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Improving Lower-Secondary Science Learning Through QuizWhizzer-Assisted Educational Games

A Two-Cycle Classroom Action Research Study

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ABSTRACT

Digital game-based learning can support participation and formative assessment, but evidence on QuizWhizzer in lower-secondary science remains context-dependent. This study examined an iterative QuizWhizzer-assisted educational-game approach in Grade VIII science at MTs Muhammadiyah Wuring, Indonesia. A two-cycle classroom action research design involved 21 students (13 boys and 8 girls) studying the structure and function of the human excretory system. Cycle I combined teacher explanation, a handout/presentation, QuizWhizzer-based formative questions, and an end-of-cycle essay test. Reflection on low mastery and limited participation informed Cycle II, which retained QuizWhizzer while adding an instructional video and stronger classroom-management and prompting strategies. The primary learning outcome was the end-of-cycle essay score, with mastery defined as a score of at least 70; teacher implementation and student activity were recorded through structured observation checklists. Mean achievement increased from 39.48 (range 2-60; 0 of 21 students mastered) in Cycle I to 82.14 (range 70-100; 21 of 21 mastered) in Cycle II. Teacher implementation increased from 52% to 96%, while student activity increased from 12.5% to 81.3%. The refined second-cycle instructional sequence therefore met the prespecified classroom success criterion of at least 85% mastery. Because the study had no untreated comparison group or pre-intervention baseline and Cycle II introduced multiple refinements, the findings support QuizWhizzer as a component of an iterative classroom-improvement strategy rather than establish its isolated causal effect.

Keywords
Classroom Action Research
Digital Game-Based Learning
Formative Assessment
QuizWhizzer
Science Education

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Introduction

Science education at the lower-secondary level is expected to develop conceptual understanding together with inquiry-oriented reasoning, participation, and the capacity to relate scientific ideas to observable phenomena. Interactive learning environments can strengthen these outcomes when technology is integrated with purposeful pedagogy rather than treated as an add-on. A recent network meta-analysis in science education reported that interactive digital games outperformed conventional instruction for cognitive outcomes, while a systematic review of game-based learning in school science similarly identified positive potential across knowledge and competence domains [1],[2].

Gamification and digital game-based learning are increasingly used to make practice, feedback, and assessment more participatory. In K-12 settings, systematic and meta-analytic evidence indicates that gamified learning can improve academic performance and motivation, although the magnitude of benefit varies with design, educational level, implementation duration, and the way game elements are aligned with learning tasks [3]–[6]. This qualification is important: competition, points, or visual progress do not automatically produce learning. Their instructional value depends on whether they sustain attention, provide meaningful opportunities to retrieve and apply knowledge, and preserve students' sense of competence and autonomy.

Formative feedback is one mechanism through which technology-rich learning can contribute to achievement. A meta-analytic review found that feedback in technology-rich environments produced a meaningful average improvement in academic performance, with explanatory feedback showing particularly strong effects [7]. In a classroom quiz environment, immediate response to answers can therefore be pedagogically useful when it is followed by explanation, correction, and opportunities to try again. QuizWhizzer is one platform that packages questions in a board-game-like digital interface and can be used for interactive formative assessment.

Recent studies have begun to examine QuizWhizzer in Indonesian classrooms. Development research has reported its feasibility as an interactive medium for science learning [8]. Quasi-experimental and pre-experimental studies have associated QuizWhizzer-supported instruction with higher learning outcomes in senior-secondary biology and science contexts [9]–[11], while work in junior-secondary informatics has also reported positive

student engagement and achievement [12]. Classroom research on optical-instrument concepts likewise documented gains when QuizWhizzer was embedded within problem-based learning [13]. However, this emerging literature is dominated by product-development or comparison designs, and evidence is still limited on how teachers can use QuizWhizzer within a systematic reflection-refinement cycle in a lower-secondary biological systems lesson.

Accordingly, this study examined a two-cycle classroom action research intervention in Grade VIII science. The objective was not to estimate a stand-alone causal effect of QuizWhizzer, but to determine whether an instructional sequence that incorporated QuizWhizzer and was revised through structured reflection could improve essay-based science achievement, class mastery, teacher implementation, and student activity. The article first describes the action-research procedure, instructional refinements, instruments, and success criteria; it then reports the learning and observation outcomes and interprets them in relation to current evidence on digital game-based learning and formative assessment.

Material and Methods

A. Research Design and Setting

The study employed classroom action research, an iterative form of practitioner inquiry in which evidence from one cycle is used to revise subsequent teaching. This logic is consistent with contemporary action-research guidance emphasizing planned intervention, systematic observation, reflection, and evidence-informed adjustment [14]. Two cycles were conducted, each comprising planning, action, observation, and reflection. The research took place at MTs Muhammadiyah Wuring, Nangahure Lembah, Indonesia, during the second semester of the 2024/2025 academic year. Cycle I was implemented on 8 February 2025 and Cycle II on 17 February 2025.

