



Development and evaluation of a web-based interactive flashcard tool (Aero'Zen) for low-impact rhythmic activity instruction in physical education

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A – Research concept and design

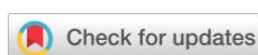
B – Collection and/or assembly of data

C – Data analysis and interpretation

D – Writing the article

E – Critical revision of the article

F – Final approval of article



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ABSTRACT

Background: Teaching rhythmic activities in physical education continues to face challenges due to the limited availability of visual learning aids that demonstrate movements systematically, repeatedly, and accessibly.

Objectives: This study aimed to develop and evaluate Aero'Zen, a web-based interactive flashcard tool integrating movement illustrations, QR codes, and demonstration videos for basic low-impact rhythmic activities.

Methods: This research and development study employed the ADDIE model. Following product development and expert validation, learning outcomes were evaluated using a one-group pretest–posttest pre-experimental design involving 30 tenth-grade students at SMK Negeri 2 Semarang. Product feasibility was assessed by media experts, subject matter experts, and a physical education practitioner. Pretest and posttest scores were analyzed using the Shapiro–Wilk test for normality and paired-samples t-tests, with the significance level set at $\alpha = .05$.

Results: Aero'Zen was rated highly suitable by media experts (95.75%), subject matter experts (94.50%), and a physical education practitioner (88.75%). Mean scores increased from 75.40 to 89.97 in the cognitive domain, from 28.80 to 32.77 in the affective domain, and from 19.87 to 32.00 in the psychomotor domain. Paired-samples t-tests revealed significant differences between pretest and posttest scores across all three domains (all $p < .001$).

Conclusions: Aero'Zen is a highly suitable web-based learning medium with the potential to support students' cognitive, affective, and psychomotor learning outcomes, including movement coordination and performance, in low-impact rhythmic activities. Its integrated flashcards, QR-code access, and demonstration videos provide a flexible resource for repeated and independent learning. Future studies should use randomized controlled trials with larger and more diverse samples to strengthen causal inference and generalizability.

Keywords: Aero'Zen, low-impact aerobic exercise, physical education, rhythmic activities, web-based interactive flashcards.

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INTRODUCTION

Rhythmic activities are an important component of Physical Education, Sports, and Health (PJOK) instruction because they contribute to coordination, balance, and the synchronization of movement with rhythm. These activities involve sequences of body movements performed in accordance with a specific tempo or musical accompaniment. Aerobic activities integrated into rhythmic activities have been associated with improvements in physical fitness, cognitive function, and executive function through physiological and neurobiological mechanisms (Garrett et al., 2024; Ren et al., 2024). One form of rhythmic activity taught in schools involves basic low-impact movements in aerobic exercise. Recent evidence also indicates that video-based coaching can support performance development in aerobic gymnastics, particularly in artistic expression and movement creativity (Fahmi, Herlambang, & Wiyanto, 2025). Low-impact movements provide an important foundation because they emphasize stepping patterns, body control, and balance while involving a relatively low risk of injury, making them suitable for beginners and potentially beneficial for cardiovascular fitness (Rismayanthi et al., 2022).

Although rhythmic activities are included in the Physical Education, Sports, and Health (PJOK) curriculum under Ministry of Education and Culture Regulation No. 24 of 2016, their instruction continues to face various challenges. Students may experience difficulty understanding movement techniques and mastering motor skills when instruction relies predominantly on conventional, teacher-centered approaches with limited interactivity (Zhao et al., 2024). This situation highlights the need for instructional media capable of presenting movement demonstrations in a visual, interactive, and easily accessible manner. Advances in educational technology suggest that integrating digital and visual media into physical education can enhance learning motivation, student engagement, and understanding of movement skills (Jastrow et al., 2022). Furthermore, flashcards as a visual learning medium have been shown to improve memory retention and simplify complex information, thereby facilitating understanding (Le & Luong, 2023).

