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DETECTIVE WEB-GAME: BBLRMS BASED WEBSITE DEVELOPMENT TO ENHANCE INFORMATION LITERACY COMPETENCE

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Abstract

This study aimed to develop a Detective Web-game based on Brain Based Learning, Reading, Mind Mapping, and Sharing (BBLRMS) to enhance information literacy competence on invertebrate topics among senior high school students. The rapid growth of digital information demands students to possess information literacy skills. However, preliminary findings indicated that student's information literacy, particularly in use of information, synthesis, and evaluation, remained at moderate levels. Using Research and Development with the ADDIE model, the media was developed and tested for validity, effectiveness, and user response. Expert validation involved material, media, and language validators. Effectiveness testing used pretest-posttest design with 32 tenth-grade students. Instruments included expert validation sheets, information literacy tests based on The Big 6 model, and response questionnaires. Expert validation yielded very valid results with 91% average. Effectiveness testing showed a significant improvement in students' information literacy skills, achieving a high category growth. Student and teacher responses were 80% and 92%, respectively, both in very feasible categories. In conclusion, the BBLRMS based Detective Web-game is valid, effective, and positively perceived for enhancing student's information literacy competencies through active and meaningful learning.

Keywords: Information Literacy; Detective Web-Game; BBLRMS; The Big 6; Invertebrate

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INTRODUCTION

The rapid growth of digital information in the 21st century has fundamentally transformed how students access, manage, and utilize information in educational contexts. Currently, students are required not only to obtain information quickly but also to critically evaluate the credibility and relevance of information sources. The increasing volume, speed, and diversity of information flow demand that students develop information literacy competencies that enable them to filter credible sources, critically comprehend content, and use information responsibly in both academic and everyday settings (Adi et al., 2017; Lase, 2019; Yusuf et al., 2023).

Information literacy is closely linked to higher-order thinking skills, as students are expected not merely to locate information but to evaluate its quality, integrate multiple sources, and draw logical conclusions (Nurhayati et al., 2020; Trilling & Fadel, 2009). According to the ACRL framework, information literacy includes the ability to recognize,

evaluate, and ethically use information to construct new understanding and knowledge (ACRL., 2016). Despite widespread access to digital technology, research consistently indicates that students' information literacy skills remain underdeveloped. Students tend to rely on instant internet information without thorough verification, seldom consider source credibility, and struggle to synthesize information from multiple references (Gross & Latham, 2012; Head et al., 2018; Suwarto et al., 2022). A preliminary study conducted at a senior high school in Sukabumi City revealed that students' information literacy competencies, particularly in the use of information, synthesis, and evaluation, were at moderate levels (64.5%, 63.1%, and 63.1%, respectively). Teachers also reported that students frequently copied information from the internet or used AI tools without critical selection, and conventional teaching methods limited active student engagement in information processing. The development of instructional media integrating investigative gamification with BBLRMS models presents a promising approach to address these gaps. Detective web-games naturally train students to define problems, search for relevant information, and evaluate source accuracy before concluding (Bagus & Octavian, 2020; Zou, Zou, et al., 2021). The Brain Based Learning, Reading, Mind Mapping, and Sharing (BBLRMS) model, with its structured phases of reading, mapping, and sharing with verification, provides systematic scaffolding for organizing information, reflecting on knowledge, and strengthening meaningful memory (Nuraini et al., 2025). However, research integrating detective web-games with BBLRMS to specifically target information literacy on complex biology topics, such as invertebrates, remains limited. This study addresses this gap by developing and validating a BBLRMS based Detective Web-game designed to enhance students' information literacy competencies on invertebrate topics.

METHODS

This study employed Research and Development (R&D) using the ADDIE model, consisting of five phases: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009; Sugihartini & Yudiana, 2018). The research was conducted the even semester of the 2025/2026 academic year. In the Analysis phase, needs assessment was conducted through interviews with biology teachers, observation of learning processes, and preliminary tests to identify student's information literacy levels using The Big 6 framework. The analysis revealed that student's competencies in task definition (39.1%), synthesis (53.1%), and use of information (64.5%) were below expectations. The Design phase involved constructing the conceptual framework of the Detective Web-game, mapping BBLRMS syntaxes to digital activities, and developing research instruments. The game scenario positioned students as biology detectives tasked with identifying and classifying mysterious invertebrates through investigative missions. The media was developed as a web-based application using HTML, CSS, and JavaScript, accessible via PC and laptop browsers. The Development phase produced the prototype, which underwent expert validation by three validators (material, media, and language experts) using 4-point Likert scale instruments. The instruments assessed material accuracy (16 items), media design (20 items), and language appropriateness (12 items). Validation results guided product revisions before implementation. The Implementation phase involved 32 tenth-grade students (19 males, 13 females) selected through purposive sampling. Students used the media in a structured learning session including pretest, media interaction, mind mapping activities, and posttest. The information literacy test consisted of 12 items representing six indicators of The Big 6 model (two items per indicator). Response questionnaires were administered to both students (12 items) and teachers (12 items). The

Evaluation phase analyzed validity percentages, N-Gain scores for effectiveness, and descriptive percentages for responses. Statistical analysis included Shapiro-Wilk normality test and Wilcoxon Signed-Rank Test for hypothesis testing at significance level 0.05.

