ORIGINAL ARTICLE

Smart physical education: Integrating flipped classroom with IoT and android for enhanced learning

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ABSTRACT

This study aims to develop and test the effectiveness of Internet of Things (IoT) and Android-based applications in flipped classroom for physical education in elementary schools. This technology is expected to improve students' basic movement skills, physical abilities, interactive skills, behaviour, self-confidence, and preschool perspective. This study uses Borg and Gall research and development (R&D) methods with two main objectives, namely product development and effectiveness testing. The sample consisted of 197 students in Grades 4, 5, and 6 who had previously been tested for digital literacy. Validation is carried out by two experts in the field of credible materials and media, consisting of lecturers and software developers. The validation results show this app gets an assessment of "*very good*" from material experts and "*good*" from media experts. Trials on students and teachers showed "*very good*" results in the display, content and learning aspects. Effectiveness testing using an Independent t-test showed significant improvements in students' Pulse and cognitive variables. In conclusion, This IoT and Android application is valid and effective in flipped classroom, improving material access, interaction, collaboration, and objective assessment. Further research is suggested to compare the effectiveness of learning between IoT-based flipped classroom and Android with traditional methods or flipped classroom without additional technology.

Keywords: Physical education, Flipped classroom, Internet of things, Android.

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INTRODUCTION

Physical education today faces two main problems. One of them is the limited interaction between students and teachers, because in many colleges and universities, this course is usually only held once a week, so the opportunity to communicate and interact directly is very limited. (Hernández et al., 2019; Vagle et al., 2023). Flipped learning has been trending in recent years, but there is a lack of research in physical education that integrates this system. Yet results have shown a positive impact on motivation, learning and motor skill development (Osterlie et al., 2023; Østerlie et al., 2023; Aliriad et al., 2024). The model consists of analysis, design, development, implementation and evaluation stages, with a focus on learner analysis, curriculum analysis, cooperative instructional design and physical activity support strategies (Yip et al., 2023). Research on the design and implementation of digital and in-class instructional components is needed to guide best practices (Zhu et al., 2023). In the classroom, students and teachers use more forms of communication and discussion. Students learn on their own through teaching resources designed and planned by teachers, such as teaching videos, micro-classes, and open online courses.

The Internet of Things-based technology acceptance learning management framework in physical education helps set clear goals, organize resource allocation, and carry out effective team management (Che et al., 2023). IoT technology and physical education can also help improve students' basic movement skills, physical abilities, interactive skills, behaviour, self-confidence, and preschool perspectives (Lei et al., 2021). IoT in physical education can improve knowledge and performance, optimizing the learning process.

Android-based tools have been developed to help physical education teachers collect data on students' skills related to physical fitness (Santoso et al., 2023). Students have shown positive perceptions of using Android-based learning media in physical education, with familiarity and using videos and images for learning purposes (Haryanti et al., 2021) various diversity of benefits of applying Android in learning.

Indonesia has a diverse signal distribution. However, teachers must remain integrated with technology. The use of the internet integrated with Android is rare in Indonesia. Internet is accessed with an easy signal, and the Android system places with limited signals. In 2022 and 2023, researchers produced a needs analysis of internet and intranet "*fusion*" in physical education learning. This research aims to overcome the weaknesses of the internet with the Android system and vice versa *(reciprocal).*

Some limitations of previous research (Martin et al., 2015) were the limited assessment resources available to physical educators and the difficulty in constructing creative assessments due to program and curriculum variations. Assessments can only be accessed when the signal is stable. (Chen & Dong, 2022) need for clarity in evaluation objectives, indices, and content. There needs to be more diversity and authority in evaluation methods and results, which will be refined in this study. (Sigit et al., 2022) Quota and signal quality are expensive, using an Android base, and the price is costly, as well as internal factors such as student motivation and learning environment—lack of transfer between learning and actual teaching situations (Slingerland & Weeldenburg, 2019). Assessments at lower levels of Miller's pyramid have higher reliability but lower validity. Some of the studies above used a single medium. The learning media was tested on conventional learning. No press or multimedia has been tested on flipped learning. Some studies found some obstacles, such as culture, sample, assessment, and evaluation of learning. This research is novel, namely the use of two media fused into one: the Internet of Things and Android. Then, the effectiveness trial will be carried out on learning set up by Flipped Learning.