Previous studies have demonstrated the potential of QR-code-based and flashcard media; however, their contexts, content characteristics, and learning outcomes differ from the specific needs of physical education. Dewi & Zuhdi (2023) developed QR-card media for digestive-system learning in elementary school using the ADDIE model and reported positive validity, effectiveness, and user-response results. However, the media was designed primarily to support understanding of conceptual science content rather than the acquisition and performance of motor skills. Consequently, these findings do not directly address the need for students to observe, imitate, and repeatedly practice physical movements. Similarly, Sagita & Hidayah (2025) developed barcoded flashcards for heat-related science content for fifth-grade elementary students and reported high validity, practicality, and learning gains. Nevertheless, the intervention focused on scientific literacy and did not incorporate movement demonstrations or performance-based learning activities. Annastasya & Fathurrahman (2024) developed QR-code-based flashcards for cultural-diversity content for fourth-grade students and found significant improvements in learning outcomes; however, the media addressed academic content rather than physical movement skills. Pujiyanto, Royana, & Wibisana (2025) developed and evaluated an Android-based multimedia application for healthy lifestyle instruction and reported

positive expert validation, student responses, and learning outcomes across the cognitive, affective, and psychomotor domains. These findings demonstrate the potential of technology-based multimedia to support learning in physical education. Similarly, [Kresnapati, Royana, & Hadi \(2026\)](#) developed an augmented reality-based adaptive physical education learning module using the ADDIE model to support motor skill development, further demonstrating the potential of technology-based media for movement-oriented instruction. However, these studies primarily employed mobile multimedia or augmented reality approaches rather than integrating physical flashcards, QR-code access, and web-based movement demonstrations into a single learning medium.

These limitations indicate a contextual and functional gap in previous research. Existing QR-code- and flashcard-based media have largely been developed for conceptual or academic subjects, whereas limited research has integrated physical flashcards, QR-code access, and web-based movement demonstrations specifically for rhythmic motor-skill instruction in physical education. Therefore, there is a need for a learning medium that connects movement concepts with observable demonstrations and enables students to access and repeatedly view movement examples during practice.

To address this gap, this study introduces Aero'Zen, a web-based hybrid visual-digital learning medium that integrates physical flashcards, QR-code access, and movement demonstration videos for low-impact rhythmic activities. The medium was designed to support independent, flexible, and repeated learning according to students' needs. The flashcard visuals and demonstration videos provide contextual representations of movement, allowing students to observe coordination and synchronization during movement performance. The novelty of Aero'Zen lies in integrating physical flashcards, QR-code access, and web-based demonstration videos into a single learning medium specifically designed for rhythmic motor-skill instruction in physical education. This integration is intended to bridge the gap between understanding movement names and descriptions and observing how those movements are performed.

Accordingly, this study aimed to develop and evaluate Aero'Zen as a web-based interactive learning medium for low-impact rhythmic activities, assess its feasibility through expert validation and user feedback, and examine differences in students' cognitive, affective, and psychomotor outcomes before and after implementation. Theoretically, this study contributes to the literature on technology-supported learning media in physical education. Practically, Aero'Zen is intended to provide teachers and students with an accessible resource for repeated movement demonstrations and independent practice.

METHODS

Study Design and Participants

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation ([Masrukhan et al., 2025](#); [Spatioti et al., 2022](#)). After the Aero'Zen learning medium had been developed and validated,

pre-post learning outcomes were evaluated using a pre-experimental one-group pretest-posttest design. The overall development procedure is presented in [Figure 1](#).



Figure 1. ADDIE Development Model

The study was conducted at SMK Negeri 2 Semarang in April 2026 over three learning sessions on low-impact rhythmic aerobic exercise. The population consisted of 10th-grade students enrolled in the Physical Education, Sports, and Health (PJOK) course. Purposive sampling was employed based on students' prior participation in rhythmic activity lessons and access to web-based learning media ([Etikan, Musa, & Alkassim, 2016](#)). The large-scale trial involved 30 10th-grade students, whereas the small-scale trial involved 10 PJOK students from PGRI University of Semarang. The university students were selected because they had a basic understanding of rhythmic activities and learning media development, enabling them to provide initial feedback on the readability, appearance, and usability of the media.

Ethical approval statement

Ethical approval for this study was granted by the Research Ethics Committee of the Faculty of Social Sciences and Physical Education at PGRI University of Semarang (Approval No. 005/AM/FPIPSKR/IV/2026). Before the study began, all participants were informed about the study objectives and procedures and were required to provide their consent to participate.

Pre-Post Evaluation Design

A pre-experimental one-group pretest-posttest design was employed to evaluate changes in students' learning outcomes following the implementation of the Aero'Zen web-based flashcard medium by comparing outcomes before and after implementation ([Saputro & Sunarno, 2021](#)). The implementation was conducted over three learning sessions in April 2026. A pretest was administered before the learning sessions, followed by the planned learning activities using Aero'Zen, and a posttest was administered after the learning sessions using the same assessment framework.