RESULTS & DISCUSSION

Results

This study employed the ADDIE model consisting of five systematic phases: Analysis, Design, Development, Implementation, and Evaluation (Sugihartini, & Yudiana, 2018). Each phase produced specific outputs that collectively demonstrated the validity, effectiveness, and user acceptance of the BBLRMS-based Detective Web-game. The overall results are presented sequentially below according to each ADDIE phase.

1. Analysis Phase

The analysis phase identified critical needs in biology learning, particularly on invertebrate topics. Preliminary testing revealed that three information literacy indicators were at low to moderate levels: Task Definition (39.1%), Synthesis (53.1%), and Use of Information (64.5%). Teacher interviews confirmed that students frequently copied information from the internet without critical evaluation, and learning was still dominated by conventional PowerPoint presentations. The complete needs analysis results are presented in Table 1

Table 1.
Needs Analysis Results for Media Development

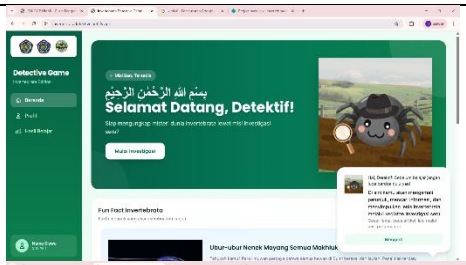
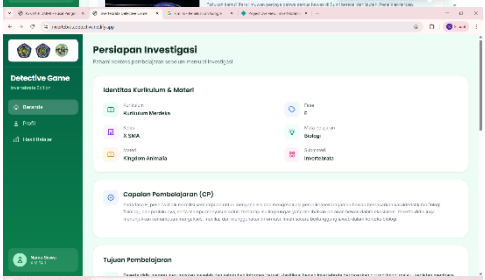
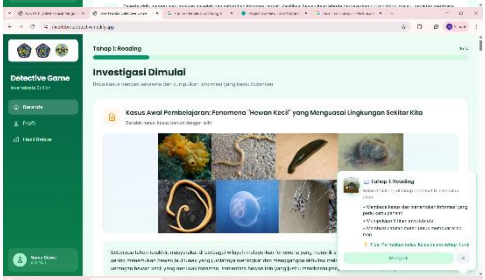
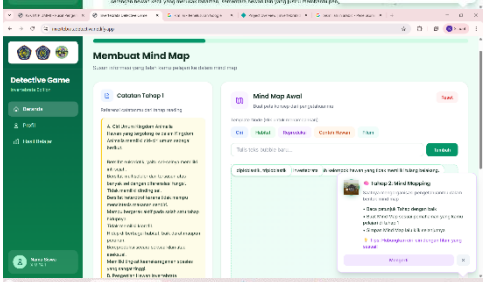
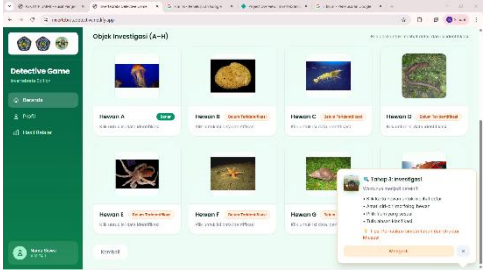
Analysis Component	Findings	Source & Implication
Problem Identification	Low information literacy: Use of Information (64.5%), Synthesis (63.1%), Evaluation (63.1%)	Info literacy test (n=32); Media training processing & evaluation needed
Current Condition	PPT-dominated learning; students copy info from internet/AI without selection	Teacher interview; Interactive media promoting selection & evaluation needed
Ideal Condition	Students determine info needs, select credible sources, process & evaluate independently	Literature review; Big6-based media integrated with BBLRMS model
Student Characteristics	Grade X students familiar with digital devices; enthusiastic about technology-based learning	Teacher interview & observation; Web-game potential to increase engagement
Technology Readiness	School has computer lab but biology learning rarely uses technology	Observation & interview; Digital media integrating existing facilities needed

