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Digital Transformation in Physical Education: The Effectiveness of M-Gym Mobile Media in Enhancing Students' Rhythmic Gymnastics Competence

Eva Faridah [1] *, Indra Kasih [2], Sinung Nugroho [3], M. Irfan [4]

[1] Dept. of Physical Education, Health and Recreation, Fac. of Sport Science, Universitas Negeri Medan, Indonesia, 0000-0003-0255-0383
[2] Dept. of Physical Education, Health and Recreation, Fac. of Sport Science, Universitas Negeri Medan, Indonesia, 0000-0002-9867-1296
[3] Department of Sport Science, Fac. of Sport Science, Universitas Negeri Medan, Indonesia, 0000-0002-6345-526X
[4] Dept. of Physical Education, Health and Recreation, Fac. of Sport Science, Universitas Negeri Medan, Indonesia, 0000-0003-1236-9828
* Corresponding author: Eva Faridah (evafaridah@unimed.ac.id)

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Abstract

This study aims to determine the effectiveness of M-Gym, an Android-based mobile learning media, in enhancing students' rhythmic gymnastics competence as part of the ongoing digital transformation in physical education. This research integrates technology-supported learning into sports education to foster a more interactive and flexible learning environment. The study employs the Borg and Gall research and development (R&D) model, consisting of ten systematic stages: preliminary study, research planning, prototype development, limited and wider field testing, expert validation, product revision, feasibility testing, and dissemination. The participants were 115 students of the Physical Education, Health, and Recreation Department at Universitas Negeri Medan, divided into small (n=25), large (n=35), and control (n=32) groups. Data were collected using performance tests, expert assessments, observation sheets, and student response questionnaires. Quantitative data were analyzed using paired sample t-tests, while qualitative data were examined descriptively. The results revealed a significant improvement ($p < 0.001$) in students' rhythmic gymnastics competence after using the M-Gym media, indicating its strong impact on skill mastery. Additionally, 62.5% of students rated the media as very good, while lecturer evaluations reached a practicality score above 93%. These findings demonstrate that M-Gym effectively enhances digital-based learning outcomes, supports student engagement, and facilitates lecturers in delivering rhythmic gymnastics instruction. Overall, the study confirms that mobile learning innovation through M-Gym contributes positively to the digital transformation of physical education by promoting active, technology-integrated, and student-centered learning.

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Introduction

Changes in the technological landscape, especially the penetration of the internet and mobile devices, have driven the transformation of the way of learning and teaching globally. On an international scale, the concept *of digital transformation in education* emphasizes the use of technology to improve accessibility, personalization of learning, and the relevance of the curriculum to the needs of the 21st century (Naveed, 2023). In Indonesia, the adoption of educational technology is accelerated by post-pandemic learning recovery policies and the Independent Curriculum initiative that provides flexibility for educational units to implement innovative learning methods and media (Hadi, 2023; evaluation of the Independent Curriculum 2024–2025). This approach encourages higher education institutions to integrate digital solutions that facilitate more adaptive, collaborative, and student-centered learning. Quantitatively, Indonesia's digital ecosystem has shown significant growth. The Digital Report 2024 and the 2025 update note the increasing internet penetration and mobile usage, with the percentage of national internet users approaching 80% and the dominance of access through mobile devices (We Are Social, 2024–2025). This data confirms that mobile-based learning (m-learning) platforms have great reach opportunities and high relevance for lecture and students in Indonesia (We Are Social, 2024; Reuters, 2025).

The development and use of technology in the learning process in Indonesia is framed by national education policies. Law of the Republic of Indonesia No. 20 of 2003 concerning the National Education System (Law No. 20/2003) affirms the state's responsibility to ensure the equitable distribution and improvement of the quality of education and its relevance to the changing times (Law No. 20/2003, 2003). Furthermore, the directives and implementation documents from the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) — including the development of the Independent Curriculum — emphasize increasing digital literacy, curriculum flexibility, and pedagogical innovations that are relevant to the needs of industry and society in the era of Society 5.0 (Kemdikbudristek; Hadi, 2023). Practically, this foundation provides legitimacy for the development of digital learning media in universities, including mobile media for practical courses such as Physical Education, Sports, and Health (PJKR). Practical courses in the field of PJKR — for example, rhythmic gymnastics — require repetitive exercises, motor feedback, and hands-on demonstrations to achieve graduation competencies. However, in reality, in many universities there are obstacles that limit the effectiveness of practical learning: (1) limited face-to-face time due to the burden of other curricula; (2) high ratio of lecturers: students so that individual feedback is limited; (3) inadequate training facilities; and (4) disruption of face-to-face processes during and after the COVID-19 pandemic that changed learning patterns towards blended/hybrid. These conditions increase the need for learning media that supports independent practice, visualization techniques, and instructions that can be accessed at any time (Suharjana, 2010; Yudho et al., 2020).