Because the study used a single-group design, potential threats to internal validity were considered. The implementation was conducted within a short, predefined period using the same learning topic, procedures, and assessment framework for all participants. These procedures helped limit variation associated with changes in instructional conditions or extended maturation. Nevertheless, history, maturation, and testing effects could not be completely ruled out in the absence of a control group. Therefore, the observed pretest-posttest differences should be interpreted as improvements associated with the implementation of Aero'Zen rather than definitive evidence of a causal effect attributable to the medium alone.

Research Instruments

The research instruments consisted of an expert validation form, a student response questionnaire, and learning outcome assessments. Product validation was conducted by media experts, subject matter experts, and physical education practitioners using a four-point Likert-type scale with the categories very unsuitable, unsuitable, suitable, and very suitable (Table 1).

Table 1. Assessment Instruments and Scoring Procedures for Learning Outcomes

Domain	Instrument/Assessment Component	Operational Criterion	Scoring Scale
Affective	Student self-report questionnaire	Students reported their responses and perceptions regarding participation in rhythmic activity learning through 10 questionnaire items	4 = Strongly Agree 3 = Agree 2 = Disagree 1 = Strongly Disagree
Psychomotor	Performance assessment of basic aerobic movements	Teacher assessed students' performance of the practiced basic aerobic movements, including coordination, counting, balance, and overall choreography performance	4 = Very Good 3 = Good 2 = Fair 1 = Poor

A student response questionnaire was used to assess students' responses to Aero'Zen during low-impact rhythmic aerobic exercise lessons. The questionnaire used a four-point Likert-type scale with the following scoring criteria: 1 = strongly disagree/very unsuitable, 2 = disagree/unsuitable, 3 = agree/suitable, and 4 = strongly agree/very suitable.

Learning outcome assessments were administered before and after the implementation of Aero'Zen. The cognitive domain was assessed using a 10-item multiple-choice test. Affective learning responses were assessed using a 10-item student self-report questionnaire administered before and after implementation. The questionnaire assessed students' responses and perceptions regarding their interest, enthusiasm, participation, persistence, attention, respect for peers, confidence, motivation, and learning experiences during rhythmic activity learning. Each item was rated using a four-point Likert-type scale: 4 = strongly agree, 3 = agree, 2 = disagree, and 1 = strongly disagree.

Psychomotor performance was assessed by the teacher using a performance assessment sheet covering the basic aerobic movements practiced during the learning sessions. Students' performance was assessed with particular attention to coordination, counting, and balance. Each performance aspect was rated using a four-point scale: 1 = poor, 2 = fair, 3 = good, and 4 = very good. The assessment also included an overall choreography score. The psychomotor assessment covered the basic aerobic movements practiced during the learning activities, including V-step, Knee Up, Butterfly, Swing, and Overhead, which were evaluated according to the performance aspects specified in the original assessment instrument.

To ensure scoring consistency, the same 10-item affective questionnaire and four-point response scale were used at both pretest and posttest. Similarly, the same psychomotor performance assessment sheet, movement tasks, assessment aspects, and four-point rating scale were used at both measurement points. Thus, the same indicators and scoring procedures were applied across the pretest and posttest assessments. Before implementation, all instruments underwent content validation through expert judgment by media experts, subject matter experts, and physical education practitioners with expertise in physical education and digital learning media (Yusoff, 2019).

In addition to content validation through expert review, the validity and reliability of the research instruments were evaluated in a small pilot study involving 10 participants. Construct validity was assessed using Pearson product-moment correlations, and internal consistency reliability was assessed using Cronbach's alpha. An instrument was considered to have acceptable reliability when Cronbach's alpha was $\geq .70$, whereas a value of $\geq .80$ indicated high reliability.

Data Analysis

Data were analyzed using descriptive and inferential statistics with IBM SPSS Statistics version 25. Descriptive statistics were used to summarize media suitability based on validation results from media experts, subject matter experts, and physical education practitioners, as well as student responses during the small- and large-scale trials. Students' learning outcomes were summarized using the mean and standard deviation of the pretest and posttest scores. The percentage results were interpreted according to the suitability categories presented in Table 2.

