Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 26 July 2026
Revised 30 Aug 2026
Accepted 18 Sep 2026

Natural Resources for Human Health 2026, Vol. 6 (22s): 1115–1120

KEYWORDS:
STEM education; science module; Google Workspace for Education; ADDIE; educational design research; junior high school.

Design and Development of STEM-Based Science Learning Modules Supported by Google Workspace for Education in Junior High Schools

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ABSTRACT: This research developed and evaluated STEM-based junior high school science learning modules supported by Google Workspace for Education and informed by deep-learning pedagogy in West Muna, Indonesia. The research adopted the ADDIE research-and-development framework, incorporating needs analysis, design, prototype development, expert validation, classroom implementation, and evaluation. The needs assessment identified a gap between formally available teaching documents and meaningful STEM and digital classroom practices. Expert evaluations rated the module highly feasible: media 86.80%, subject matter 92.00%, and language 91.50%. Observed classroom implementation averaged 92.42%, while teacher-rated practicality reached 94.00%. Among 45 students, mean pretest and posttest scores were 47.26 and 89.03, respectively; the group-mean normalized gain was 0.792, indicating a high descriptive gain. These findings suggest that a coherent digital ecosystem can support inquiry, collaboration, project design, assessment, and reflection. However, the single-group pretest–posttest design does not establish causal effectiveness. The study contributes a context-responsive design framework for integrating STEM activities, cloud collaboration, and reflective learning in junior high school science.

1. INTRODUCTION

Science learning increasingly requires more than the reproduction of disciplinary facts. Contemporary curricula place greater weight on scientific reasoning, evidence-based explanations, collaborative inquiry, and the application of knowledge to authentic problems. Integrated STEM education offers one route to such learning by connecting scientific understanding to technological tools, engineering design, and mathematical reasoning (Bybee, 2013;Honey et al., 2014;English, 2016). However, simply attaching a digital platform to existing worksheets does not guarantee meaningful integration.

In regional and resource-constrained schools, teachers may possess required planning documents without consistently implementing interdisciplinary, project-oriented, or digitally supported instruction. This distinction between administrative readiness and instructional enactment is crucial. Effective instructional innovation requires alignment between curriculum goals, student tasks, teacher scaffolding, technology affordances, and assessment (Mishra & Koehler, 2006;Koehler & Mishra, 2009; UNESCO, 2018).

The West Muna research context showed a practical gap between the formal completeness of instructional materials and the quality of their implementation. Conventional science resources remained prominent, while digital tools were not consistently integrated into collaborative scientific work. Rather than treating Google Classroom, Docs, Slides, Forms, and Meet as unrelated utilities, this study conceptualized Google Workspace for Education as an interconnected learning environment. This design emphasis addresses a practical need for teachers to orchestrate learning sequences rather than merely distribute electronic documents.

Active learning and collaborative problem solving provide the theoretical justification for the intervention. Students learn more deeply when they generate explanations, evaluate alternatives, interact with evidence, and reflect on their reasoning (Chi & Wylie, 2014;Freeman et al., 2014;Prince, 2004). Inquiry-based and problem-based learning also emphasize productive

engagement with uncertainty and authentic problems (Hmelo-Silver, 2004; National Research Council, 2012). The design therefore combines STEM tasks with collaborative digital production and feedback.

The present article reports the design, expert appraisal, implementation, practicality, and descriptive learning outcomes of the developed module. Its contribution is not the claim that any particular Google application independently causes achievement gains, but the articulation and initial evaluation of a coordinated, context-responsive instructional design. The research questions concern the needs informing development, feasibility of the resulting materials, classroom enactment, teacher perceptions, and observed learning improvement.

2. THEORETICAL FRAMEWORK

2.1 Integrated STEM learning. STEM integration is pedagogically meaningful when students use knowledge across disciplinary boundaries to investigate or solve problems rather than encounter isolated subject labels. Engineering-design challenges can create a productive need for scientific explanation, measurement, modeling, revision, and communication (Sanders, 2009;Bybee, 2013;English, 2016). The resulting learning activities should make disciplinary contributions visible while preserving coherent science objectives.

2.2 Digital collaborative learning. Technological pedagogical content knowledge highlights the interdependence of subject matter, pedagogy, and digital tools (Mishra & Koehler, 2006;Chai et al., 2013). A cloud environment can support shared documents, iterative feedback, submission workflows, synchronous discussion, and assessment. Such affordances require deliberate facilitation; availability of software is not itself evidence of learning. Collaborative learning theory emphasizes structured interaction and shared accountability (Vygotsky, 1978;Slavin, 2014;Garrison et al., 2000).

2.3 Meaningful and reflective learning. The study operationalized deep learning as meaningful, mindful, and joyful classroom engagement rather than as machine-learning technology. Learning tasks were intended to foster conceptual understanding, attention to reasoning, and positive participation. Experiential learning, multimedia learning, and self-regulated learning offer complementary rationales for design cycles, multimodal resources, and feedback (Kolb, 1984;Mayer, 2009;Lai & Hwang, 2016).