Mobile learning (m-learning) leverages mobile devices (smartphones/tablets) to deliver materials, provide video demonstrations, interactive quizzes, and asynchronous feedback. Recent systematic reviews and meta-analyses show that m-learning is able to improve access, motivation, and learning outcomes if its design considers pedagogical aspects, user engagement (engagement), and content quality (Naveed, 2023; Krokhina, 2024; Garzón, 2025). A 2025 meta-analysis by Garzón et al. that included hundreds of studies found a significant positive effect of m-learning on learning gains, but emphasized the variability of effects depending on the quality of instructional

design and disciplinary context (Garzón, 2025). Therefore, for courses that demand motor skills, the m-learning design must present quality demonstration videos, step-by-step guides, performance assessment rubrics, and feedback mechanisms that allow for motion reflection. Empirical research on m-learning in higher education has grown rapidly. Naveed (2023) presents a review of 161 articles (2016–2022) that show that m-learning improves learning flexibility, but demands further research related to *skill acquisition* in practical subjects. Krokhina (2024) and several other reviews (2024–2025) confirm the benefits and challenges of m-learning implementation, including the issue of reliability of practical assessments and the need for institutional support. For the context of physical education, some early studies tested the integration of instructional videos, exercise apps, and sensors (wearables) to measure physical performance; However, specific studies testing rhythmic gymnastics competency through mobile applications are still relatively limited and often in the format of small-scale development studies (Naveed, 2023; Krokhina, 2024).

At the national level, a number of mobile media development studies in Indonesia have reported positive results on improving understanding and skills, for example the development of Android-based learning applications for certain mathematics, languages, or engineering materials (Widyatama & Pratama, 2021; Khomarudin & Efriyanti, 2023). For rhythmic gymnastics in particular, a study that developed M-Gym (Android-based Media Gymnastics) by Eva Faridah et al. (2024) reported an increase in student performance scores on pre-post tests and generally positive user responses. However, many of these studies are development reports that need to be supplemented with expert validation documentation, broader trials, and comprehensive statistical analysis in order to be generalized. From the review of the international and national literature, several gaps emerged: (1) there are still few R&D studies that apply systematic measures (e.g. Borg & Gall) for the development of m-learning media specific to motor skills; (2) evidence on the effectiveness of m-learning in *skill acquisition* (not just knowledge or motivation) is still fragmented; (3) the need for valid and reliable measurements of motor competence that can be relied upon in the design of pretest-posttest research; and (4) lack of documentation on faculty admissions (usability) and institutional readiness to integrate such media into the curriculum (Naveed, 2023; Garzón, 2025). Attention to this gap is important so that technological solutions are not only technically appealing but also valid, effective, and widely applicable.

Based on the above conditions, the research that develops and evaluates M-Gym as an Android-based learning medium for rhythmic gymnastics in PJKR students has a dual urgency. First, pragmatically, M-Gym can be a support tool that enables structured exercises, visual demonstrations, self-assessments, and documentation of student performance development—features that have the potential to overcome the limitations of in-person and facilities. Second, academically, this kind of research can fill the empirical evidence gap regarding the effectiveness of m-learning on the mastery of motor skills with a systematic R&D approach (Borg & Gall) as well as valid and reproducible statistical tests (Faridah et al., 2024; Rohmaini et al., 2020). Technology adoption theories such as TAM (Technology Acceptance Model) and UTAUT (Unified Theory of Acceptance and Use of Technology) are relevant to explain the acceptance of M-Gym by students and lecturers, emphasizing *performance expectancy*, *effort expectancy*, and *facilitating conditions* as a predictor of intent of use (Venkatesh et al., 2003 — a general summary in m-learning review). In addition, the motor learning theory framework emphasizes the need for demonstration, repetition, reinforcement, and feedback to achieve *automation skills* —

elements that can be supported by interactive video media and structured training modules such as those in the M-Gym app. The combination of these theories underlies the selection of research variables: effectiveness (change in pre-post performance score), user acceptance (questionnaire/usability), and validity/practicality of the product (expert review).

This research is expected to contribute as follows: (1) strong empirical evidence regarding the effectiveness of M-Gym in improving students' rhythmic gymnastics competencies through R&D design and quantitative tests; (2) development models and implementation guidelines that can be adapted by other study programs in Indonesia for the integration of m-learning in practical courses; and (3) practical policy recommendations for institutions and policymakers to strengthen infrastructure support, lecturer training, and curriculum integration that utilizes mobile media to realize relevant educational goals in the era of digital transformation (Law No. 20/2003; Independent Curriculum). this background shows that (a) digital opportunities in Indonesia support the adoption of m-learning (We Are Social, 2024–2025), (b) national education policies provide legitimacy to improve the quality and innovation of learning (Law No. 20/2003; Independent Curriculum), (c) the practical learning challenges in PJKR require solutions that facilitate independent practice and feedback, and (d) although international and national evidence suggests the potential of m-learning, there is a need for systematic R&D research and robust empirical testing in the context of rhythmic gymnastics. Therefore, research that develops and evaluates M-Gym as a mobile learning medium for rhythmic gymnastics in PJKR students is very relevant and strategic to answer the challenges of physical education in the digital era.