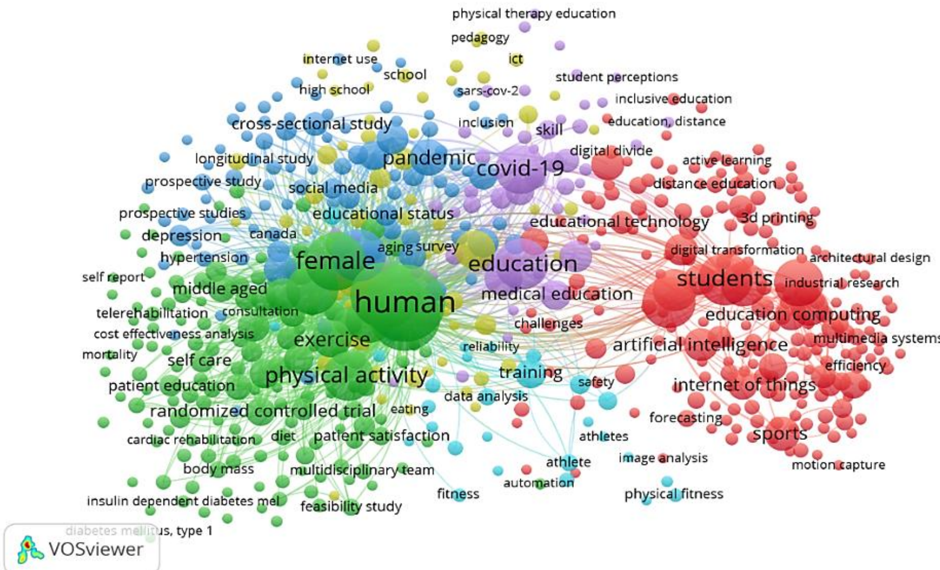

Figure 1. Bibliometric research topics supporting *State Of The Art.*

The researcher strengthened the novelty by analysing research on Scopus, as many as 1000 articles, to find research trends that are often researched. The keyword typed is physical education technology. Researchers analysed from 2021-present. Internet use, the digital divide, educational technology, multimedia systems, the internet of things, flipped learning, and Android base are minimally researched topics in physical education research. This research is expected to pioneer the effectiveness of using two media in a flipped learning class.

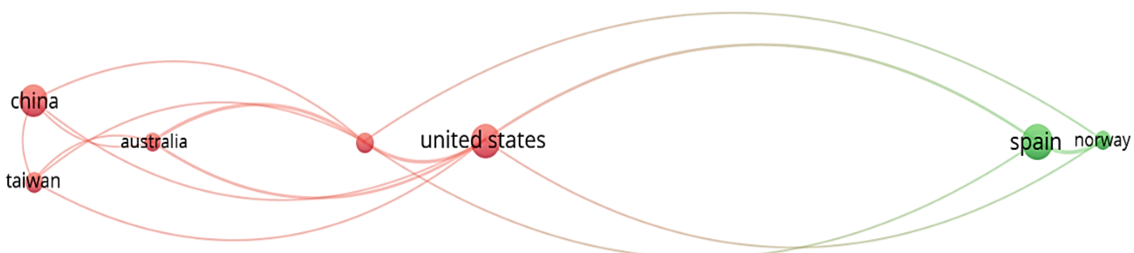

Figure 2. Distribution of researcher countries.

The author then analysed the Scopus database with the keyword flipped learning in physical education learning. It was found that countries that often research this are America, Spain, Taiwan, Australia, and China. Meanwhile, Indonesia rarely carries out this research. This research aims to produce IoT and Android products through developing, validating, and pilot testing flipped learning in physical education.

This study offers novelty by integrating the flipped classroom model into physical education, which has not been widely applied in this context. The main innovation lies in the use of Internet of Things (IoT) technology to collect student performance data through wearable devices, as well as the development of an Android application to support learning and data management. The research process also includes validation and pilot study stages, ensuring that the approach is not only theoretically designed but also empirically tested for effectiveness and practical implementation in the physical education context.

METHODS

Research design

The sample of this study amounted to 197 elementary school students. The samples selected were grades 4, 5, and 6. Teachers tested in advance regarding "*digital literacy*". The research and development procedure consists of two main objectives, namely: (1) product development and (2) testing the effectiveness of the product in achieving the objectives. This development model is descriptive because the procedures used describe the steps and are used to make the software product "*amongrogo*."

Collection of research instruments

This product consists of two main developments, namely the Internet and Android, which are united in one whole. The first stage in this development is a needs analysis, which begins with a survey of Physical Education (PE) learning through several questions related to the learning process and the interest of teachers and students in applications that can facilitate learning. At this stage, an analysis of the use of gadgets by teachers and students was also carried out, as well as an analysis of literature from reliable sources such as Scopus, WoS, and Sinta. Furthermore, an assessment of the problems faced, early product development in the form of learning media applications, analysis of product objectives and characteristics, identification of content sources for product design, and setting the stages of product manufacture.