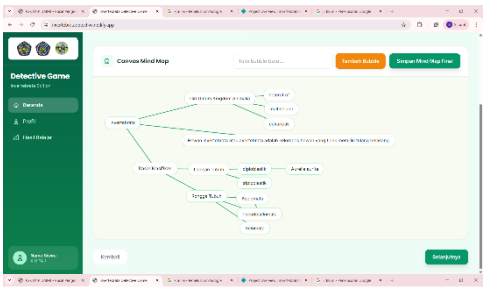
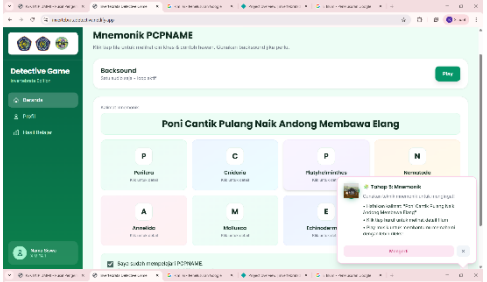
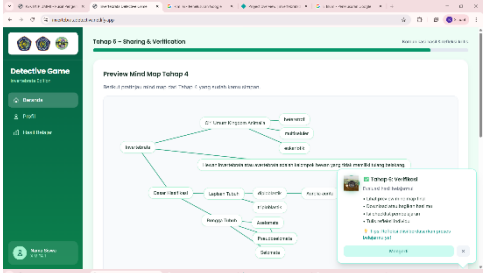
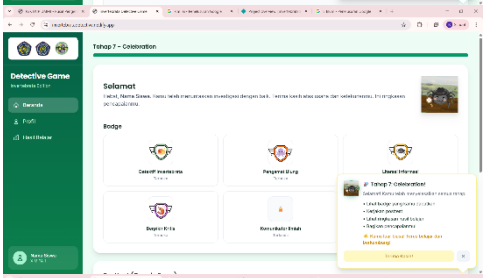
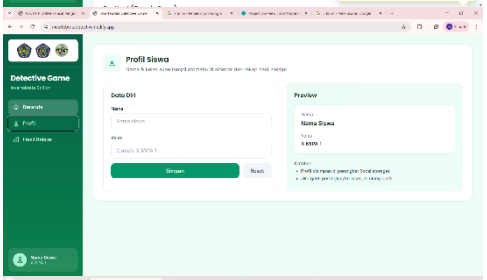
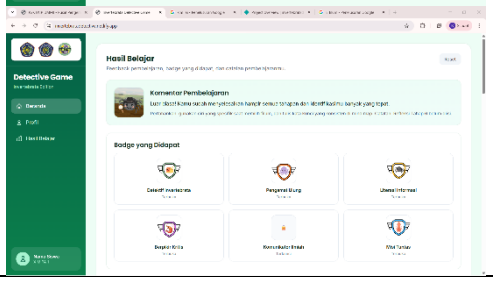
Source: Research data (2026)

2. Design Phase

The design phase established the conceptual framework of the Detective Web-game. The game scenario positioned students as biology detectives tasked with identifying and classifying mysterious invertebrates through investigative missions. The media was designed as a web-based application using HTML, CSS, and JavaScript, consisting of 11 main interfaces sequenced according to BBLRMS syntax. Each interface was mapped to specific Big6 indicators to ensure systematic literacy training. The interface specifications are presented in Table 2.

Table 2.
Interface Description of Detective Web-Game

No	Page	Interface	Description
1	Dashboard		Media info, fun facts, progress, badges
2	Learning Orientation		Identity, objectives, Quran connection, pretest
3	Reading		Case intro, reading sources, quick quiz
4	Mind Mapping		Interactive concept map board
5	Initiation		Mystery animal cards with morphology clues

6	Elaboration		Drag-and-drop concept relationships
7	Incubation		Mnemonic, summary, relaxation music
8	Sharing & Verification		Mind map sharing, reflective quiz
9	Celebration		Scores, badges, posttest
10	Profile		Name, class
11	Learning Result		Evaluation, scores, badges, reflection

Source: Research data (2026)

3. Development Phase

The development phase produced the Detective Web-game prototype, which was validated by three experts (material, media, and language) using 4-point Likert scale instruments. The prototype was revised based on validator feedback before implementation. Validation results are presented in Table 3.

Table 3.
Expert Validation Results

Validator	Profile	Aspect	Score (%)	Category
Media Expert	Educational Lecturer Managing Media Courses	Display & Interface	95%	Very Valid
Material Expert	Biology Lecturer	Learning Material	80%	Valid
Language Expert	Language Lecturer	Language	98%	Very Valid
Average		-	91%	Very Valid

Source: Research data (2026)

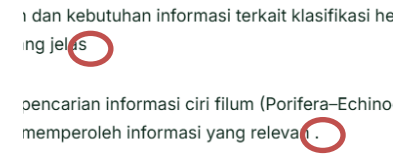
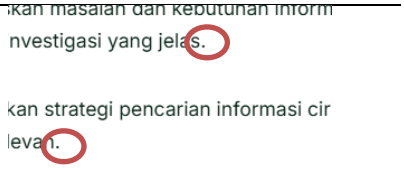
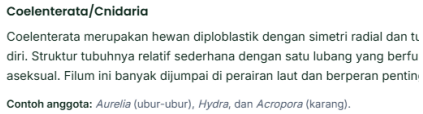
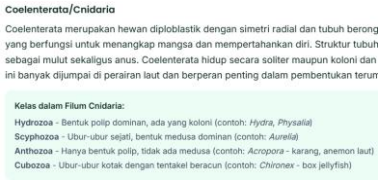
All qualitative feedback from validators was addressed through revisions. Summary of revisions is presented in Table 4.