Digital transformation in education refers to the process of integrating digital technology into educational learning, administration, and management practices to improve access, quality, and relevance of learning (Naveed et al., 2023). This shift is not only about device adoption, but involves re-engineering the learning process to be more adaptive, personalized, and responsive to the needs of the 21st century. Mobile learning (m-learning) — learning that utilizes mobile devices such as smartphones and tablets — stands out as one of the manifestations of this transformation due to its reach, portability, and potential to provide just-in-time materials and on-demand learning activities (Naveed, 2023). Recent meta-analyses and literature reviews indicate the positive effects of m-learning on learning gains, motivation, and accessibility, but also emphasize the heterogeneity of outcomes depending on the quality of instructional design, contextualization of materials, and institutional support (Garzón, 2025; Krokhina, 2024). In other words, the success of m-learning depends largely on how content, interactions, and feedback mechanisms are designed for specific disciplines, including areas that demand mastery of motor skills.
Motor learning theory emphasizes four main elements in skill acquisition: demonstration/modeling, practice (repetition), feedback, and varied training conditions (Schmidt & Lee, theoretical summary). In the context of physical education, visual feedback (e.g. video modeling, augmented video feedback) has been shown to accelerate technique correction and performance improvement compared to verbal feedback alone, especially when large classroom conditions or face-to-face time are limited (Mödinger et al., 2022; Han et al., 2022). Systematic studies have shown that video-based visual feedback is effective in improving students' motor skills because it provides concrete representations of movement, allows motion analysis, and supports learners' reflection. Therefore, mobile-based learning media that includes demonstration videos, slow-motion, and pre-post comparison features have the potential to support the acquisition of rhythmic gymnastics skills. An understanding

of the acceptance of technology is necessary to explain how much students and faculty are willing to use new products like M-Gym. The two models that are often used are TAM (Technology Acceptance Model) and UTAUT (Unified Theory of Acceptance and Use of Technology). TAM emphasizes *perceived usefulness* and *perceived ease of use* as the main determinants of use intention, while UTAUT expands the variables by including *performance expectancy*, *effort expectancy*, *social influence*, and *facilitating conditions* (Venkatesh et al., 2003). M-learning studies show that these factors consistently influence adoption at the higher education level: content quality (performance expectancy), ease of navigation (effort expectancy), institutional support (facilitating conditions) and peer recommendations/lecturer access (social influence) significantly predict intention to use. Therefore, M-Gym's evaluation needs to include user acceptance measurement instruments to ensure not only performance effectiveness, but also the possibility of long-term adoption.

An effective instructional design for skill acquisition on a mobile platform must incorporate several principles: material segmentation (micro-learning), multimodality (video + text + graph), scaffolding (step-by-step), and specific and measurable feedback mechanisms (rubric/score). These principles are also reflected in recommendations for the development of sports content: progressive modeling video tutorials, structured exercises, assessment checklists, and documentation features (student video recordings) to facilitate asynchronous feedback from lecturers or peers (Tannoubi et al., 2023; Martín-Rodríguez et al., 2025). The implementation of these features in the mobile app allows students to conduct self-training, record performance, and receive quality feedback even outside of face-to-face hours.

The combination of video feedback and simple analytics (e.g. playback, frame-by-frame, overlay) has been shown to improve corrective ability in motor learning. Contemporary research is also beginning to explore the integration of wearable sensors (IMUs, accelerometers) to provide quantitative metrics of motion—although their application in educational settings still requires ethical and cost reviews. The 2024–2025 articles highlight the potential synergies between video-based feedback and sensor data to provide more objective feedback, but emphasize the need for infrastructure and teacher capacity to interpret such data (Zhong et al., 2025; Trabelsi et al., 2025). In the context of M-Gym, the integration of basic video and analytics features can be a feasible starting point before adding more complex sensor elements. Recent systematic reviews and meta-analyses state that m-learning generally contributes positively to learning outcomes in higher education, but there is still little specific evidence for *skill acquisition* in courses that require fine motor or artistic skills (Naveed, 2023; Garzón, 2025). In the realm of physical education, several pilot studies and small-scale reviews show that the use of video modeling, exercise apps, and gamification increases participation, motivation, and in some cases improves technical skills (Martín-Rodríguez, 2025; Ha et al., 2024). Empirical studies in Indonesia on Android-based sports learning applications (e.g. application development for gymnastics training, school sports) reported positive results regarding validity, practicality, and initial effectiveness (Handayani, 2023; Widyatama & Pratama, 2021). Specifically for rhythmic gymnastics, the M-Gym development study by Faridah et al. (2024) showed an increase in pre-post scores and positive user responses, but the study affirmed the need for more extensive testing and more complete documentation of the R&D process to ensure generalization of results.

In learning media development research, the Borg & Gall model remains relevant as a systematic framework for

producing valid, practical, and effective products—from preliminary studies, design, limited field tests to extensive field tests and dissemination (Rohmaini et al., 2020). For the assertability of results on motor skill mastery, it is important to use validated assessment instruments (performance rubrics, observation standards, and reliable skill tests) as well as pre-post designs that are able to capture the effects of interventions. In addition to statistical analysis (e.g., paired t-test), effect size analysis and intergroup variability reports will strengthen claims of effectiveness. The combination of quantitative (performance score) and qualitative (interviews, observations, usability feedback) data will provide a comprehensive picture of the functionality and possible adoption of the product. The adoption of educational technology is also strongly influenced by the condition of the institution: the availability of connectivity, supporting policies, lecturer training, and periodic evaluation mechanisms. Review studies show that without *facilitating conditions* — technical support, pedagogical training, and curriculum integration — many technological innovations are not optimally utilized even though they are technically effective (Krokhina, 2024; Martín-Rodríguez, 2025). Therefore, research that tests M-Gym should also assess the practicality (usability), the need for lecturer training, and implementation recommendations so that large-scale adoption can occur.