Table 2. Media Feasibility Interpretation Criteria

Percentage	Category
81–100%	Highly Feasible
61–80%	Feasible
41–60%	Moderately Feasible
<40%	Not Very Feasible

To examine differences in students' learning outcomes before and after the implementation of Aero'Zen, inferential analyses were performed. Data normality was assessed using the Shapiro–Wilk test. Differences between pretest and posttest scores were then analyzed using paired-samples t-tests at a significance level of $\alpha = .05$. Statistical significance was determined at $p < .05$.

RESULTS

Analysis Phase: Analysis of Instructional Media Needs

The analysis phase was conducted through observations of physical education classes, teacher interviews, and identification of students' needs regarding digital learning media for rhythmic activities. The analysis indicated a need for learning media that could present rhythmic movement content in a visual, systematic, interactive, and easily accessible format. Based on these findings, the Aero'Zen platform was developed by integrating interactive flashcards with a website, QR codes, and demonstration videos. The website included a homepage, movement catalog, video tutorials, and QR-code access to support independent learning.

Analysis Phase: Analysis of Instructional Media Needs

The Aero'Zen platform was designed as a web-based interactive flashcard tool for teaching basic low-impact rhythmic activities within the Physical Education, Sports, and Health (PJOK) curriculum. The platform design was based on the needs analysis of students and physical education teachers, which indicated the need for visual-digital learning materials that were interactive, systematic, and easily accessible during the learning process.

a) Aero'Zen Interactive Flashcard Design

The main product developed was an interactive flashcard system integrated with a website and movement demonstration videos. The flashcards were organized into two sets: one for arm movements and one for leg movements, with each set consisting of 10 basic low-impact aerobic exercise movements. Each flashcard included the name of the movement, a visual illustration, a brief description, the movement count, and a QR code linking directly to the corresponding demonstration video.

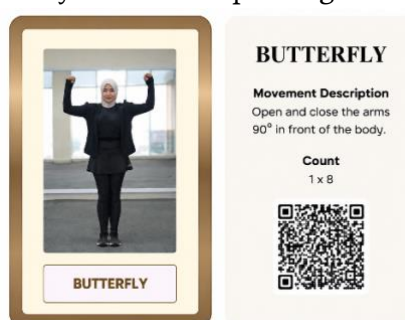


Figure 2. Aero'Zen Interactive Flashcard Bundle

b) Aero'Zen Website Design

The Aero'Zen website was integrated with the interactive flashcards, QR codes, and demonstration videos (Figure 3). The website included a homepage, movement catalog, video tutorials, and QR-code access to facilitate independent learning. The interface text shown in Figures 2–5c was presented in Indonesian because Aero'Zen was specifically developed for Indonesian students and implemented in an Indonesian school context. The original interface language was therefore retained to preserve the authenticity and contextual relevance of the learning medium.

