Physical Education Teachers' Acceptance of an IoT-Based Intelligent Decision Support System for Outdoor Physical Education Activities

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Abstract

This study aimed to (1) develop an intelligent decision-support system for outdoor physical education activities using Internet of Things (IoT) technology and real-time air quality analysis, (2) investigate student physical education teachers' technology acceptance of the developed system, and (3) examine their satisfaction with its use. A quantitative research design was employed. The participants consisted of 30 student physical education teachers selected through purposive sampling. The research instruments included an IoT-based intelligent decision-support system, a system quality evaluation form, a technology acceptance questionnaire based on the Technology Acceptance Model (TAM), and a user satisfaction questionnaire. Data were analyzed using frequency, percentage, mean, and standard deviation.

The results revealed that the developed system consisted of IoT-based environmental sensors, a real-time data transmission system, an air quality dashboard, and a recommendation module for outdoor physical education activity management. Expert evaluation indicated that the overall quality of the system was at a high level (M = 4.35, SD = 0.50). Student physical education teachers demonstrated technology acceptance at a high level overall (M = 4.09, SD = 0.89), with perceived usefulness receiving the highest mean score (M = 4.24, SD = 0.85). In addition, overall satisfaction with the system was at a high level (M = 4.01, SD = 0.89), with perceived benefits rated highest among all dimensions (M = 4.06, SD = 0.90). The findings suggest that the developed system has the potential to support safe and effective decision-making for outdoor physical education activities by providing real-time environmental monitoring and intelligent recommendations.

Keywords: Technology Acceptance, Internet of Things, Decision Support System, Air Quality Monitoring, Physical Education

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Introduction

Outdoor physical education activities are recommended to promote child health, well-being, and the development of lifelong physical activity habits from childhood through adolescence, as stated in the World Health Organization guidelines on physical activity (World Health Organization [WHO], 2019, 2020). In Thailand, 46.9% of the population aged 15–29 years and 44.1% of the metropolitan population were classified as having a low global physical activity level, according to the National Health Examination Survey 2024–2025 (Pathanawanit, 2025). These data indicate that a substantial proportion of the population does not engage in sufficient physical activity to maintain optimal health and well-being. At the macro level, the Thai government and physical activity stakeholders responded by launching the National Plan to Promote Physical Activity (2018–2030) and its Action Plan (2018–2020), representing an important milestone in promoting healthy lifestyles (Topothai, 2022). Regular physical activity has been recognized as one of the key protective factors supporting motor development and cognitive function in children (Zeng et al., 2017). Nevertheless, physical activity among school-age children remains insufficient despite schools and educational institutions being encouraged to provide regular outdoor physical education activities (Aubert et al., 2018).

While outdoor physical activity promotes individual health and well-being, the potential health benefits must be weighed against the risks associated with ambient air pollution. Previous environmental research conducted in northern Thailand has demonstrated a strong association between ambient particulate matter concentrations and adverse health outcomes, including increased morbidity and mortality (Supasri et al., 2023). Exposure to high concentrations of PM2.5 has been associated with reduced lung function and respiratory and cardiovascular diseases, particularly among vulnerable populations with pre-existing health conditions (Amnuaylojaroen & Parasin, 2024; Supasri et al., 2023). Polluted ambient air is considered a health hazard and is classified by the Air Quality Index (AQI) into six levels of health concern. Air quality begins to pose health risks for sensitive groups when the AQI exceeds 100 ("Unhealthy for Sensitive Groups") (United States Environmental Protection Agency [EPA], n.d.). Therefore, outdoor physical activity and exercise should be minimized when air quality reaches unhealthy levels.