Implementation of learning applications that involve student video recording, performance data storage, or potential sensor integration must pay attention to ethical and privacy aspects: participant consent, data security, and data retention policies. In addition, equality of access is a real issue: not all students have the same devices or connectivity; therefore, the solution design must consider offline options, data-saving file sizes, and alternative mechanisms for students with limited access (Martín-Rodríguez, 2025; Garzón, 2025). Based on the above theoretical studies, it can be concluded: (1) m-learning is a relevant strategy in the context of digital transformation of education, but its success depends on instructional design and institutional support; (2) motor learning theory and empirical evidence of video-based feedback support the use of video tutorial media and feedback mechanisms to improve rhythmic gymnastics skills; (3) the technology adoption model (TAM/UTAUT) provides a framework to evaluate user acceptance; (4) R&D methods (Borg & Gall) and the use of validated performance appraisal instruments are important to produce evidence of accountable effectiveness; and (5) issues of ethics, privacy, and equal access must be anticipated in the design and implementation of M-Gym. This combination of theoretical frameworks underpins a research design that not only tests changes in pre-post performance, but also practicality, product validity, and possible adoption in a college context.

Method

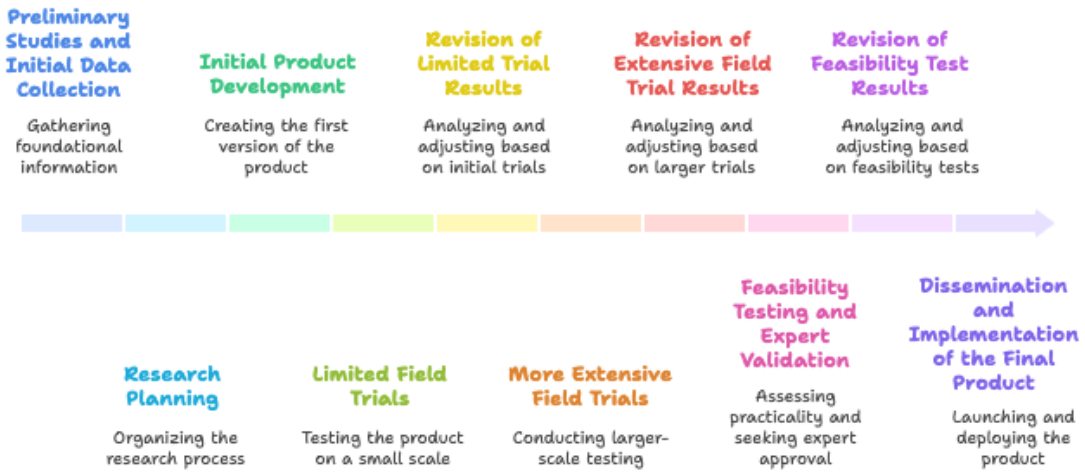
This research uses the research and development (R&D) method with the development model of Borg and Gall which has been adapted to the context of physical education. This model was chosen because it is able to produce valid, practical, and effective learning products through a series of systematic stages. The development process includes ten main stages, namely.

This model is aligned with the *Design-Based Research* (DBR) approach widely used in the development of digital learning media (Nieveen & McKenney, 2023), as it emphasizes continuous iteration between design, field tests, and empirical reflections.

In the context of this research, the product developed is in the form of M-Gym, which is an Android-based rhythmic gymnastics learning media that contains demonstration videos, theory materials, movement assessment rubrics, and interactive quizzes to help students practice independently and guided. The research aims to test the effectiveness of M-Gym in improving the rhythmic gymnastics competency of students of the Physical Education, Health, and Recreation Study Program (PJKR). The research activities were carried out for one academic semester, namely in April-September 2024, which included the initial development stage, expert validation, limited trials, extensive trials, and effectiveness evaluations.

The research were carried out at the Faculty of Sports Sciences, Universitas Negeri Medan, especially in the Physical Education, Health, and Recreation Study Program (PJKR). The selection of locations is based on:

1. the availability of *Rhythmic Gymnastics* courses as part of the compulsory curriculum,
2. the availability of sports laboratory facilities and gymnastics studios, as well as
3. readiness of lecturers and students to implement Android-based learning media.



Picture 1. Product Development Process (Rohmaini et al., 2020)

The research population is all PJKR students of Universitas Negeri Medan who took *the Rhythmic Gymnastics* course in the event semester of the 2023/2024 academic year, with a total of 115 students. The sample determination technique uses purposive sampling, because the selection of participants is based on academic criteria and readiness to follow the media trial process. The research sample was divided into three groups:

- Small class (n = 25) for limited trials,
- Large class (n = 35) for wide field trials, and
- A comparator class (n = 32) as a control group without M-Gym media treatment.

In addition to students, three lecturers in the Rhythmic Gymnastics course and two sports learning media experts were involved in the process of content validation, product feasibility tests, and media practicality assessments.

The research instrument was designed to measure three main aspects: the validity, practicality, and effectiveness of M-Gym media. The instruments used include:

1. **Expert validation sheet**

- Used to assess the suitability of the content, appearance, language, and pedagogical aspects of the media.
- The assessment was carried out by two media experts and one rhythmic gymnastics material expert using a Likert scale of 1–5 (not feasible to very feasible).