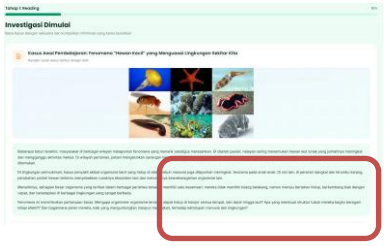
Table 4.
Revision Notes Based on Validator Feedback

No	Validator	Feedback	Revision Result
1	Language	Punctuation fixes per PUEYD	Punctuation revised per PUEYD
2	Material	Add class examples for each phylum	Class descriptions added per phylum
3	Media	Add tutorial/usage guidance and quick quiz in reading	Mascot tutorial added; quiz in reading; evaluation in results

Source: Research data (2026)

Table 5.
Expert Revision Results

No	Revision	Before	After
1	Punctuation fixes per PUEYD		
2	Add class examples for each phylum		

3	Add tutorial/usage guidance and quick quiz in reading		

Source: Research data (2026)

4. Implementation Phase

Implementation was conducted with 32 grade X students (19 males, 13 females). Students used the media in one structured learning session, including pretest, media interaction, mind mapping, and posttest. Gender distribution is presented in Table 6.

Table 6.
Gender Distribution of Participants (n=32)

Gender	n	Percentage (%)
Male	19	59.4%
Female	13	40.6%
Total	32	100%

Source: Research data (2026)

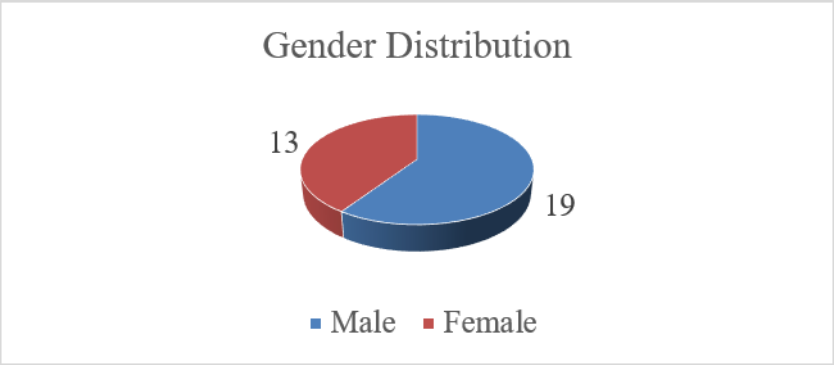


Figure 1.
Gender Distribution of Participants
Source: Research data (2026)

Effectiveness testing used N-Gain analysis. The information literacy test consisted of 12 items representing six Big 6 indicators. Results are presented in Table 6.

Table 7.
Overall N-Gain Results for Information Literacy Competence

Mean Pretest (%)	SD	Mean Posttest (%)	SD	N-Gain	Category
60.94	*23.52*	*90.10*	*10.03*	*0.75*	*High*

Source: Research data (2026)

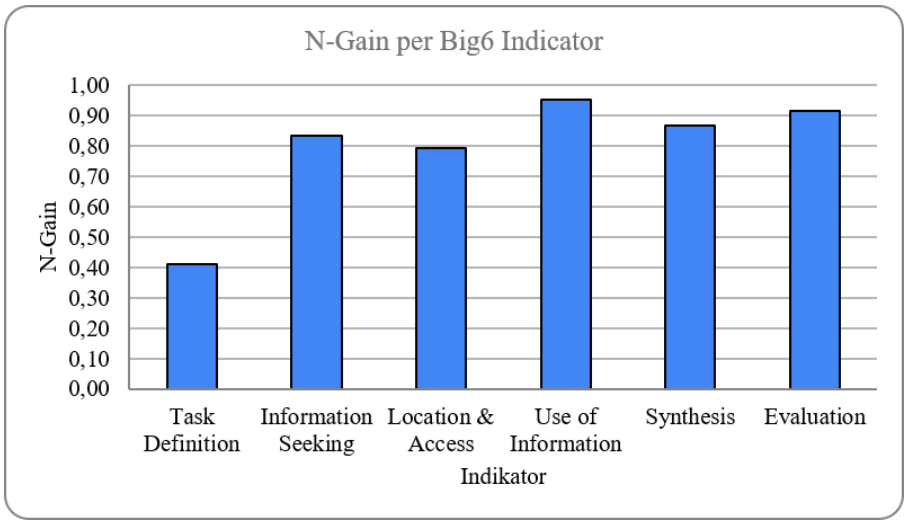


Figure 2.
N-Gain per Big6 Indicator
Source: Research data (2026)