2.4 Design and development methodology. ADDIE provides a practical sequence of analysis, design, development, implementation, and evaluation (Branch, 2009). Educational design research similarly emphasizes iterative development under authentic constraints, linking product decisions to empirical evidence (Brown, 1992; Design-Based Research Collective, 2003;Wang & Hannafin, 2005;McKenney & Reeves, 2012). The present study uses ADDIE as its stated operational development framework rather than presenting a randomized causal trial.

3. MATERIALS AND METHODS

3.1 Research setting and design. This research-and-development study was conducted in junior high school settings in West Muna Regency, Southeast Sulawesi, Indonesia. It employed ADDIE, with a needs assessment of teaching practices and resources, a design blueprint, expert validation and revision, small-group and classroom implementation, and evaluation of practicality and learning outcomes. Data reported here were extracted from the primary dissertation research conducted in 2026.

3.2 Instructional product. The product was a STEM-based science learning module supported by Google Workspace for Education. The intended learning cycle integrated investigation of contextual problems, collaborative production, engineering-oriented tasks, communication of findings, formative assessment, and reflection. Digital components served pedagogical functions rather than being treated as independent interventions.

3.3 Data collection and evaluation. Sources included teacher needs-assessment responses, expert appraisals of media, content, and language, observation of implementation, teacher practicality questionnaires, and student pretest and posttest results. The needs-analysis materials included responses from 24 teachers. Classroom learning-outcome analysis reported 45 students; teacher practicality ratings were obtained from three teachers. These are different analysis groups and should not be conflated.

3.4 Analysis. Feasibility and implementation were summarized with percentages and qualitative categories specified in the original study. Pretest and posttest means were compared descriptively, and normalized gain was interpreted as a measure of

observed improvement (Hake, 1998). Given the one-group design, descriptive gains should not be interpreted as proof of treatment causality. The article does not infer unreported statistical tests or reconstruct unavailable participant-level records (Creswell & Creswell, 2018).

4. RESULTS AND DISCUSSION

4.1 Needs analysis and product architecture. The initial analysis identified misalignment between the existence of formal instructional materials and the enactment of contextual, collaborative, and reflective science learning. Teachers needed a practical design that combined STEM tasks and digital coordination. The module blueprint consequently linked learning objectives, inquiry prompts, group tasks, collaborative documents, feedback, and assessment within a common sequence. This design is consistent with the argument that successful technology integration is pedagogical and organizational rather than merely technical (Koehler & Mishra, 2009;Graham, 2006).

Table 1. Expert feasibility evaluation of the developed module

Validation domain	Score (%)	Reported interpretation
Media	86.80	Highly feasible
Subject matter	92.00	Highly feasible
Language	91.50	Highly feasible

Source: Primary research data, processed (2026).

4.2 Expert review and revision. All three expert-review domains were classified as highly feasible. Content evaluation was highest (92.00%), followed by language (91.50%) and media (86.80%). The pattern suggests that content alignment and accessibility of expression were viewed favorably while interface and media quality offered relatively greater scope for refinement. Expert validation establishes judged appropriateness of a prototype, not definitive evidence of learning impact. Iterative refinement is therefore essential (Anderson & Shattuck, 2012;Bannan-Ritland, 2003).

Table 2. Classroom implementation and teacher appraisal

Indicator	Observed result	Interpretation
Classroom implementation	92.42%	Very good
STEM integration, first meeting	68.76%	Initial observation
STEM integration, fifth meeting	90.49%	Final observation
STEM integration, overall mean	79.45%	Across five meetings
Teacher-rated practicality (n = 3)	94.00%	Very good
Teacher perceptions (overall)	93.87%	Very good

Source: Primary research data, processed (2026).

4.3 Implementation and feasibility in practice. Classroom implementation reached 92.42%, indicating that the instructional sequence could be enacted by participating teachers. The recorded STEM integration measure increased from 68.76% in the first meeting to 90.49% in the fifth, with a five-meeting average of 79.45%. This pattern is compatible with a gradual familiarization process, although the observation sequence alone does not establish why the increase occurred. Structured collaboration and repeated engagement may have helped teachers and learners negotiate unfamiliar task routines (Slavin, 2014;Hmelo-Silver, 2004).

Teacher-rated practicality averaged 94.00%, with individual teacher ratings of 90.00%, 94.67%, and 97.33%. The overall teacher-perception score was 93.87%. These favorable evaluations support local acceptability and perceived usability, but three teacher ratings cannot establish general usability across different school systems. The design should be further examined in settings with different device access, connectivity, teacher preparedness, and student digital literacy (UNESCO, 2018;Chai et al., 2013).