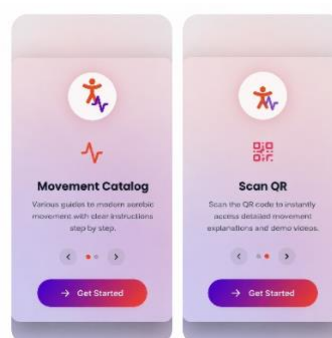


Figure 3. Aero'Zen Website Home Page

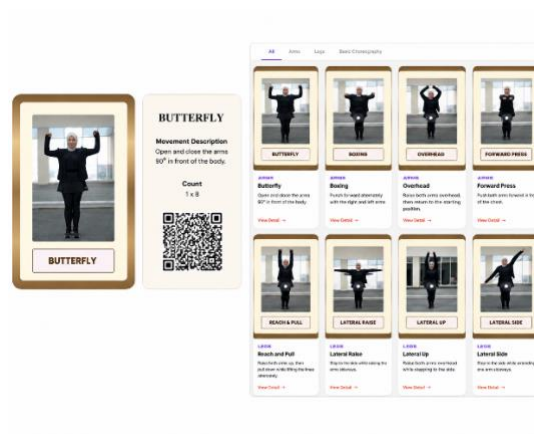


Figure 4. Aero'Zen Exercise Catalog Menu

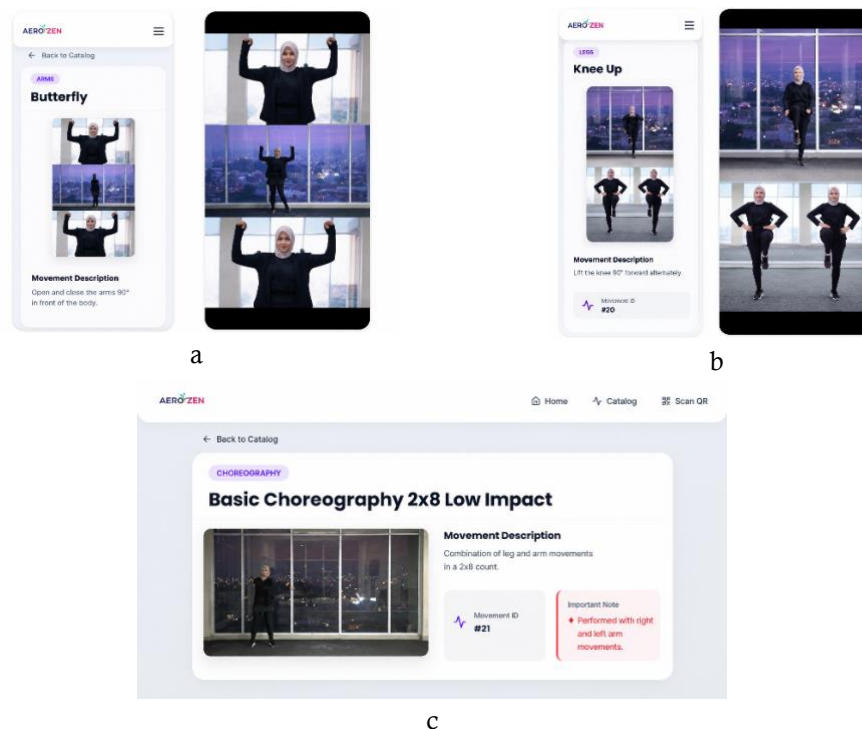


Figure 5. Aero'Zen video tutorial interface showing (a) arm movement demonstrations, (b) leg movement demonstrations, and (c) a simple choreographed movement sequence.



Figure 6. QR code for accessing the web-based Aero'Zen learning platform.

Development Phase: Media Validation and Feasibility

During the development phase, Aero'Zen underwent validation by media experts, subject matter experts, and physical education practitioners to determine its suitability before implementation.

Expert Validation Results

The validation results indicated that Aero'Zen was highly suitable for use in learning activities. Media experts rated the product at 95.75%, subject matter experts at 94.50%, and physical education practitioners at 88.75% (Table 3). All three scores fell within the Highly Suitable category. These findings indicated that Aero'Zen achieved high ratings in terms of media quality, content accuracy, functionality, and practicality for classroom implementation.

Table 3. Expert Validation Results

Validator	Percentage	Category
Media Expert	95.75%	Highly Suitable
Subject Matter Expert	94.50%	Highly Suitable
Physical Education Practitioner	88.75%	Highly Suitable

Instrument Validity and Reliability

Prior to implementation, the research instruments were evaluated in a pilot study involving 10 participants. The validity analysis showed that all questionnaire items had correlation coefficients greater than the critical r value of .632, indicating that all items met the predetermined validity criterion. Reliability analysis yielded Cronbach's alpha coefficients ranging from .864 to .951, indicating high to very high internal consistency (Table 4).

Table 4. Reliability Test Results

Variable	Cronbach's Alpha	Category
Media Presentation	0.902	Very High
Ease of Use	0.911	Very High
Media Interactivity	0.951	Very High
Learning Motivation	0.864	High

Media Implementation Results

The implementation phase consisted of small-scale and large-scale trials. The small-scale trial involving 10 university students yielded positive responses, with percentages ranging from 94% to 95%. Similarly, the large-scale trial involving 30 students at SMK Negeri 2 Semarang yielded positive responses ranging from 86.7% to 89.5% (Table 5). These findings indicated that participants perceived Aero'Zen positively in terms of its usability and learning-related features.

Table 5. User Response Results

Trial	Result
Small-scale Trial	94-95% (Very Good)
Large-scale Trial	86.7-89.5% (Very Good)

Pre-Post Learning Outcome Evaluation

Descriptive statistics showed higher posttest scores than pretest scores across the cognitive, affective, and psychomotor domains following the implementation of Aero'Zen. The mean and standard deviation values are presented in Table 6.