2. **Rhythmic gymnastics skill test (performance test)**
   - Measuring students' ability to perform basic movements of rhythmic gymnastics (coordination, flexibility, balance, expression).
   - The test was given twice (pretest and posttest) using a validated performance assessment rubric (Faridah et al., 2024).
3. **Student Response Questionnaire**
   - It is used to measure students' perception of ease of use, attractiveness of appearance, and benefits of media.
   - The instrument was developed based on *the Technology Acceptance Model (TAM)* indicator: *perceived usefulness* and *perceived ease of use* (Venkatesh et al., 2003).
4. **Lecturer response questionnaire (usability evaluation)**
   - Measuring the practicality, flexibility, and ease of integration of M-Gym in the learning process.
5. **Learning observation sheet**
   - Recording the learning implementation process using M-Gym, including student participation and lecturer involvement during the activity.

Research Procedure

The research steps follow the stages of the model which are adapted to the needs of digital media development:

1. *Preliminary Studies*
   - Observation of the implementation of rhythmic gymnastics learning in PJKR.
   - Interviews with lecturers and students to identify constraints, media needs, and technology usage preferences.
2. *Product Planning*
   - Formulate learning objectives, rhythmic gymnastics materials, application menu structure, and main features (demonstration videos, grade rubrics, quizzes).
3. *Initial Product Development (Prototype 1)*
   - Design application interface (UI/UX), input materials and videos of rhythmic gymnastics movements according to the course syllabus.
4. *Small Group Trial*
   - Involving 25 students and two teaching lecturers.
   - Measure the validity of content and gather initial feedback.
5. *Phase I Product Revision*
   - Improvements are made based on the advice of media experts, subject matter experts, and limited test results (e.g. on video clarity or navigation menus).
6. *Large Group Trial*

- Applied to 35 students in the next semester.
- Measure the initial effectiveness and response of students to the media.

7. *Effectiveness Test (Pretest–Posttest Design)*
    - Using a pretest-posttest one group design with a control group to compare competency changes before and after M-Gym use.
8. *Data Analysis and Final Validation*
    - The data of pretest, posttest, and questionnaire results are processed and analyzed to draw conclusions about the validity, practicality, and effectiveness of the product.

Data is collected through several methods:

- Skill test (performance test): to obtain quantitative data on students' rhythmic gymnastics skills before and after the use of media.
- Direct observation: to record student learning behavior, participation, and interaction during learning using M-Gym.
- Semi-structured interviews: with lecturers and media experts to gain an in-depth view of the feasibility and practicality of the media.
- Closed-ended and open-ended questionnaires: to obtain students' responses to the media and their learning experiences.

All data collection processes are carried out with due regard to research ethics: participant consent, confidentiality of identity, and the use of data only for academic purposes.

The data from the validation results of media experts and subject matter experts were analyzed quantitatively using the formula Interpretation criteria:

- 81–100% = Very Worthy
- 61–80% = Eligible
- 41–60% = Fairly Decent
- 21–40% = Less Eligible
- ≤20% = Not Eligible

The results of the questionnaire responses of lecturers and students were analyzed using descriptive statistics (percentage and average score). An average score of ≥ 80% indicates that the medium is practical to use. The effectiveness of M-Gym was tested using a pretest–posttest design. The data was analyzed with:

1. Normality and homogeneity tests to ensure parametric test requirements are met.
2. Paired sample t-test to find out the significant difference between pretest and posttest scores in the experimental group.
3. Independent t-test to compare the results of the experimental group and the control group.

Decision-making criteria:

- If the p value < 0.05, then there is a significant difference and the media is declared effective in

improving rhythmic gymnastics skills.

Data from observations, interviews, and open comments from respondents were analyzed thematically (thematic analysis) to strengthen the quantitative results and identify the strengths and weaknesses of the M-Gym media.

M-Gym media is declared successful and suitable for use if it meets three criteria:

1. High validity (≥ 80%) based on expert judgment,
2. The high practicality of the results of the lecturer and student questionnaires, and
3. Significant effectiveness ($p < 0.05$) on improving students' rhythmic gymnastics skill scores.

This research upholds the ethical principles of educational research. All respondents signed informed *consent* before participating, and all data was collected anonymously. There are no activities that pose physical or psychological risks to participants, because all rhythmic gymnastics exercises are carried out under the supervision of lecturers and assistant instructors.

Results

This research aims to develop and test the effectiveness of M-Gym, an Android-based learning media to improve the rhythmic gymnastics competency of students of the Physical Education, Health, and Recreation Study Program (PJKR) of the Universitas Negeri Medan. The results of the study are presented following the stages of the model, including: preliminary study, initial product development, limited trial, phase I revision, broad field trial, expert validation, effectiveness test, and final evaluation. The initial stage of the research was carried out through field observation and semi-structured interviews with lecturers and students of *the Rhythmic Gymnastics* course.
From the results of observations of three classes totaling 115 students, several main problems were found:

- As many as 72% of students stated that it was difficult to understand the basic techniques of movement due to the limitations of direct demonstrations.
- 65% of lecturers said that there was not enough practice time to provide individual feedback.
- 80% of students hope that there is digital media that can help them practice independently outside of lecture hours.