Table 3. Descriptive learning outcomes after module implementation

Outcome	Value
Students included	45
Mean pretest score	47.26
Mean posttest score	89.03
Mean score increase	41.77
Normalized gain (based on group means)	0.792
Interpretation of gain	High

Source: Primary research data, processed (2026).

4.4 Student learning and interpretation. Among 45 students, mean scores increased by 41.77 points from pretest to posttest. The normalized gain calculated from group means was 0.792, a high descriptive gain under conventional thresholds (Hake, 1998). The dissertation also reports an average of individual normalized gains of approximately 0.7963; this differs slightly from the group-mean calculation because the two aggregation procedures are not identical. Reporting the computation method is therefore necessary for transparency.

The results are consistent with theoretical expectations that integrated tasks, active learning, feedback, and collaborative knowledge construction can support understanding (Freeman et al., 2014;Chi & Wylie, 2014;Prince, 2004). Nevertheless, there was no parallel control group in the reported pretest–posttest implementation. Practice effects, maturation, instruction outside the module, and assessment alignment may also contribute to score change. Accordingly, this article describes promising classroom outcomes without attributing the entire increase causally to the module.

4.5 Pedagogical contribution. The distinctive design feature is the coordination of STEM inquiry, cloud-based collaboration, and mindful, meaningful, and joyful learning in one instructional sequence responsive to local needs. The dissertation reports mean implementation scores of 88.51% for mindful learning, 90.84% for meaningful learning, and 87.91% for joyful learning. These indicators offer process evidence about the intended pedagogical orientation. They should not be treated as direct measures of long-term conceptual transfer or durable dispositions without further validation.

Table 4. Reported deep-learning implementation indicators

Indicator	Mean (%)
Mindful learning	88.51
Meaningful learning	90.84
Joyful learning	87.91

Source: Primary research data, processed (2026).

4.6 Implications for design and scale-up. Schools adopting the module should prioritize a shared instructional blueprint, professional development in integrated STEM pedagogy, access planning for low-bandwidth settings, and routine evaluation of student work. Teachers can use collaborative documents to document evidence, shared slides to communicate models, forms to gather feedback, and classroom workflows to sequence tasks. The value of the approach rests on the coherence of these functions. Future research should use multi-school comparative or randomized designs, delayed retention measures, and documented implementation fidelity to establish transferability and causal impact (McKenney & Reeves, 2012;Wang & Hannafin, 2005;Hattie, 2009).

4.7 Methodological limitations and future directions

A central methodological consideration is the distinction between product feasibility, implementation fidelity, and effectiveness. Expert ratings address the judged quality of instructional resources; classroom observation addresses whether teachers and students can implement the intended process; student test results address performance over the observed period.

None of these alone establishes a counterfactual outcome. A stronger future design would include comparable classes assigned to the developed module or conventional instruction, baseline equivalence checks, pre-specified learning outcomes, and analyses that account for classroom clustering. Independent scoring of STEM artifacts and delayed assessments would additionally test whether learners transfer scientific reasoning beyond the immediate lessons (National Research Council, 2012;McKenney & Reeves, 2012;Creswell & Creswell, 2018).

The development process also invites attention to equity. Cloud collaboration presupposes reliable access to devices, connectivity, accounts, and teacher support. In schools where students share devices or have limited home connectivity, the same learning design may need offline alternatives, staged downloads, or classroom-based group access. Such adjustments should be treated as design adaptations requiring evaluation rather than as trivial implementation details. Future research should document the digital access conditions under which modules are feasible, the preparation time required by teachers, and the distribution of learning opportunities among students with different prior digital experience. These considerations align with educational technology integration frameworks that emphasize pedagogy and context alongside tools (Mishra & Koehler, 2006; UNESCO, 2018).

A second consideration concerns the meaning of deep learning. The three observed indicators—mindful, meaningful, and joyful learning—describe aspects of classroom enactment. Their high scores are encouraging process indicators but should not be equated automatically with deep conceptual mastery. Complementary evidence might include student explanations, revised models, reflective journals, transfer tasks, and structured rubrics evaluating the quality of evidence-based reasoning. This triangulation would connect engagement and perceived meaningfulness to demonstrated conceptual understanding, while limiting common-method bias when teachers both implement and evaluate a module (Chi & Wylie, 2014;Mayer, 2009;Hattie, 2009).

5. CONCLUSION

The study developed a context-responsive STEM-based junior high school science module supported by Google Workspace for Education using the ADDIE framework. Expert reviewers judged media, content, and language highly feasible, and participating teachers reported high practicality. Observations documented strong classroom implementation and increasing STEM integration over five meetings. Student test scores improved substantially, with a high descriptive normalized gain. The study contributes an integrated instructional design and initial field evidence; however, its single-group outcome design and limited teacher sample require cautious interpretation. Further controlled, multisite evaluations are recommended before broad causal or generalizability claims are made.

ACKNOWLEDGEMENTS

The authors thank participating schools, teachers, students, and expert validators in West Muna Regency for their contributions to the development and evaluation process.

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