As urbanization continues to increase worldwide, exposure to environmental factors during outdoor activities has become an important public health concern (Abidin et al., 2025; Kelly & Fussell, 2015; Luangwilai et al., 2025). The health impacts of particulate matter are especially concerning during physical activity because exercise increases respiratory rate and ventilation volume, resulting in greater inhalation of airborne pollutants (Yu & Zhang, 2023). Consequently, poor air quality may pose substantial health risks, particularly for susceptible young learners (Yu & Zhang, 2023). In the context of physical education, teachers are responsible not only for achieving educational objectives but also for ensuring student safety during learning activities. Decisions regarding whether to conduct outdoor activities, modify exercise intensity, relocate activities indoors, or suspend outdoor sessions should therefore be based on accurate and timely environmental information. However, the implementation of real-time environmental monitoring in physical education remains limited by educators' awareness and attitudes toward its use, as demonstrated in previous research on heat illness surveillance among school students in Bangkok (Somboonwong et al., 2012). Consequently, inappropriate decisions may increase students' exposure to unhealthy environmental conditions, particularly among susceptible children (Somboonwong et al., 2012).

Furthermore, despite extensive evidence linking particulate matter exposure to adverse health outcomes, researchers have identified significant gaps in understanding individual-level exposure. More accurate assessments of particulate matter exposure in real-world environments have therefore been identified as an important research priority (Vilcassim & Thurston, 2023). Recent advances in Internet of Things (IoT) technology offer promising opportunities to address this challenge (Garcia et al., 2025). IoT systems enable environmental sensors to continuously collect and transmit real-time data, including PM2.5 concentrations, temperature, and humidity. When integrated with online dashboards and intelligent decision-support systems, these technologies can provide physical education teachers with real-time environmental information and practical recommendations regarding activity management. For example, the system may recommend proceeding with outdoor activities, reducing exercise intensity, relocating activities indoors, or suspending outdoor sessions according to current air quality conditions.

Therefore, this study aimed to develop an intelligent decision-support system for outdoor physical education activities using Internet of Things (IoT) technology and real-time air quality analysis. In addition, the study examined student physical education teachers' technology acceptance and satisfaction with the developed system. The findings are expected to contribute to the integration of digital technology into physical education management and to support safer outdoor learning activities.

Research Objectives

1. To develop an intelligent decision-support system for outdoor physical education activities using Internet of Things (IoT) technology and real-time air quality analysis.
2. To investigate the level of technology acceptance among physical education teachers regarding the use of the intelligent decision-support system for outdoor physical education activities.
3. To examine the satisfaction of physical education teachers with the use of the intelligent decision-support system for outdoor physical education activities.

Research Hypotheses

1. The intelligent decision-support system for outdoor physical education activities developed in this study will demonstrate quality at a high level or above.
2. Physical education teachers will exhibit technology acceptance toward the intelligent decision-support system for outdoor physical education activities at a high level or above.
3. Physical education teachers will report satisfaction with the intelligent decision-support system for outdoor physical education activities at a high level or above.

Research Methodology

Research Design

This study employed a quantitative research design. The study aimed to (1) develop an intelligent decision-support system for outdoor physical education activities using Internet of Things (IoT) technology and real-time air quality analysis, (2) investigate student physical education teachers' technology acceptance toward the developed system, and (3) examine their satisfaction with the use of the system.

Participants

The participants consisted of 30 student physical education teachers selected through purposive sampling. The participants were undergraduate students majoring in Physical Education who had experience participating in outdoor physical education activities and were considered potential users of the intelligent decision-support system for instructional planning and activity management.

Research Instruments

The research instruments consisted of four components as follows

1) Intelligent Decision-Support System for Outdoor Physical Education Activities The developed system consisted of PM2.5, temperature, and humidity sensors integrated with an Internet of Things (IoT) platform. The system provided real-time environmental monitoring, online data transmission, a dashboard for data visualization, and recommendations for outdoor physical education activity management based on current air quality conditions.

2) System Quality Evaluation Form A five-point rating scale questionnaire was developed for expert evaluation of the developed system. The evaluation covered four aspects: content, system design, system usability, and practical usefulness and applicability. The form consisted of 20 evaluation items and was completed by three experts.