In addition, the documentation shows that only 30% of students are able to display rhythmic gymnastics movements with good coordination and rhythm based on the course assessment rubric. These findings reinforce the need for interactive and flexible mobile learning media capable of providing visual demonstrations and structured exercises — thus underpinning the development of M-Gym as a digital learning solution in the field of sports.

Initial Product Development (Prototype 1)

Based on the identified needs, the researchers developed an initial prototype of the M-Gym app using the Android operating system. Key features developed include:

1. Basic and advanced movement tutorial videos (coordination, flexibility, flexibility, and balance).
2. Movement theory and evaluation guide (visual assessment rubric).
3. Interactive quizzes and self-reflection to measure understanding of rhythmic gymnastics concepts.
4. A self-practice mode menu that allows students to watch and imitate movements repeatedly.

The app is tested on a variety of devices (Android 10–13) and is designed using the Java programming language with a simple interface to make it easy for students to access.

Small Group Trial

The limited trial involved 25 students and two lecturers teaching the Rhythmic Gymnastics course. The data collected included expert validation, observations, and student response questionnaires.

Expert Validation Results

Three experts (two media members and one material expert) provide an assessment of the feasibility aspects of the content, appearance, and functionality of the media. The following table 1 presents the validation results:

Table 1. The Validation Results

Aspects Assessed	Average Score	Percentage	Category
Content Eligibility	4.70	94%	Highly Worth It
Display and Navigation	4.55	91%	Highly Worth It
Language and Instructions	4.40	88%	Proper
Curriculum Fit	4.75	95%	Highly Worth It
Total Average	4.60	92%	Highly Worth It

Experts consider M-Gym to be in accordance with learning needs and has high relevance to course learning outcomes (CPL). Recommendations for revision at this stage include:

- Add voice over narration for each motion video.
- Include an assessment rubric in an interactive form.

The revision was carried out before the extensive field test stage.

Large Group Trial

The extensive field test stage was carried out to 35 students and one teaching lecturer using a revised version of M-Gym (Prototype 2). This activity lasts for 6 weeks (April–May 2024) and includes:

- Provision of pretest rhythmic gymnastics skills,
- Learning to use M-Gym for 4 meetings,

- Posttest, and
- Filling out a user response questionnaire.

Rhythmic Gymnastics Skill Test Results

The following table provides the results of the comparison of pretest and posttest scores:

Table 2. The Results of the Comparison of Pretest and Posttest Scores

Statistics	Pretest	Posttest
Number of Participants (n)	35	35
Average Score	43.12	67.45
Minimum Score	27	58
Maximum Value	64	75
Standard Deviation	8.15	4.02

Analysis using a paired sample t-test yielded:

- t_hitung = 18,478
- p-value = 0.000 (< 0.05)

These results show that there is a significant difference between the ability before and after learning using M-Gym. Thus, M-Gym is effective in improving students' rhythmic gymnastics competencies.

Student Response to the Use of M-Gym

The results of the questionnaire given to 80 students from two stages of the trial (small and large) showed a high level of acceptance and satisfaction.

Table 3. Student Responses

Assessment Criteria	Frequency	Percentage (%)
Excellent	50	62.5
Good	29	36.25
Enough	1	1.25
Less	0	0
Total	80	100

Most students find the M-Gym app attractive, easy to use, and helpful in understanding rhythmic gymnastics movements. The students' open comments show their appreciation for the demonstration video and self-practice features that can be accessed at any time.

Lecturers' Responses to Media Practicality

Three lecturers of the rhythmic gymnastics course were asked to fill out a questionnaire on the practicality of using M-Gym (see Table 4).

Table 4. The Results of the Assessment

Assessment Indicators	Lecturer 1	Lecturer 2	Lecturer 3	Average (%)
Ease of Use	3	3	3	100
Supporting Learning	3	3	3	100
Flexibility in Use	2	3	3	93
Solving Learning Problems	3	3	2	93
Increase student engagement	3	3	3	100
Total Average	—	—	—	96% (Very Practical)

The lecturer stated that M-Gym simplifies the teaching process because it is able to display movement examples accurately, save demonstration time, and increase student participation.

Effectiveness Tests and Intergroup Comparisons

To ensure the effectiveness of the media, a comparison was made between the experimental group and the control group (without the use of M-Gym) (see Table 5).

Table 5. Effectiveness Tests and Intergroup Comparisons

Group	Quantity (n)	Average Pretest	Posttest Average	Increase (%)	p-value
Experiment (M-Gym)	35	43.12	67.45	+56.5	0.000
Control (Conventional)	32	42.98	49.65	+15.5	0.042

The results showed that the average increase in the value of the experimental group was significantly higher ($p < 0.001$) than that of the control group. Thus, the use of M-Gym has been proven to be more effective than conventional methods in improving the competency of students' rhythmic gymnastics skills.

Qualitative Analysis (Observation and Interview)

Thematic analysis of the results of observations and interviews with lecturers and students revealed several important findings:

- Students are more enthusiastic about practicing because they can play back videos as needed.
- Understanding of rhythm concepts and coordination is improved thanks to direct visualization.
- Students show improved flexibility, coordination, and balance after self-training with the app.
- Students feel more confident and brave to appear in the final assessment.