Table 6. Descriptive Statistics of Learning Outcomes

Domain	Pretest (Mean $\pm$ SD)	Posttest (Mean $\pm$ SD)
Cognitive	75.40 $\pm$ 9.317	89.97 $\pm$ 6.896
Affective	28.80 $\pm$ 3.508	32.77 $\pm$ 3.588
Psychomotor	19.87 $\pm$ 2.945	32.00 $\pm$ 2.166

The Shapiro–Wilk test indicated that the pretest and posttest scores for all three domains met the normality assumption (all $p > .05$) (Table 7). Therefore, paired-samples t-tests were used to compare pretest and posttest scores.

Table 7. Summary of the Shapiro–Wilk Normality Test

Domain	Pretest p	Posttest p	Result
Cognitive	0.777	0.426	Normal
Affective	0.211	0.208	Normal
Psychomotor	0.208	0.083	Normal

Paired-Samples t-Test

Paired-samples t-tests showed statistically significant differences between pretest and posttest scores across the cognitive, affective, and psychomotor domains (all $p < .001$). The magnitude of the standardized within-group changes was also substantial.

The cognitive domain showed a mean increase of 14.57 points (95% CI [13.53, 15.61]), with a very large paired-samples Cohen’s d of 5.25. The affective domain showed a mean increase of 3.97 points (95% CI [2.27, 5.67]), corresponding to a large effect size ($d = 0.87$). The psychomotor domain showed a mean increase of 12.13 points (95% CI [10.73, 13.53]), with a very large effect size ($d = 3.23$).

These results indicated substantial standardized within-group pre–post changes. However, the effect sizes represent the magnitude of within-group change and should not be interpreted as evidence of causal intervention effects because the study used a one-group pretest–posttest design without a control group. The complete results are presented in Table 8.

Table 8. Summary of the Shapiro–Wilk Normality Test

Domain	Mean Difference	95% CI	t	df	p	Cohen’s d	Interpretation
Cognitive	14.57	13.53–15.61	28.748	29	$< .001$	5.25	Very large
Affective	3.97	2.27–5.67	4.781	29	$< .001$	0.87	Large
Psychomotor	12.13	10.73–13.53	17.686	29	$< .001$	3.23	Very large

DISCUSSION

The validation results from media experts, subject matter experts, and physical education practitioners indicated that Aero’Zen was highly suitable as a web-based learning medium. The integration of visual flashcards, demonstration videos, and concise explanations is consistent with the Cognitive Theory of Multimedia Learning, which proposes that appropriately combining visual and verbal information can facilitate information processing and learning (Mayer, 2024).

The high validation scores suggest that Aero’Zen was considered suitable in terms of media quality, content, functionality, and practicality. Its integration of visual flashcards and demonstration videos provides students with multiple representations of movement concepts. These characteristics are consistent with previous research highlighting the potential of digital media and visual learning resources to support student engagement, information retention, and learning in physical education (Jastrow et al., 2022; Le, 2023). The staged presentation of movement information through flashcards and QR-code-linked videos may also facilitate information

processing by allowing students to access movement demonstrations repeatedly and at their own pace (Cavanagh & Kiersch, 2023).

The positive responses obtained during the small- and large-scale trials further support the usability of Aero'Zen as a learning resource. Students reported positive perceptions of the platform, suggesting that its combination of visual materials, QR-code access, and demonstration videos was well received during rhythmic activity learning. The ability to repeatedly access movement demonstrations may provide greater opportunities for independent learning and reduce students' reliance on direct teacher demonstrations. This characteristic is consistent with student-centered approaches that emphasize learner autonomy and flexible access to instructional resources (Kerimbayev et al., 2023). Digital learning resources may also support motivation and engagement when appropriately integrated into the learning process (Wong & Hughes, 2023; Zhao et al., 2024).

The pre-post evaluation showed statistically significant differences between pretest and posttest scores across the cognitive, affective, and psychomotor domains (all $p < .001$). Higher posttest scores were observed in all three domains following the implementation of Aero'Zen, indicating improvements in students' cognitive learning outcomes, affective responses, and movement performance over the study period. However, because the study did not include a control group, these improvements cannot be attributed solely to Aero'Zen. The findings should therefore be interpreted as within-group changes associated with the implementation period rather than definitive evidence of a causal intervention effect.