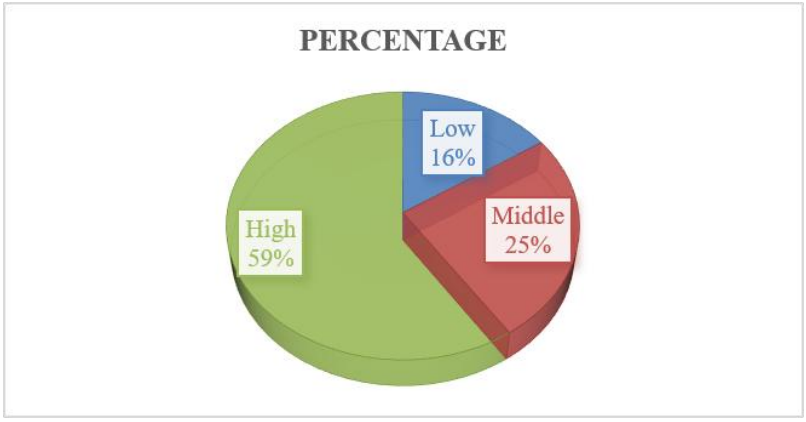


Figure 3.
Students N-Gain Distribution
Source: Research data (2026)

Normality testing using Shapiro-Wilk showed data were not normally distributed (p & 0.05), so Wilcoxon Signed-Rank Test was used. Results are in Table 8 and Table 9.

Table 8.
Shapiro-Wilk Normality Test Results

Data	Statistic	p-value	Conclusion
Pretest	0.842	<0.001	Not Normal
Posttest	0.714	<0.001	Not Normal

Source: SPSS analysis (2026)

Table 9.
Wilcoxon Signed-Rank Test Results

Variable	W Statistic	p-value	Conclusion
Information Literacy	0.000	> 0.001	Significant*

*Source: SPSS analysis, *Significant at alpha=0.05 (2026)*

Descriptive and statistical analyses were conducted to determine differences in the improvement of information literacy competencies between male students (M, n=19) and female students (F, n=13). The results are presented in Table 10 and Table 11.

Table 10.
Descriptive Statistics by Gender

Aspects	Male	SD	Female	SD
Mean of Pretest	67,54	22,72	51,28	22,01
Mean of Posttest	91,67	8,78	87,82	11,59
Mean of N-Gain	0,701	0,347	0,678	0,321
Category of N-Gain	High	–	High	–

Table 11.
Statistics by Gender

Variable	U Statistics	p-value	α	Category
N-Gain	133,000	0,724	0,05	Not Significant

The Mann-Whitney U test was used because the N-Gain distribution for Group L was not normal (Shapiro-Wilk p=0.003).

Gender-based analysis showed no significant difference (Mann-Whitney U, p=0.724). Both male (N-Gain=0.701) and female (N-Gain=0.678) students achieved high category improvement.

Furthermore, the students' learning process is also assessed and analyzed using the Heatmap in Figure 4 to display the development patterns of scores at three measurement points, namely the pretest, mind map, and posttest for each student. The red-yellow-green color gradient reflects the range from low to high scores, allowing individual learning patterns to be comprehensively identified.