The lecturer emphasized that the integration of mobile technology through M-Gym helps them manage large classes efficiently, without compromising the quality of technical guidance.

Validity, Practicality, and Effectiveness of the Final Product

Based on the overall test results, M-Gym meets three main success criteria. (see Table 6).

Table 6. Validity, Practicality, and Effectiveness of the Final Product

Criterion	Indicators	Average Score	Category
Validity	Media and Material Expert Ratings	92%	Highly Valid
Practicality	Lecturer and Student Responses	96%	Very Practical
Effectiveness	Improvement of Student Competency ($p < 0.05$)	56.5%	Highly Effective

This, M-Gym is declared feasible and effective to be used as a digital learning medium in the Rhythmic Gymnastics course. Based on user feedback and final validation, minor revisions were made on:

1. Added a *progress tracking feature* so that students can monitor the development of their abilities.
2. Color and layout adjustments to be more friendly to various sizes of smartphone screens.

The final product of M-Gym version 3.0 was then disseminated on a limited basis to PJKR UNIMED lecturers and tested for integration in blended learning in the next semester.

Discussion

The results of the study show that Android-based M-Gym learning media has proven to be valid, practical, and effective in improving the rhythmic gymnastics competency of students of the Physical Education, Health, and Recreation Study Program (PJKR) of the Universitas Negeri Medan. This finding was shown through an increase in the average student score from 43.12 to 67.45 with a significance of $p < 0.001$, as well as a very positive response from lecturers and students to the convenience and usefulness of the media. The success of M-Gym not only reflects the effectiveness of digital media in the context of learning motor skills, but also shows that digital transformation in physical education can enhance students' learning experience if designed with the right pedagogic approach. According to Mishra & Koehler (2006) in the *Technological Pedagogical Content*

Knowledge (TPACK) model, the effectiveness of digital media depends on the integration between content, pedagogy, and technology. In this context, M-Gym has combined rhythmic gymnastics content (content knowledge), exercise-based learning strategies (pedagogical knowledge), and interactive mobile technology (technological knowledge), thus supporting the creation of a holistic learning environment.

A significant increase in students' skill scores shows that M-Gym is effective as a mobile-based learning medium that can strengthen the learning process of rhythmic gymnastics. These results are in line with Purnomo's (2019) research which found that the use of Android-based *mobile learning* is able to improve student learning outcomes because it provides flexible learning access and is based on individual needs. Similar findings were also revealed by Widyatama and Pratama (2021) in their research on *the PINTHIR* application for mathematics, which proves that *mobile-based learning* can increase student independence and engagement. In the international context, Cai et al. (2022) emphasized that mobile-based learning in the field of physical education has a positive impact on increasing participation, motivation, and understanding of motor concepts. Research by Yilmaz & Baydas (2020) also found that *mobile learning* helps physical education students develop psychomotor skills through interactive video access and visual feedback. Theoretically, the success of M-Gym can be explained through the Multimedia Learning theory by Mayer (2021) which states that the integration of text, images, and interactive video can improve cognitive processes because it utilizes dual channels (verbal and visual). Through M-Gym, students not only read theory, but also see and imitate correct rhythmic movements, thus strengthening *visual memory* and motor coordination.

Media experts and subject matter experts' assessments of M-Gym showed a validity rate of 92%, while lecturers' responses to practicality reached 96%. This figure shows that the product developed has met the pedagogical, technological, and aesthetic feasibility criteria. The validity of learning media includes the suitability of content, appearance, and ease of use. All three aspects have been fulfilled in M-Gym through an iterative process of expert validation and product revision. The high practicality of media is also in line with the results of Khomarudin and Efriyanti's (2023) research which shows that *Android-based mobile learning* has high practicality (>90%) in artificial intelligence learning in universities. In the context of physical education, García-González et al. (2023) emphasized that digital media that has an interactive and easy-to-use display can increase student participation, especially in motor skills-based exercises. Similar results were found by Bourke & Doherty (2021) who stated that *mobile PE learning* applications are able to support lecturers in managing large classes while maintaining the quality of individual learning. Thus, M-Gym meets not only the formal validity aspect but also the implemented practicality, which makes it worth using on an ongoing basis in the physical education digital curriculum.

In physical education learning, learning outcomes include not only cognitive aspects, but also affective and psychomotor aspects. The results of observations and interviews in this study show that M-Gym has a positive impact on these three domains. Students understand the basic theories of rhythmic gymnastics such as rhythm, coordination, and balance better because they can access interactive videos and quizzes. This supports the theory of the Cognitive Theory of Multimedia Learning (Mayer, 2021) that movement visualization helps the mental formation of strong models. Most college students report increased interest and motivation to learn. This result

is in line with the research of Deci & Ryan (2020) through *Self-Determination Theory* which explains that learning autonomy through digital media increases students' intrinsic motivation. The improvement in motor skills was evident from the difference in pretest and posttest scores ($p < 0.001$). This supports the *Motor Learning theory* by Schmidt & Lee (2019) that repetition and visual feedback play an important role in the formation of movement skills. Thus, the use of M-Gym provides a *whole learning experience* through the integration of three learning domains.