3) Technology Acceptance Questionnaire The technology acceptance questionnaire was developed based on the Technology Acceptance Model (TAM). The questionnaire consisted of four dimensions: Perceived Usefulness (4 items), Perceived Ease of Use (4 items), Attitude Toward Use (3 items), and Behavioral Intention to Use (3 items), for a total of 14 items. All items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

4) User Satisfaction Questionnaire A five-point Likert scale questionnaire was developed to assess user satisfaction with the developed system. The questionnaire consisted of four dimensions: system design (3 items), system usability (3 items), information and data presentation (3 items), and perceived benefits (3 items), comprising 12 items in total.

Instrument Validation and Reliability

The technology acceptance questionnaire and the user satisfaction questionnaire were evaluated by three experts to determine content validity. The Item-Objective

Congruence (IOC) values ranged from 0.67 to 1.00, indicating acceptable content validity. Subsequently, the questionnaires were pilot-tested with 30 student physical education teachers who possessed characteristics similar to those of the target population. Reliability was assessed using Cronbach's alpha coefficient. The technology acceptance questionnaire yielded a reliability coefficient of 0.92, while the user satisfaction questionnaire yielded a reliability coefficient of 0.90, indicating high internal consistency.

Data Collection

The data collection procedures were conducted as follows

1. Review relevant literature, theories, and previous studies related to IoT technology, air quality monitoring, outdoor physical education activities, and technology acceptance.
2. Design and develop the intelligent decision-support system.
3. Submit the developed system to three experts for system quality evaluation.
4. Develop the technology acceptance and user satisfaction questionnaires.
5. Examine the content validity and reliability of the research instruments.
6. Implement the developed system with student physical education teachers.
7. Collect data on technology acceptance and user satisfaction after participants had used the system.
8. Verify the completeness of the collected data and conduct statistical analyses.

Data Analysis

The collected data were analyzed using the following statistical techniques

1. Frequency and percentage were used to analyze participants' demographic characteristics.
2. Mean and standard deviation were used to evaluate the quality of the developed system.
3. Mean and standard deviation were used to determine the level of technology acceptance.
4. Mean and standard deviation were used to determine the level of user satisfaction.
5. Item-Objective Congruence (IOC) was used to assess content validity.
6. Cronbach's alpha coefficient was used to determine instrument reliability.

The interpretation criteria for mean scores were as follows

4.51 - 5.00 = Very High
3.51 - 4.50 = High
2.51 - 3.50 = Moderate
1.51 - 2.50 = Low
1.00 - 1.50 = Very Low

Results

Part 1: Demographic Information of Participants

The participants in this study consisted of 30 student physical education teachers. The demographic analysis showed that the majority of the participants were female (n = 16, 53.33%), while male participants accounted for 14 (46.67%). Regarding age, most participants were 20–21 years old (n = 22, 73.33%), followed by those aged 22 years or above (n = 7, 23.33%) and below 20 years (n = 1, 3.33%), respectively. In addition, 16 participants (53.33%) had previously used an air quality monitoring application or website (PM2.5/AQI), whereas 14 participants (46.67%) had no prior experience using such applications.

Table 1 Demographic Information of Participants

Demographic Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	14	46.67
Female	16	53.33
Total	**30**	**100.00**
Age		
Below 20 years	1	3.33
20–21 years	22	73.33
22 years or above	7	23.33
Total	**30**	**100.00**
Previous Use of Air Quality Monitoring Applications/Websites (PM2.5/AQI)		
Yes	16	53.33
No	14	46.67
Total	**30**	**100.00**

Part 2: Results of Intelligent System Development

The intelligent decision-support system developed in this study was designed to assist **student physical education teachers** in planning and managing outdoor physical education activities based on real-time environmental conditions. The system continuously monitored air quality, displayed environmental information through an online dashboard, and generated recommendations for outdoor activity management according to current air quality conditions.

The developed system consisted of four major components

1. IoT-based sensors for monitoring PM2.5 concentration, temperature, and humidity.
2. A real-time online environmental data transmission system.
3. An air quality dashboard for data visualization.
4. A decision-support module providing recommendations for outdoor physical education activities.

Examples of the system recommendations included

Good air quality: Outdoor physical education activities can be conducted as normal.

Moderate air quality: The intensity or duration of activities should be reduced.