The next stage is Software Planning and design, where we design and determine the classification of the results of the needs analysis, including the layout and appearance of the application. The results of these steps are consulted with physical education experts and media or informatics engineering experts to ensure the development of coding applications according to user criteria. After the planning and design is completed, validation is carried out by media and material experts who have credibility in their fields, involving two experts, namely lecturers and software developers.

After validation, field trials are conducted aimed at getting feedback and revising the product. These trials were conducted on a small and large scale, where the small-scale trial involved two classes of Upper Primary School students, while the large-scale trial was conducted in eight classes of four primary schools. The subjects involved in this trial were teachers and students. After the trial process, revisions are made based on expert input as well as test results to improve product quality before widespread use. The final stage of this development is the refinement of the product into an application based on the Internet of Things and Android, which will be equipped with a manual for users. Features that will be embedded in the application.

The output of earlier research, which was restricted to material, was the creation of websites. The website's features will be improved in the next research phase with the addition of random pre-test and post-test questions as well as a separate teacher menu to better control learning in the cognitive, affective, and psychomotor domains. Attendance and presence throughout. The Android application has intranet features for each of these aspects. All of these activities will be put to the test on "*Flipped Learning*" in this study.

Design and implementation of a "*amongrogo*"-integrated, flipped classroom teaching model for physical education. When it comes to teaching design, having standardized, well-defined learning objectives has a direct impact on whether or not the lessons are being taught correctly. In order for students to self-learn in accordance with the goals before learning, correct deviations during the learning process, and conduct self-evaluation regarding the goals after learning, it can guide them step-by-step to the depth of their learning and clarify the level they want to reach. Second, in order to prevent vagueness and abstraction—which will make the objectives hard for students to understand—objectives should be clear, actionable, and measurable. There are three sections to this flipped learning framework: pre-class, in-class, and post-class.

In the pre-class phase, the students are grouped into small groups based on their real-world circumstances, and the expected learning goals are established for each group. In accordance with the syllabus, the physical education teacher gathers teaching videos—brief films lasting three to five minutes—pictures, teaching materials, and documents on the subject matter and uploads them to "*amongrogo*." While teachers post pertinent questions on the platform and permit students to participate in online discussions in groups, students download the instructional and learning materials on their own. The instructor employs various types of "*questions*" throughout the discussion to enable students to interact online in accordance with the questioning principle. Questions help students think more deeply and develop their understanding of autonomous learning as well as their profound learning ability.

During the in-class phase, students log in after the teacher releases the sign-in via the learning platform. Greetings, announcements of the course objectives and teaching material, and trainee organization are all done by teachers and students. By asking questions about teaching resources or observing how students complete the teacher-created quiz, the platform can assess students' independent learning before class.

The teacher gave clear and precise explanations for the students' collective concerns, and the three groups learned about the issues and uncertainties they had identified. Subsequently, the instructor assigns students to complete warm-up exercises (encompassing both general and sport-specific warm-ups) in physical education class. Following this, representatives from each group are sent to provide an overview of the preclass preview's contents. While other students assess, the teacher only provides guidance and a comprehensive explanation of a portion of the knowledge points. The most crucial aspects of this process are encouraging students to learn actively, helping them to understand key concepts and challenges, and helping them to solidify their knowledge understanding. Following that, students study in groups where team members practice independently and have discussions about the material being covered. Group cooperative learning creates a positive learning environment and helps students identify and resolve issues. In real instruction, the instructor guides, poses questions for the class to respond to, and assists the learners in developing their critical thinking skills.

At the conclusion of the lesson, the instructor sets up activities or games that help students get in better physical shape. Some of these activities include sit-ups, agility games, and re-entry running. We can engage in some relaxing activities after that. Together, the teachers and students will describe the current state of the class, assess if the expected teaching goals have been met, and use feedback to further refine the goals for the following session. The notice of the class's departure is then given.

During the post-class period, the instructor provides open-ended assignments to the students, to which there is no right or wrong response. Pupils analyse the assigned material in-depth on their own, absorb the new information, and ultimately develop higher-order thinking abilities.

Data analysis

The data were processed using descriptive statistics. To complete this study, the researcher also measured the differences in students' pulse rate and cognitive aspects. The data analysed is data that passes the normality and homogeneity test. The average and standard deviation values for each are calculated using SPSS 24. On the pulse and cognitive variables, were tested using the independent sample t-test.