The observed changes may be understood in relation to the characteristics of the Aero'Zen learning medium. The integration of visual flashcards, demonstration videos, and QR-code-based access provided students with opportunities to view movement information through multiple formats and repeatedly access demonstrations during learning. According to the Cognitive Theory of Multimedia Learning, appropriately combining visual and verbal information can facilitate information processing and support understanding and retention (Mayer, 2024). Previous research has similarly highlighted the potential of interactive digital media to support engagement and learning in physical education contexts (Jastrow et al., 2022; Zhao et al., 2024). Nevertheless, these theoretical mechanisms should be regarded as plausible explanations for the observed changes rather than mechanisms directly tested in the present study.

The psychomotor domain showed a particularly substantial within-group change, with scores increasing from 19.87 ± 2.945 at pretest to 32.00 ± 2.166 at posttest. The mean increase was 12.13 points (95% CI [10.73, 13.53]), with a very large paired-samples effect size (Cohen's $d = 3.23$). The availability of repeated movement demonstrations may have contributed to this change by providing students with opportunities to observe and imitate movement models, which is consistent with observational learning principles (Han et al., 2022). However, this interpretation should be treated cautiously. Because the same assessment framework was used at pretest and posttest and no control group was included, testing effects, repeated exposure to the movement tasks and assessment criteria, familiarity with the learning activities, and other uncontrolled factors may also have contributed to the observed change. Therefore, the large effect size represents the magnitude of the standardized within-group change rather than an estimate of the causal effect of Aero'Zen.

This study extends previous research on QR-code-based learning media, digital flashcards, and instructional videos by integrating these components into a web-based hybrid learning medium specifically designed for low-impact rhythmic activities in secondary school physical education. Unlike learning media developed primarily for conceptual or academic content, Aero'Zen combines physical flashcards, QR-code access, and web-based movement demonstrations to connect movement-related information with observable performance examples. This integration represents the primary contribution of Aero'Zen and provides a flexible resource that can be accessed repeatedly during learning and independent practice.

The findings also highlight the potential practical application of Aero'Zen as a digital learning resource for physical education teachers and students. Its integration of visual flashcards, QR codes, and demonstration videos may support more flexible and interactive learning by providing additional opportunities to access movement demonstrations beyond direct teacher instruction. This potential is consistent with broader research emphasizing the role of digital media in supporting physical education and health-related learning (Knoke, 2024).

Limitations of the study

Several limitations should be considered when interpreting these findings. First, the study involved students from only one school, which limits the generalizability of the findings to other educational contexts and student populations. Second, the one-group pretest–posttest design did not include a control group; therefore, history, maturation, testing effects, repeated exposure, and other uncontrolled factors cannot be excluded as alternative explanations for the observed changes. Third, the implementation of Aero'Zen depends on access to suitable digital devices and reliable internet connectivity, which may limit its applicability in schools with inadequate technological infrastructure. Future research should involve larger and more diverse samples, employ controlled or randomized experimental designs, and include longer follow-up periods to provide stronger evidence regarding the effectiveness, sustainability, and generalizability of Aero'Zen.

CONCLUSION

This study developed and evaluated Aero'Zen, a web-based interactive flashcard medium integrating visual illustrations, QR-code access, and demonstration videos for low-impact rhythmic activity instruction in physical education. The findings indicate that Aero'Zen is a feasible and practical learning medium with the potential to support students' cognitive, affective, and psychomotor learning outcomes, including movement coordination and performance, while providing opportunities for more interactive and independent learning. The integration of visual flashcards, QR-code access, and web-based demonstration videos represents the primary contribution of Aero'Zen to rhythmic activity instruction. However, the observed pretest–posttest improvements should not be attributed solely to Aero'Zen because testing effects, repeated exposure, and other uncontrolled factors cannot be excluded in the one-group pretest–posttest design. Future studies should involve larger and more diverse samples and employ controlled or randomized experimental designs with longer follow-up periods to provide stronger evidence regarding the effectiveness and generalizability of Aero'Zen.

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AI DISCLOSURE STATEMENT

During the preparation of this manuscript, the authors used Grammarly to improve language clarity, readability, grammar, and overall linguistic quality. These tools were used solely for language refinement and did not contribute to the study design, data collection, data analysis, interpretation of the results, or formulation of the scientific conclusions. All AI-assisted revisions were carefully reviewed, edited, and verified by the authors. The authors take full responsibility for the accuracy, originality, integrity, and final content of the manuscript.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to participant privacy and confidentiality considerations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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