Air quality beginning to affect health: Indoor activities are recommended.

Unhealthy air quality: Outdoor activities should be suspended.

Table 2 Results of System Quality Evaluation by Experts

Evaluation Aspects	Mean (M)	SD	Interpretation
Content	4.40	0.50	High
System Design	4.27	0.49	High
System Usability	4.33	0.50	High
Practical Usefulness and Applicability	4.40	0.49	High
Overall	**4.35**	**0.50**	**High**

The results presented in Table 2 indicate that the overall quality of the intelligent decision-support system was rated at a high level (M = 4.35, SD = 0.50). When each evaluation aspect was considered separately, Content and Practical Usefulness and Applicability received the highest mean scores (M = 4.40), followed by System Usability (M = 4.33) and System Design (M = 4.27), respectively.

These findings indicate that experts considered the developed intelligent decision-support system to be of high quality in terms of content, usability, design, and practical applicability. The results suggest that the system is appropriate for supporting outdoor physical education activity planning based on real-time environmental information and has the potential to facilitate informed decision-making in educational settings.

Part 3: Technology Acceptance of the Intelligent System among Physical Education Teachers

Technology acceptance was evaluated based on the Technology Acceptance Model (TAM), which included four dimensions: perceived usefulness, perceived ease of use, attitude toward use, and behavioral intention to use.

Table 3 Technology Acceptance of the Intelligent System among Physical Education Teachers

Technology Acceptance Dimensions	Mean (M)	SD	Interpretation
Perceived Usefulness	4.24	0.85	High
Perceived Ease of Use	3.99	0.90	High
Attitude Toward Use	4.02	0.90	High
Behavioral Intention to Use	4.09	0.92	High
Overall	**4.09**	**0.89**	**High**

The results shown in Table 3 revealed that the overall level of technology acceptance was high, with a mean score of 4.09 and a standard deviation of 0.89. Among the four dimensions, perceived usefulness received the highest mean score (M = 4.24, SD = 0.85), followed by behavioral intention to use (M = 4.09, SD = 0.92), attitude toward use (M = 4.02, SD = 0.90), and perceived ease of use (M = 3.99, SD = 0.90), respectively.

These findings indicate that the participants generally demonstrated a positive acceptance of the intelligent system. They perceived the system as useful for supporting outdoor physical education activities and expressed favorable attitudes and intentions toward its future use. However, the slightly lower score for perceived ease of use suggests that further improvements in system usability and user interface design may enhance users' overall experience and encourage wider adoption.

Part 4: Satisfaction with the Intelligent System

User satisfaction with the developed intelligent decision-support system was evaluated across four dimensions: System Design, System Usability, Information and Data Presentation, and Perceived Benefits.

Table 4 User Satisfaction with the Intelligent System

Satisfaction Dimensions	Mean (M)	SD	Interpretation
System Design	4.01	0.89	High
System Usability	4.02	0.89	High
Information and Data Presentation	3.93	0.88	High
Perceived Benefits	4.06	0.90	High
Overall	**4.01**	**0.89**	**High**

The results presented in Table 4 indicate that the overall satisfaction of student physical education teachers with the intelligent decision-support system was high (M = 4.01, SD = 0.89). Among the evaluated dimensions, Perceived Benefits obtained the highest mean score (M = 4.06, SD = 0.90), followed by System Usability (M = 4.02, SD = 0.89), System Design (M = 4.01, SD = 0.89), and Information and Data Presentation (M = 3.93, SD = 0.88), respectively.

These findings suggest that participants were generally satisfied with the intelligent decision-support system. In particular, they recognized its practical benefits for supporting outdoor physical education activities. Although all dimensions were rated at a high level, the relatively lower score for Information and Data Presentation indicates that further improvements in the presentation and visualization of air quality information may enhance user satisfaction and the overall effectiveness of the system.