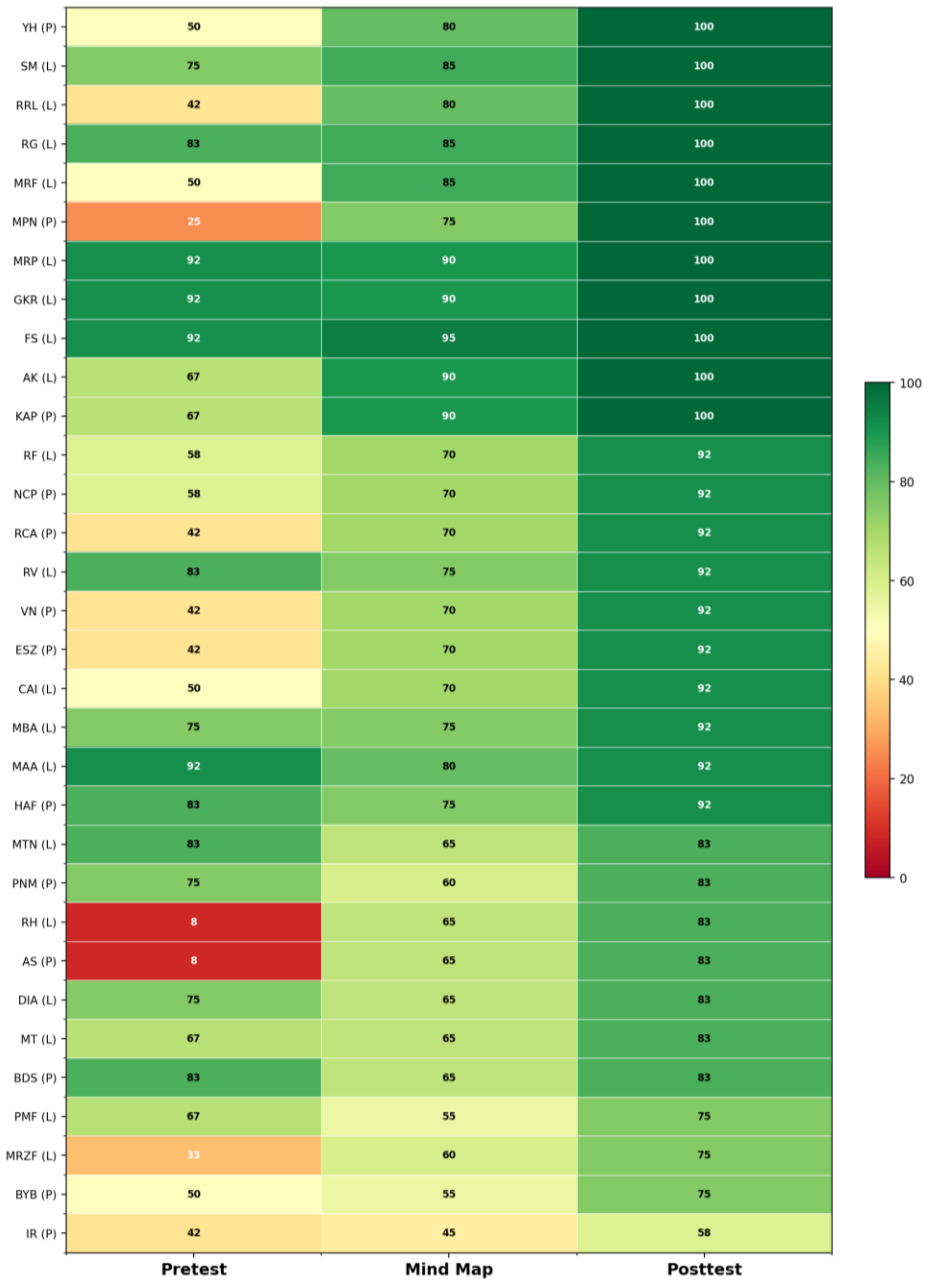


Figure 4.
Heatmap of learning process
Source: Research data (2026)

5. Evaluation Phase

Evaluation was conducted using student and teacher response questionnaires with Likert scale 1-4. Results are presented in Table 12 and Table 13.

Table 12.
Student Response Results (n=32)

Indicator	Score	Max Score	Percentage	Category
Display	199	256	77.7%	Feasible
Ease of Use	201	256	78.5%	Feasible
Content Suitability	206	256	80.5%	Very Feasible
Material Benefit	208	256	81.3%	Very Feasible
Effectiveness	209	256	81.6%	Very Feasible
Literacy Evaluation	207	256	80.9%	Very Feasible
Total	1,230	1,536	80.1%	Very Feasible

Source: Research data (2025/2026)

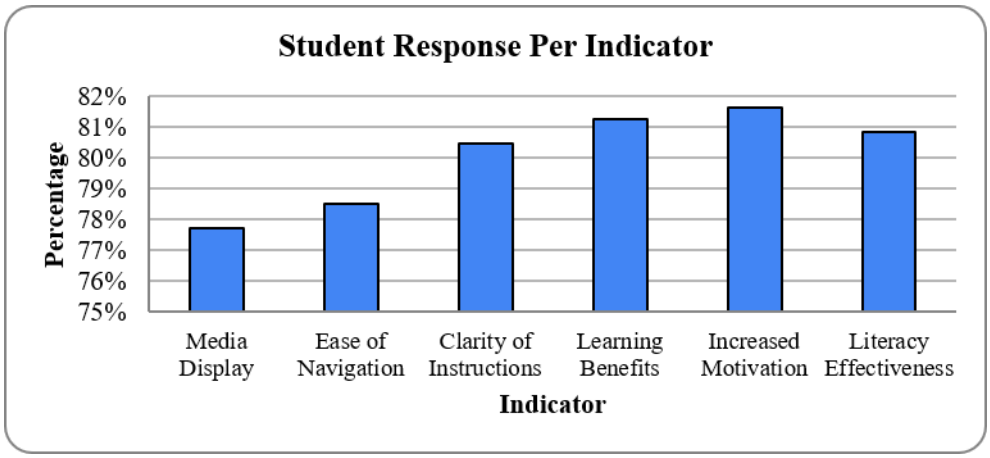


Figure 5.
Student Response per Indicator
Source: Research data (2026)

Table 13.
Teacher Response Results (n=1)

Indicator	Score	Max Score	Percentage	Category
Curriculum Alignment	10	12	83%	Very Feasible
Content Suitability	10	12	83%	Very Feasible
Material Benefit	10	12	83%	Very Feasible
Display	9	12	78%	Feasible
Ease of Use	9	12	79%	Feasible
Effectiveness	10	12	83%	Very Feasible
Literacy Evaluation	10	12	83%	Very Feasible
Total	44	48	92%	Very Feasible

Source: Research data (2026)

