresi manusia. Edu

Cendikia: Jurnal Ilmiah Kependidikan, 4(1), 15–19. https://doi.org/10.47709/educendikia.v4i01.3776

Kahfi, M., Nurparida, N., & Srirahayu, E. (2021). Penerapan multimedia interaktif untuk meningkatkan motivasi belajar dan hasil belajar siswa pada pembelajaran IPA. Jurnal PETIK, 7(1), 63–70. https://doi.org/10.31980/jpetik.v7i1.986

Lestari, V., Antika, R., & Alpindo, O. (2022). Pengembangan E-LKPD berbasis problem based learning menggunakan Live Worksheets pada materi turunan fungsi aljabar kelas …. Jurnal Pendidikan Matematika. http://repositori.umrah.ac.id/4067/

Li, L., Hew, K. F., & Du, J. (2024). Gamification enhances student intrinsic motivation, perceptions of autonomy and relatedness, but minimal impact on competency: A meta-analysis and systematic review. Educational Technology Research and Development, 72, 765–796. https://doi.org/10.1007/s11423-023-10337-7

Ma, J., Zhang, Y., Zhu, Z., Zhao, S., & Wang, Q. (2023). Game-based learning for students' computational thinking: A meta-analysis. Journal of Educational Computing Research, 61(7). https://doi.org/10.1177/07356331231178948

Mayer, R. E., & Fiorella, L. (Eds.). (2021). The Cambridge handbook of multimedia learning (3rd ed.). Cambridge University Press. https://doi.org/10.1017/9781108894333

Ningrum, P. C., Novita, L., & Safitri, N. (2024). Pengembangan LKPD digital menggunakan Wordwall pada subtema kekayaan sumber energi di Indonesia. Pendas: Jurnal Ilmiah Pendidikan Dasar, 9(3), 456–468. https://doi.org/10.23969/jp.v9i3.17817

Noviana, I. V., Utami, W. S., & Widodo, B. S. (2024). Pengembangan E-LKPD Liveworksheets berbasis problem based learning pada materi perairan darat. Journal of Education Research, 5(3), 3902–3912. https://doi.org/10.37985/jer.v5i3.1518

Pertiwi, S. C. I., & Kadarisma, G. (2023). Pengaruh penggunaan LKPD Liveworksheet bermodelkan problem based learning materi aritmatika social terhadap kemampuan pemecahan masalah matematis siswa SMP. Jurnal Pembelajaran Matematika Inovatif, 6(5), 1911–1920.

Prastowo, A. (2013). Panduan kreatif membuat bahan ajar inovatif (8th ed.). Diva Press.

Qalfin, M., Saptono, S., & Ellianawati, E. (2024). Effectiveness of differentiated digital student worksheets based on socio-scientific issues to improve students' science literacy. Unnes Science Education Journal, 13(2). https://doi.org/10.15294/usej.v13i2.10030

Ramadhani, D. S., & Gularso, D. (2025). Development of an e-worksheet supported by Liveworksheet and Wordwall to improve elementary students' cognitive competence on the topic of natural features. Indonesian Journal of Social Studies, 8(1), 12–22. https://journal.unesa.ac.id/index.php/jpips/index

Ramírez Ruiz, J. J., Vargas Sanchez, A. D., & Boude Figueredo, O. R. (2024). Impact of gamification on school engagement: A systematic review. Frontiers in Education, 9, Article 1466926. https://doi.org/10.3389/feduc.2024.1466926

Ren, J., Xu, W., & Liu, Z. (2024). The impact of educational games on learning outcomes: Evidence from a meta-analysis. International Journal of Game-Based Learning, 14(1), 1–25. https://doi.org/10.4018/IJGBL.336478

Rosmana, P. S., Iskandar, S., Rosafina, M., Ningrum, N. C., Prabowo, S. A., & Robin, S. J. (2023). Pengaruh media pembelajaran digital Liveworksheets dan Wordwall terhadap peningkatan pembelajaran IPS pada siswa SD kelas VI UPTD SDN 02 Ciseureuh. Jurnal Pendidikan dan Konseling, 5(1), 2731–2740. https://doi.org/10.31004/jpdk.v5i1.11397

Sanca, K., Lintangesukmanjaya, R. T., Dwikoranto, & Putri, N. A. A. (2026). Implementation of PBL-based digital worksheets to improve students' problem-solving skills: A literature review. Journal of Digitalization in Physics Education, 2(1), Article 52051. https://doi.org/10.26740/jdpe.v2i1.52051

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. Interdisciplinary Journal of Problem-Based Learning, 1(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Supana, & Setiawan, D. L. (2024). Penerapan aplikasi Wordwall berbasis website untuk meningkatkan hasil belajar siswa pada mata pelajaran TIK di SMP Negeri 2 Japara. Jurnal PETIK, 10(2), 158–166. https://doi.org/10.31980/petik.v10i2.1518

Suryaningsih, S., & Nurlita, R. (2021). Pentingnya lembar kerja peserta didik elektronik (E-LKPD) inovatif dalam proses pembelajaran abad 21. Jurnal Pendidikan Indonesia, 2(7), 1256–1268. https://doi.org/10.59141/japendi.v2i07.233

Tempelaar, D., Bátori, A., & Giesbers, B. (2024). Understanding self-regulation strategies in problem-based learning through dispositional learning analytics. Frontiers in Education, 9, Article 1382771. https://doi.org/10.3389/feduc.2024.1382771

Xu, W., Xu, G.-R., & Xing, Q.-W. (2025). The impact of different combinations of game elements for gamified learning in higher education on student learning outcomes: A multilevel meta-analysis. Studies in Higher Education, 50(11), 2376–2403. https://doi.org/10.1080/03075079.2024.2416498

Zeng, J., Sun, D., Looi, C.-K., & Fan, A. C. W. (2024). Exploring the impact of gamification on students' academic performance: A comprehensive meta-analysis of studies from the year 2008 to 2023. British Journal of Educational Technology, 55(6), 2478–2502. https://doi.org/10.1111/bjet.13471