6. Conclusion

This study developed an intelligent decision-support system for outdoor physical education activities using Internet of Things (IoT) technology and real-time air quality analysis. The developed system successfully integrated PM2.5, temperature, and humidity sensors with an online dashboard and an intelligent recommendation module capable of supporting activity planning based on current environmental conditions. Expert evaluation indicated that the overall quality of the system was high, confirming its appropriateness in terms of content, system design, usability, and practical applicability.

The findings further demonstrated that student physical education teachers exhibited a high level of technology acceptance toward the developed system. Among the Technology Acceptance

Model (TAM) dimensions, perceived usefulness received the highest score, indicating that participants recognized the value of the system in supporting instructional planning and enhancing safety during outdoor physical education activities. In addition, users reported a high level of overall satisfaction, particularly regarding the practical benefits of the system for educational use.

Overall, the findings suggest that integrating IoT technology with intelligent decision-support functions can effectively support outdoor physical education management by providing real-time environmental information and evidence-based recommendations. Such systems have the potential to improve decision-making, reduce students' exposure to unhealthy air quality, and promote safer learning environments in physical education.

7. Discussion

The findings indicate that the intelligent decision-support system developed in this study demonstrated high overall quality and was considered appropriate for supporting outdoor physical education activities. By integrating Internet of Things (IoT) technology with real-time monitoring of PM2.5, temperature, and humidity, the system provided practical recommendations for activity management based on current environmental conditions. These findings are consistent with previous studies reporting that IoT technology enables continuous environmental monitoring and supports real-time decision-making in various applications (Garcia et al., 2025). Furthermore, the developed system responds to the need for more accurate real-world assessment of particulate matter exposure to reduce health risks associated with air pollution (Vilcassim & Thurston, 2023).

The participants also demonstrated a high level of technology acceptance toward the developed system. The highest score was observed for perceived usefulness, indicating that student physical education teachers recognized the value of real-time environmental information in supporting lesson planning and decision-making for outdoor activities. This finding reflects the increasing importance of digital technologies in promoting safer educational practices, particularly in environments where air pollution may adversely affect students' health (Yu & Zhang, 2023). The relatively lower score for perceived ease of use suggests that improvements in interface design and dashboard visualization may further enhance user experience and encourage wider adoption.

User satisfaction was also rated at a high level, particularly regarding the perceived benefits of the system. Participants acknowledged that the system could support safer management of outdoor physical education activities by providing timely environmental information and appropriate recommendations. These findings are consistent with previous studies showing that exposure to elevated PM2.5 during physical activity increases respiratory health risks, particularly among children and adolescents (Amnuaylojaroen & Parasin, 2024; Supasri et al., 2023). Therefore, providing real-time air quality information can assist teachers in making appropriate decisions to reduce unnecessary exposure to unhealthy environmental conditions.

Overall, this study demonstrates the potential of integrating IoT technology with intelligent decision support to improve outdoor physical education management. The developed system provides a practical approach for translating environmental monitoring data into educational decision-making, thereby supporting student safety and promoting evidence-based instructional practice. Future studies should further improve data visualization and evaluate the effectiveness of the system among in-service physical education teachers and in different educational settings.

Recommendations

Practical Recommendations

1. Educational institutions should consider implementing IoT-based air quality monitoring systems to support evidence-based decision-making for outdoor physical education activities and enhance student safety.
2. Physical education teachers should use real-time environmental information together with students' health conditions, activity intensity, and learning objectives when planning outdoor physical education lessons.
3. Training or orientation should be provided before system implementation to improve users' confidence and maximize the effective use of the intelligent decision-support system.

Recommendations for Future Research

1. Future studies should evaluate the effectiveness of the developed system among in-service physical education teachers and in different educational settings to improve the generalizability of the findings.
2. Future research should investigate the impact of the intelligent decision-support system on educational outcomes, such as lesson planning, teacher decision-making, student participation, and safety during outdoor physical education activities.
3. The system should be further developed by incorporating additional environmental parameters, such as the Air Quality Index (AQI), UV index, rainfall, wind speed, or weather forecasts, to provide more comprehensive decision support.
4. Future development should include a mobile application or notification system to provide real-time alerts and recommendations, thereby improving accessibility and supporting timely decision-making.

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