B. Participants and Instructional Context

The research participants were the complete set of 21 students from Class VIII C at MTs Muhammadiyah Wuring, consisting of 13 male and 8 female students. The class functioned as one unified learning group, with no control or comparison group. Both research cycles addressed the topic of the structure and function of the human excretory system. Cycle I was implemented over two lesson periods, whereas Cycle II extended across three lesson periods, consistent with the time allocation and schedule set by the madrasah. The variation in lesson duration between the cycles formed part of the classroom action research context and was not handled as a strictly controlled experimental variable. Before the study began, the researcher submitted a research proposal to the Investment and One-Stop Integrated Services Agency in order to obtain a research recommendation letter. After receiving that recommendation, the researcher requested research authorization from the Principal of MTs Muhammadiyah Wuring. The principal approved the study and then informed the teacher whose class served

as the research subject about the study's purpose, objectives, and implementation. Accordingly, the research was carried out following institutional approval from the madrasah. The study was conducted within the setting of classroom learning activities, and student data were used for research purposes while safeguarding the confidentiality of students' identities.

C. Intervention and Cycle Refinement

During planning, the researchers prepared lesson plans, learning materials, a QuizWhizzer activity, essay tests, observation checklists, and supporting documentation. The lesson plans were reviewed by two validators and judged suitable for classroom use. No numerical content-validity coefficient was available; accordingly, the validation evidence is reported qualitatively. In Cycle I, the teacher introduced the lesson, activated prior knowledge, explained the target concepts, and then used QuizWhizzer to present interactive multiple-choice questions. Students accessed the activity through their devices. A handout and presentation materials supported the lesson, and a three-item essay test was administered at the end of the cycle.

Reflection after Cycle I identified three practical problems: weak participation in questioning, inconsistent attention during explanation, and limited reading engagement that constrained performance on the essay tasks. Cycle II therefore retained the same curricular topic and QuizWhizzer activity while adding a relevant instructional video, more direct teacher prompting of students who lost focus, stronger classroom management, and explicit motivational guidance. A second three-item essay test was administered at the end of Cycle II. Table 1 summarizes the elements that remained stable and the changes introduced after reflection.

Table 1. Instructional design and reflection-led refinements across the two action-research cycles

Phase	Duration	Core learning sequence	Reflection/refinement
Cycle I	2 lesson periods	Teacher explanation; handout/presentation; QuizWhizzer formative questions; end-of-cycle essay test.	Low mastery; limited questioning; inconsistent focus; limited reading engagement.
Cycle II	3 lesson periods	Same science topic and QuizWhizzer use; instructional video added; end-of-cycle essay test.	Stronger teacher prompting, classroom management, and motivation based on Cycle I reflection.

Source: Research data, 2025.

D. Instruments and Outcome Measures

Two forms of assessment served different purposes. First, multiple-choice items delivered through QuizWhizzer were used during instruction as a formative, game-based activity. Second, learning achievement was measured with an end-of-cycle essay test consisting of three questions in each cycle (six questions across the study). The essay score, rather than the QuizWhizzer game score, was specified as the primary learning-outcome measure. This

distinction aligns the outcome definition with the student-level essay scores used in the analysis.

Mastery was defined using the school minimum mastery criterion (Kriteria Ketuntasan Minimal, KKM) of 70. During the learning process, the teacher's implementation of instruction and the associated student activities were monitored with a structured, checklist-based observation form. The observations were carried out by two observers: the researcher and another science teacher who did not participate in delivering the instruction. In every cycle, both observers conducted direct observations using the same observation instrument throughout the learning process. The teacher activity observation sheet addressed elements including lesson preparation, classroom management, the use of instructional media, the application of teaching strategies, and closing activities. In parallel, the student activity observation sheet focused on aspects such as readiness for learning, attention, participation, involvement in learning activities, and confidence in giving responses. Each indicator was rated with a Guttman scale, assigning a score of 1 to activities that were carried out and a score of 0 to those that were not. The observational data from both observers were then used to produce a descriptive account of how teacher and student activities were implemented.

The implementation percentage was determined by comparing the obtained score with the maximum possible score and interpreting it according to categories defined for the study. Accordingly, the reported activity percentage functions as a descriptive indicator of the implementation of the learning process in each cycle, rather than as a score from a psychometric instrument that would be subjected to inter-rater reliability testing.