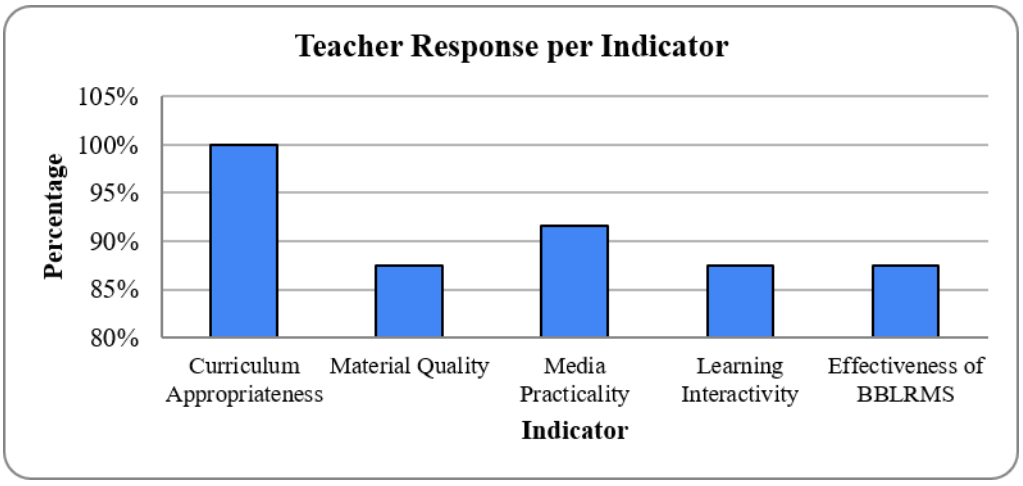


Figure 6.
Teacher Response per Indicator
Source: Research data (2026)

Discussion

This study successfully developed and evaluated a BBLRMS-based Detective Web-game that strategically integrates investigative gamification elements with a structured BBLRMS (Blended Learning with Reading, Mind Mapping, and Sharing) framework. The findings demonstrated that the developed media was capable of facilitating students' information literacy competencies effectively. The development of this digital learning media was driven by a clear and pressing need identified through preliminary analysis, which confirmed the existence of significant gaps in students' information literacy skills. These gaps were particularly pronounced in several critical areas: Task Definition, where students demonstrated only 39.1%; Synthesis, at 53.1%; and Use of Information, at 64.5%. These competencies are fundamental components of The Big 6 framework, a widely recognized model for systematic information management originally conceptualized by Eisenberg (2008) and further elaborated by Nuraini et al., (2025). The identification of these substantial deficiencies provided strong justification for developing an educational media that could offer structured scaffolding throughout the learning process, specifically by aligning instructional activities with the sequential phases of the BBLRMS model.

The quality and appropriateness of the developed media were thoroughly assessed through a comprehensive validation process involving material, media, and language validators. The results were highly favorable, with the media achieving an impressive average validation score of 91% across all validator categories. This result suggests that the media was appropriate to be implemented in biology learning, especially for invertebrate materials (Anisah & Afifah, 2023). Furthermore, the pedagogical foundation of the media was strengthened by the deliberate alignment between BBLRMS phases and Big 6 indicators. This alignment provided a pedagogically sound framework wherein each learning activity systematically targeted specific information literacy competencies, ensuring that students were not merely exposed to content but were guided through a structured developmental progression in their information handling abilities.

The effectiveness of the BBLRMS-based Detective Web-game was rigorously evaluated through quantitative measures, and the results demonstrated that the media significantly improved students' information literacy competencies. The high N-Gain score (0.75) indicated that the learning media contributed positively to improving students'

abilities after the learning process. Additionally, the Wilcoxon Signed-Rank Test yielded a statistically significant result ($p < 0.001$), further confirming that the observed improvements were not attributable to chance. This finding strongly aligns with the seminal work of Ali, N., Ullah, S., & Khan, (2022), who demonstrated that interactive-engagement approaches consistently produce higher normalized gains compared to traditional, passive instructional methods. The detective game mechanics, which required students to actively investigate clues, evaluate evidence, and solve problems, embodied this interactive-engagement philosophy and translated it into measurable learning outcomes (Wilson et al., 2017; Zou, Zhang, et al., 2021).

When examining the improvements across specific information literacy indicators, the results revealed differentiated but consistently positive gains. The greatest improvement occurred in Use of Information, which achieved an exceptional N-Gain of 0.95, and Evaluation, which reached an N-Gain of 0.92. These remarkable gains indicate that the detective game mechanics were particularly effective in training students to critically analyze clues, verify the authenticity and relevance of evidence, and assess source quality before drawing conclusions. These skills are central to information literacy as defined by the ACRL., (2016) Framework for Information Literacy for Higher Education and are consistent with the critical evaluation competencies (Zou, Zou, et al., 2021). Similarly, the Information Seeking Strategies indicator achieved a strong N-Gain of 0.83, while Location and Access reached 0.79. These improvements reflect how the investigative missions embedded within the game successfully guided students through structured information-searching processes, aligning these activities with the BBLRMS Reading and Initiation phases, where students learn to locate, access, and navigate diverse information sources systematically.