RESULTS

Before being tested, the application was validated by two experts. The experts are materials expert and media expert.

Table 1. Research development validation.

Variable	Average	St. Deviation	Min.	Max.	Conclusion
Materials expert	4.4	0.17	4.2	4.6	Very good
Media expert	4.1	0.20	4.0	4.5	Good

Source: Developed by author (2024).

Material experts assessed the learning aspects and content aspects. Meanwhile, media experts assessed the appearance and programming aspects. Before the average material experts and media experts provide suggestions for improvement for the perfection of the products developed. The conclusion from the materials expert is "*very good*", while the media expert is "*good*". A "*very good*" rating from a material expert relates to innovation or very adequate quality in learning, while a "*good*" rating from a media expert may indicate there is room for improvement in aspects of communication or information delivery.

Table 2. Pilot testing.

Variable	Average	St. Deviation	Min.	Max.	Conclusion
Student	4.5	0.31	4.1	5.0	Very good
Teacher	4.6	0.32	4.3	5.0	Very good

Source: Developed by author (2024).

Small-scale students tested in one school and large-scale in four schools assessed based on appearance, content and learning aspects. Meanwhile, teachers assessed based on appearance, content and learning aspects. Based on the results of the trial on students and teachers, the results were "*very good*".

Table 3. Description of student pulse rate and cognitive.

Variable		Average	Min.	Max.	SD	Sig. 2-tailed
Pulse	Pulse before	78.4	60	96	8.1	.000
	Pulse after	145.4	115	180	16.5	
Cognitive	Pre-test	57	40	70	2.1	.004
	Post-test	90	70	100	1.8	

Source: Developed by author (2024).

In flipped learning, the teacher has provided the material in advance before learning. The teacher's task during face-to-face is to be a controller. Our trial was conducted on the effectiveness of increasing heart rate and cognitive. In the pulse, students measured by holding their wrists with 30 seconds of calculation. In cognitive, students worked on questions online with 10 questions related to physical education learning. We conducted this trial before and after activities. The statistical results show that there was a significant increase in both components.

DISCUSSION

Based on the results of research that has passed validity tests, pilot testing and effectiveness tests in a flipped classroom environment, several things can be discussed. Flipped classrooms supported by the Internet of Things (IoT) and Android can provide some significant advantages in physical education learning, including:

1. Accessibility of Learning Materials: With the flipped classroom approach, learning materials such as videos, articles, or modules can be accessed online through the Android platform. IoT can extend this access by providing stable and fast internet access in various environments, allowing students to study materials anytime and anywhere.
2. Enhanced Interaction: Through IoT, for example, with motion sensors or wearable devices, teachers can track students' physical activity during practice or physical activity. The data obtained from these IoT devices can help teachers provide more targeted and personalized student feedback and monitor their progress in real-time.
3. Experiential Learning: The integration of IoT in physical education can provide a more immersive and real-world learning experience. For example, using IoT devices to measure physical parameters during training or competition, such as heart rate, pace, or movement intensity, can help students understand the impact of training on their health and performance.
4. Enhanced Collaboration and Communication: The Android platform and IoT-related apps can facilitate collaboration between students and teachers. For example, students can communicate with their teachers directly through the app to discuss learning objectives or get additional guidance.
5. More Objective Assessment: With the data obtained from IoT devices, teachers can objectively evaluate students' physical progress and performance in various aspects of physical education. It can help in decision-making related to lesson planning and developing more focused training programs.

The simulation method of the proposed framework shows that the wearable technology AI-based Internet of Things system (AI-IoTS) enables students to train themselves without the assistance of physical education teachers (Wang, 2022). Internet of Things (IoT) technology and 5G networks enable long-term data collection, real-time monitoring, and improved data transmission efficiency in physical education (Yao et al., 2021). This technology enhances engagement and motivation through gamification and progress tracking, while also improving management and evaluation by recording historical data for in-depth analysis. Additionally, IoT contributes to health and safety by offering health alerts and enabling remote monitoring. The integration of devices and applications into a unified platform also enhances collaboration and communication between students, teachers, and coaches.