E. Data Analysis and Success Criteria

The research data were examined using both quantitative and qualitative methods. The quantitative component comprised students' essay test scores for each cycle, whereas the qualitative component was gathered through observation sheets documenting teacher and student activities. A descriptive analysis was undertaken to show how learning outcomes and classroom activities progressed from Cycle I to Cycle II. Students' learning outcomes were assessed with an essay test containing three questions, with each question awarded a maximum of 10 points, so that the total possible score was 30. Each student's responses were rated on a 0–10 scale according to accuracy, completeness, and consistency with the concepts assessed. The scores for the three questions were added together and then transformed to a 0–100 scale. Learning mastery was judged using a Minimum Mastery Criterion (KKM) of 70. The class average was determined by dividing the total of all students' scores by the number of students who took the test. The proportion of classical learning mastery was computed based on how many students obtained at least 70. Descriptive summaries were also provided for changes in the average score from Cycle I to Cycle II. Inferential statistical testing was not

carried out because the study design used a single intact class, with no control group, and instructional adjustments were introduced gradually. The classroom action research success criteria were set as follows: at least 85% of students must score 70 or higher, and teacher and student activities must fall into a "high" category. The study ended after Cycle II because the mastery goals had been achieved.

Results and Discussions

A. Cycle I: Initial Implementation and Reflection

Cycle I established the initial performance level under the first QuizWhizzer-assisted instructional sequence. The class mean on the three-item essay test was 39.48 (SD = 12.61), with scores ranging from 2 to 60. None of the 21 students reached the KKM of 70. Thus, classroom mastery was 0%, substantially below the prespecified 85% criterion. The distribution is consistent with the reflection notes: students showed limited participation in asking questions, several students lost focus during teacher explanation, and reading engagement was insufficient for the essay demands.

These findings indicated that adding a digital game-based quiz alone was not sufficient to produce the desired classroom outcome in the first cycle. The purpose of the reflection stage was therefore diagnostic rather than confirmatory. QuizWhizzer was retained because students engaged with the interactive quiz, but the broader instructional sequence was revised to address attention, explanation, and support for understanding the biological system.

B. Cycle II: Revised Instruction and Learning Outcomes

After the reflection-led changes, Cycle II showed a markedly different descriptive pattern. The mean essay score increased to 82.14 (SD = 10.91), with scores ranging from 70 to 100. All 21 students met or exceeded the KKM, producing 100% classroom mastery. The mean difference between cycles was 42.66 points. Because every Cycle II score was at least 70, the 85% mastery criterion was exceeded and the classroom-action sequence was concluded after the second cycle.

Table 2 reports the aggregate outcomes calculated from the individual student essay scores. In Cycle I, no student scored 70 or higher, whereas every Cycle II score was at least 70. The student-level essay scores were therefore used consistently as the basis for the mastery calculations.

Table 2. Essay-based science learning outcomes by action-research cycle

Cycle	n	Mean	SD	Observed range	Students >=70, n	Mastery (%)
I	21	39.48	12.61	2-60	0	0.0
II	21	82.14	10.91	70-100	21	100.0

Source: Authors' calculations from student-level essay data, 2025.

C. Teacher Implementation and Student Activity

The observational indicators moved in the same direction as achievement. Teacher implementation increased from 52% in Cycle I (moderate category) to 96% in Cycle II (high category). Student activity increased from 12.5% (low) to 81.3% (high). Table 3 summarizes these implementation and participation indicators.

Table 3. Observation outcomes for teacher implementation and student activity

Indicator	Cycle I (%)	Category	Cycle II (%)	Category
Teacher implementation	52.0	Moderate	96.0	High
Student activity	12.5	Low	81.3	High

Source: Research data, 2025.

D. Interpretation in Relation to Prior Evidence

The learning pattern observed here is directionally consistent with broader evidence on digital games in STEM. A meta-analytic review of digital educational games reported a medium-to-large overall advantage for game-based STEM learning and showed that effects depend on both subject area and game design [15]. A separate meta-analysis comparing educational games and gamification likewise concluded that gameful approaches can support achievement and motivation, although the mechanisms differ across design types [16]. Mobile educational games have also shown favorable average learning effects across a synthesis of 38 studies, with educational level and implementation characteristics acting as moderators [17]. These reviews support the plausibility of the classroom pattern but do not convert the present action-research result into a causal estimate.

The science-specific literature reinforces this design-sensitive interpretation. A systematic review of value-added digital game-based learning in K-12 science emphasized that the question is increasingly not simply whether games work, but which added mechanisms improve learning [18]. Reviews of gamification in education and of serious games in science and mathematics similarly note that engagement benefits coexist with variability, implementation constraints, and occasional null or adverse responses [19]–[20]. More immersive forms of gamification show the same general principle: technology can create powerful learning experiences, but instructional design and teacher orchestration remain decisive [21]. In the present study, the largest improvement followed a cycle in which the game-based quiz was combined with a video, stronger prompting, and more deliberate classroom management. It is therefore more defensible to attribute success to the refined instructional package than to QuizWhizzer in isolation.