This study continues the previous findings with a specific focus on rhythmic gymnastics, which has not been widely studied in the context of *mobile learning*. Purnomo (2019) and Khomarudin and Efriyanti (2023) examined mobile learning for the cognitive field (language and AI), while this study combines cognitive and psychomotor domains. While García-González et al. (2023) in an international study on sports students in Spain found that the use of the *FitClass* application increased exercise participation by 40%, the results of this study confirm that the use of digital media not only increases participation, but also motor competence significantly. The results of this study also confirm the view of Casey et al. (2022) that *mobile technologies* can function as *mediated scaffolding* in physical education, which is to help students understand, practice, and assess movements with virtual guidance. Methodologically, the Borg & Gall R&D approach used has been proven to be effective in producing innovative learning products, as demonstrated by Rohmaini et al. (2020) on the development of interactive video-based media in basic sports courses. By adapting to the digital context, this research strengthens the position of the model in the realm of technology-based media development in modern physical education.

Digital transformation in physical education is one of the strategic directions of higher education in Indonesia, as stated in Permendikbudristek No. 53 of 2023 concerning Quality Assurance of Higher Education and is in line with the *Independent Learning – Independent Campus (MBKM)* agenda. The results of this study show that the use of digital media such as M-Gym is not only in line with this policy, but also supports the achievement of Graduate Learning Outcomes (CPL), especially in the aspects of practical skills and mastery of learning technology. In addition, these results reinforce the findings of Yildirim et al. (2021) who affirm that *digital transformation in physical education* allows for a more personalized, adaptive, and inclusive learning process. Through M-Gym, students can learn anywhere and anytime, according to the principle *of ubiquitous learning (u-learning).* Institutionally, these results show the importance of university support in providing digital infrastructure, lecturer training, and integration of learning applications in the university*'s Learning Management System (LMS)* to strengthen the digital learning ecosystem in the field of sports.

In addition, this research also opens up opportunities for further innovation, such as the development *of augmented reality (AR)* features or *AI-based motion feedback* to provide automatic correction of student movements. Globally, this research contributes to the literature on mobile learning in physical education, which is still relatively limited compared to other fields such as STEM or languages. These findings confirm that the use of digital technology is not just a trend, but part of a global pedagogic transformation oriented towards *active learning* and *student empowerment*. A study by Casey, Goodyear & Armour (2023) highlights the importance of *digital pedagogies* in sports to develop 21st-century skills such as collaboration, reflection, and independent decision-making. This research strengthens these findings with empirical evidence from the Indonesian context,

where M-Gym has succeeded in facilitating motor skills while increasing students' learning independence. In addition, this research has the potential to support Sustainable Development Goals (SDGs) number 4, namely *Quality Education*, by utilizing technology to equalize access to quality learning in the fields of sports and health.

Conclusion

The results of this study conclude that Android-based M-Gym learning media has proven to be valid, practical, and effective in improving the rhythmic gymnastics competency of students of the Physical Education, Health, and Recreation Study Program, Universitas Negeri Medan. The validity of the media reached 92% (very feasible category) based on the assessment of material and media experts, while the level of practicality obtained an average of 96% from the lecturer's assessment and student responses which showed that 62.5% gave a very good assessment of the ease and attractiveness of the application. In terms of effectiveness, the results of the test $t = 18.478$ with $p < 0.001$ showed a significant increase in the average score of students from 43.12 in the pretest to 67.45 in the posttest after using M-Gym. In addition to improving psychomotor skills, the use of M-Gym also has a positive impact on learning motivation, exercise independence, and active participation of students in learning rhythmic gymnastics. Overall, M-Gym media is declared worthy of being a digital learning innovation that supports the digital transformation of physical education, because it is able to facilitate interactive, flexible, and student-centered learning in accordance with the demands of the 21st century learning era.

Recommendations

Based on the research findings indicating that the M-Gym Android-based learning media proved valid (92%), practical (96%), and effective ($p < 0.001$) in improving students' rhythmic gymnastics competence, several recommendations are proposed for further development. First, for higher education institutions, it is recommended that M-Gym be systematically integrated into physical education curricula as part of the digital transformation strategy in line with Ministerial Regulation No. 53 of 2023 on Quality Assurance in Higher Education. This integration will strengthen the implementation of interactive, flexible, and student-centered digital learning environments. Second, for lecturers and physical education practitioners, this study recommends the use of M-Gym as an innovative alternative to overcome the limited time available for practical sessions and to enhance students' opportunities for independent training. Lecturers are encouraged to adapt this model to other subjects, such as floor gymnastics, fitness training, or team sports, using mobile learning approaches and student-centered pedagogies. Third, for researchers and educational technology developers, M-Gym can be further enhanced by incorporating advanced features such as *augmented reality (AR)*, *motion feedback systems*, and *AI-based coaching* to provide real-time corrections and personalized movement analysis, thereby improving the precision and effectiveness of motor skill learning. Fourth, for future researchers, it is recommended to expand the study population and context to multiple universities and conduct longitudinal studies to evaluate long-term skill retention and the sustained impact of digital media on students' motivation and performance. Overall, this research highlights the importance of collaboration among lecturers, students, and technology developers in creating an innovative, adaptive, and sustainable digital learning ecosystem for physical education, supporting the ongoing transformation of higher education in the digital era.

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