Android applications increase student achievement and effectiveness in teaching and learning (Zuhdi & Sukarmin, 2021). Students positively affect learning media based on Android in physical education, with 80% positively affecting it (Haryanti et al., 2021). Using tablets to investigate motion leads to a significant reduction of extraneous cognitive load and greater conceptual knowledge in physical education learning (Becker et al., 2020). Android-based tools can help teachers collect student skills related to physical fitness quickly, effectively, and efficiently (Santoso et al., 2023). Android technology enhances physical education by providing versatile tools that streamline and enrich the learning experience. Through educational apps, students can access instructional videos anytime and boosting engagement and motivation. Android devices also support interactive and multimedia lessons, making fitness education more dynamic. Additionally, data collection and analysis from these devices enable personalized training programs and insights into physical progress. Improved communication through messaging apps and online platforms further supports collaboration between students, teachers, and parents, making physical education more accessible and effective.

Flipped learning has positively impacted affective factors, creating a learning environment that fosters positive emotional dispositions and viewing mathematics as applicable (Lazzari, 2023). In beauty education, flipped learning classes have demonstrated higher learning motivation, immersion, and satisfaction than traditional educational methods (Ying & Thompson, 2020). In addition, flip learning based on reverse design has been proven effective in developing permanent understanding and improving students' competence and academic achievement (Joo & Park, 2023). Flipped learning has several benefits in learning. Allows for a flexible learning environment where students can learn at their own pace and participate in activities inside and outside the classroom, leading to increased learning opportunities and achievement (Zhou, 2022). Flipped learning also stimulates student motivation and increases physical activity levels, reducing sedentary behaviour (Yip et al., 2023). Overall, flip learning offers benefits such as increased engagement, motivation, and achievement, as well as increased affective factors and satisfaction in various educational contexts. Flipped learning enhances physical education by reversing the traditional classroom model, allowing students to engage with instructional content outside of class through videos and online resources. This approach maximizes class time for active participation and hands-on activities, as students arrive prepared with foundational knowledge. In PE, this means that theoretical aspects of fitness, nutrition, and sports techniques can be learned at home, while class time is dedicated to practicing skills, receiving personalized coaching, and applying concepts in real-life scenarios. This method fosters deeper understanding, increases student engagement, and enables more individualized attention, leading to a more effective and interactive learning experience.

Flipped learning in PE classes leads to 55% more class time in moderate-to-vigorous physical activity (MVPA) than traditional instruction (Killian et al., 2022). Applying deep learning in flipped classroom design improves students' interest in learning, learning efficiency, and autonomous learning ability in physical education (Huang & Yu, 2022). Maximizing students' time in active physical activity is essential in physical education. Using flipped learning, students can learn concepts, techniques, and strategies at home through videos or reading materials to allocate class time to physical activity fully. It allows students to move more and practice the skills they are learning.

In this study, it was found that students' pulse rate and cognitive abilities increased during learning. The flipped classroom method significantly boosts student engagement in PE, as evidenced by higher levels of emotional, cognitive, and behavioural engagement compared to traditional methods (Wibowo et al., 2024). Enhanced engagement can lead to increased physical activity, which is likely to affect heart rates positively during exercise sessions (Li, 2024). The combination of flipped classrooms and technology not only improves physical fitness but also enhances enjoyment in PE, which can indirectly influence heart rate responses during activities. By combining a flipped classroom model with Internet of Things (IoT) devices and Android applications, the study aims to enhance cognitive engagement and understanding of PE concepts while also monitoring and potentially improving heart rate responses during physical activities. The integration of these technologies is expected to provide a more personalized learning experience, improve students' motivation and focus, and potentially lead to better physical performance and cardiovascular health by closely tracking and adapting to individual physiological data.

CONCLUSIONS

Internet of Things (IoT) and Android fusion products with android are valid and effective for elementary school teachers and students in flipped classrooms. The product is in the form of a website, an android application, and a user manual. Flipped classrooms supported by the Internet of Things (IoT) and Android have significant advantages in physical education learning, accessibility of learning materials, pulse, cognitive, enhanced interaction, experiential learning, collaboration and communication, and more objective assessment. By utilizing the benefits of flipped learning, physical education teachers can create a more dynamic, engaged, and relevant learning experience for their students, improving their concept understanding, physical skills, and motivation. Future research recommendations include an experimental study comparing academic achievement and student engagement between classes that implement a flipped classroom with IoT and Android support, compared to traditional learning methods or a flipped classroom without additional technology.

AUTHOR CONTRIBUTIONS

Tommy Soenyoto (first author), main researcher, introduction writer/researcher/discussion writer (40%); Adi S. (second author), introduction writer/discussion writer (20%); Agus Darmawan (third author), introduction writer/methodologist (20%); Hilmy Aliriad (four author), introduction writer/discussion writer (10%). Made Bang Ready Utama (five author), introduction writer/discussion writer (10%).

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No potential conflict of interest was reported by the authors.

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