The parallel increase in observed student activity is also consistent with meta-analytic evidence that gamified environments can influence behavioral and affective outcomes. A 2025 meta-analysis of gamified flipped classrooms found positive average effects across behavioral, cognitive, and affective domains [22], while a 2026 synthesis in secondary and higher

mathematics reported a small-to-moderate positive effect on motivation and engagement [23]. More general meta-analytic evidence also reports favorable average effects of gamification on teaching and learning outcomes [24]–[26]. Importantly, these studies also document heterogeneity, indicating that game elements should be aligned with the developmental level, content, and classroom purpose rather than applied as generic rewards.

The specific QuizWhizzer literature provides closer contextual comparison. Science and biology studies have reported improved achievement when the platform was incorporated into instructional designs [9]–[11], while junior-secondary informatics research has reported positive engagement and learning outcomes [12]. QuizWhizzer has also been used as part of problem-based science instruction [13]. The present study contributes a different type of evidence: it shows how one teacher-research context used performance and observation data from an unsuccessful first cycle to redesign the second cycle. This iterative use is consistent with action research as a mechanism for improving the local learning environment rather than testing a single fixed treatment [27].

A formative-assessment perspective further explains why the second-cycle sequence may have been productive. Feedback is most useful when it helps learners recognize the gap between current and intended performance and provides information for subsequent action. Foundational work on formative assessment and feedback stresses this feedback loop [28]–[29], and technology-supported formative assessment can improve learning attitudes and achievement when feedback is integrated into instruction rather than delayed until the end [30]. In this study, QuizWhizzer created an interactive checkpoint during the lesson, while teacher explanation, prompting, and the added video supplied additional opportunities to interpret and act on that information. The cycle-to-cycle change therefore illustrates a practical combination of gameful retrieval, feedback, and teacher-led instructional adjustment.

E. Practical Implications

For lower-secondary science teachers, the findings suggest three practical principles. First, QuizWhizzer should be treated as a component of an instructional sequence rather than as a stand-alone intervention. Questions should be aligned with the intended concepts and followed by explanation or discussion. Second, low first-cycle performance should trigger targeted refinement of teaching, not merely repetition of the same digital activity. In this case, an instructional video, stronger prompting, and better classroom management were added in response to observed problems. Third, game-based participation should be evaluated alongside an independent learning measure. Using essay performance as the primary outcome avoided equating success in a game interface with conceptual understanding.

Conclusion

This classroom action research shows that introducing science instruction supported by QuizWhizzer paired with reflection and refinement in every cycle can lead to gains in learning outcomes, the quality of instructional implementation, and student engagement. The study's main contribution is the reflective process, which helps teachers recognize challenges from earlier cycles and then modify strategies, classroom management, and the use of instructional media for the subsequent cycle. Accordingly, QuizWhizzer is best understood as one element within a broader instructional improvement ecosystem, rather than as the only driver of changes in learning outcomes.

The results also imply a practical application: game-based digital formative assessments can be incorporated into a learning cycle in an adaptive way covering diagnosis, reflection, action refinement, and reassessment within junior high school science education. Because the study involved only a single class without a control group, its findings primarily provide contextual evidence about how instructional improvement unfolds and should not be taken as establishing a causal relationship between the use of QuizWhizzer and improved learning outcomes.

Limitation and Suggestions

Several limitations constrain inference. The study involved one class of 21 students at a single school, without randomization, a comparison group, or a pre-intervention baseline; Cycle I was already an intervention cycle. Cycle II also differed from Cycle I in lesson duration and introduced an instructional video, stronger teacher prompting, and classroom-management changes, so the contribution of QuizWhizzer cannot be separated from these co-interventions. Each end-of-cycle achievement test contained only three essay items, and reliability coefficients, scoring-rubric reliability, and inter-rater reliability for the observation checklists were not reported. The observation role for teacher implementation was also not documented with sufficient precision to establish assessor independence. Finally, the study measured immediate achievement and activity but not retention or transfer.

Future studies should use a pre-intervention measure, larger multi-class samples, comparable instructional time, and a comparison condition that isolates the added value of QuizWhizzer. Repeated measures over a longer period would permit analysis of retention and novelty effects. Researchers should also report instrument development, scoring rubrics, content-validity evidence, and observer agreement. Qualitative student data could clarify which game features support attention and conceptual understanding and which features may create distraction or unnecessary competition.

Conflict of Interest

The authors declare no conflict of interest.

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