The Synthesis indicator also demonstrated substantial improvement with an N-Gain of 0.87. This strong gain can be attributed in large part to the Mind Mapping feature integrated into the web-game, which supported findings from Nuraini et al., (2025) that digital mind mapping significantly enhances students' ability to integrate disparate information pieces and organize concepts in a coherent, visually structured manner. By requiring students to construct mind maps during their investigations, the media scaffolded the complex cognitive process of synthesizing information from multiple sources into a unified understanding of invertebrate biology topics.

Conversely, the moderate improvement in Task Definition, with an N-Gain of 0.41, represented the lowest gain among all indicators despite still constituting meaningful progress from the very low baseline of 39.06%. This finding is consistent with the observations of Nuraini et al., (2025), who identified task formulation as the most challenging competency to develop due to its inherent metacognitive demands. Task definition requires students to independently recognize their own information needs, articulate clear research questions, and establish parameters for their inquiry before beginning any search process (Eisenberg, 2008; Iriani, T Wicaksono, 2021). This demands a sophisticated level of metacognitive self-regulation that is difficult to develop within a single learning session or intervention cycle (Anisah, G. and Afifah, 2023). Consequently, future iterations of the Detective Web-game should strengthen scaffolding mechanisms at the initial investigation stages, such as providing more structured guidance for formulating research questions within the Learning Orientation and Reading interfaces, thereby supporting students in developing these foundational metacognitive skills more gradually and effectively (ACRL., 2016).

An important additional finding concerned the equity of learning outcomes across gender groups. The analysis revealed no significant gender differences in learning gains, as confirmed by the Mann-Whitney U test ($p = 0.724$). Male students achieved an N-Gain

of 0.701 while female students achieved an N-Gain of 0.678; both scores fall squarely within the high improvement category. This finding supports the research of Major, L., Francis, G. A., & Tsapali, (2021), who demonstrated that minimal gender differences in achievement emerge when educational interventions are carefully designed to ensure equal access and engagement opportunities for all students (Trilling & Fadel, 2009). The neutral investigative narrative of the detective game, combined with universally accessible biology content about invertebrates, appears to have successfully created an inclusive learning environment that supported both male and female students equally in developing their information literacy competencies (Hwang et al., 2023).

The heatmap visualization of individual learning trajectories across three assessment phases Pretest, Mind Map, and Posttest, for 28 participants, revealed a general upward trend in performance following the mind-mapping intervention. While pretest scores varied considerably, ranging from as low as 8 to as high as 92, the majority of participants demonstrated marked improvement during the Mind Map phase, with scores clustering between 55 and 95 (Gross, M., & Latham, 2012; Head et al., 2018). By the Posttest, most participants reached mastery levels, with numerous individuals attaining perfect scores of 100 and the vast majority scoring 83 or above (Lestari, E., Putra, P., & Wahyuni, 2023). This pattern suggests that the mind-mapping strategy effectively consolidated learning gains across diverse baseline abilities. Notable exceptions included a few participants whose posttest scores remained at 75 or below, indicating that while the intervention was broadly beneficial, its efficacy varied slightly among individuals with the lowest initial performance levels, suggesting the need for additional differentiated support for struggling learners (Nuraini et al., 2025).

Finally, the practical value and pedagogical acceptability of the media were validated through positive responses from both students and teachers. Students provided an overall positive response rate of 80%, while teachers were even more favorable at 92%. Teachers particularly appreciated the curriculum alignment, rating it at 83%, which confirms that the media effectively supports the Merdeka Curriculum's emphasis on developing information literacy and scientific reasoning skills (Lase, 2019). Students rated several dimensions in the very feasible category which are Content Suitability (80.5%), Material Benefit (81.3%), Effectiveness (81.6%), and Literacy Evaluation (80.9%), indicating strong perceived learning value and practical utility (Wilson et al., 2017). The slightly lower scores for display aesthetics (77.7%) and ease of use (78.5%) from students identify targeted areas for refinement in future development cycles (Curran et al., 2024). These limitations, combined with the study's constraints of employing a single-class sample and the absence of a control group, suggest that future research should expand the sample size, incorporate rigorous control group designs, and explore long-term retention effects to strengthen causal claims about the media's effectiveness (Bada & Jita, 2022) and to understand better the durability of the information literacy gains achieved through this innovative BBLRMS-based Detective Web-game (Branch, 2009).

CONCLUSION

This study developed and validated a BBLRMS-based Detective Web-game to enhance information literacy competencies on invertebrate topics among senior high school students. The media achieved very valid criteria through expert validation (91% average). Effectiveness testing showed a significant improvement in students' information literacy skills, achieving a high category growth. Student and teacher responses were highly positive (80.1% and 92% respectively, both very feasible). The integration of BBLRMS

phases with investigative gamification and The Big 6 framework proved effective in creating active, meaningful learning experiences that systematically develop information literacy competencies. These findings contribute to educational media development by demonstrating how BBLRMS models combined with detective game mechanics can address specific competency gaps in complex biology topics. Future research should expand the sample size, incorporate control group designs, and explore long-term retention effects to strengthen causal claims.

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