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Important Things to Know Before Developing Artificial Intelligence-Based Drone Learning Systems:
From the Experience of Educational Practice

Ted Yuan-Yen Huang
https://orcid.org/0009-0000-8419-6706
Office of Sustainable Development and University Social Responsibility, National Central University, Taiwan

Eric Zhi-Feng Liu
Graduate institute of Learning and Instruction, National Central University, Taiwan

Harry Hung-Yu Sang
Graduate Institute of Learning and Instruction, National Central University, Taiwan

ABSTRACT

This study explored drone-based learning in educational contexts using a mixed-method design to identify key learning attributes. After completing researcher-developed drone tasks, 73 learners demonstrated a significantly improved understanding of drone concepts and proficiency in Blockly coding. However, learners perceived self-efficacy as significantly lower than other self-regulated strategies in drone activities. Task-based drone activities, facilitated by group settings, encouraged learners to develop metacognition through collective scaffolding methods, such as peer discussions and team testing. The identified learning attributes provide valuable insights for educators in designing assessments for collaborative drone problem-solving. Additionally, the interplay among effort regulation, problem-solving, and cooperativity observed in this study offers essential references for the future development of distributed expertise systems.

KEYWORDS

Drone Learning, Self-Regulated Learning, Collaborative Problem-Solving, Blockly Coding, Development of Learning Systems

INTRODUCTION

Drones, or small unmanned aerial vehicles, have been applied in widespread domains, including education. Due to the flexibility and multiple functions of drones, the sensors of small unmanned aerial vehicles cope with temperature, light, and distance, which could help users to monitor the environmental conditions of the field. In atmospheric exploration, drones could be utilized for observing and determining planetary boundary layers (Wang et al., 2021). In the agriculture domain, the photogrammetric techniques mounted on drones could enhance the efficiency of generating position information for precise applications (Candiago et al., 2015). When developing detective techniques, a low-cost unmanned aerial vehicle platform and a standard flight routine were utilized for simulated scenarios such as the contour mapping of nuclear radiation (Han et al., 2012). Hence,

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a module on drone education has recently been designed for learners to study assembly, flight simulation, and semi-autonomous piloting (Abichandani et al., 2022). Besides, Abichandani et al. (2022) also proposed multiple assessments for drone-related knowledge to confirm the validity of a drone learning module. The learning arrangement, including content, practice, and evaluation, has to be considered to formulate a drone-based curriculum.

Drone learning is a science, technology, engineering, art, and mathematics (STEAM)-related context in which learners must identify the key points of the mission, edit the programs with the team members, and collectively try to complete the task the instructors assign. A collaborative learning approach has been utilized for STEAM activities such as robotics learning (Huang et al., 2017), whereby group learners share common goals and solve problems using programming and cognitive strategies. Similarly, learners in drone tasks usually have to test their programs and adjust their common grounds considering the situation of each flight. Collaborative processes and problem-solving practices are the primary learning artifacts, integrating academic knowledge and skills into hands-on STEAM learning (Khamhaengpol et al., 2022).

Artificial Intelligence-Based Predictive Learning Analytics in Learning Contexts

Although hands-on STEAM activities could facilitate collaborative inquiry in person, the trend of asynchronous problem-solving environments has also been considered due to the influence of the pandemic. While learners acquire more experiences from asynchronous platforms, they also increasingly develop motivated strategies, such as self-determination to overcome academic challenges (Reyes et al., 2024). Learning resources from recorded videos and multimedia materials also help learners to control their pace and schedule. Hence, automatic adaptive learning systems have been implemented for academic learning, such as in mathematics (Li et al., 2022), and for predicting at-risk learners (Dawson et al., 2017). Hence, artificial intelligence (AI)-based predictive analytics can be broadly utilized to analyze learning engagement and propose suggestions for instructors or learners (Lim et al., 2021; Tang et al., 2022). In addition, models of AI-based predictive systems have been updated constantly according to different learning objectives and theories. The learning patterns and interactional mechanisms of each drone task are still changing to improve algorithms, especially for collaborative problem-solving (CPS), such as drone education.

CPS Assessment Toward the Human-Agent Approach of AI-Based Predictive Analytics

Learning systems for CPS have focused on the issues of assessment. One of the assessment issues is the complicated definition of CPS. Programme for International Student Assessment (PISA) 2015 defined a 3 x 4 matrix of CPS that included collaborative skills and problem-solving skills (Organization of Economic Cooperation and Development, 2017), thus addressing the need for collaborative capacities in the digital environment. The concept framework of CPS in PISA 2015 has also been adopted to develop an adaptive learning system that considers the diverse characteristics of mission tasks and trans-disciplinary learning situations (Kuo et al., 2020). Another framework of CPS is the core competencies of the Taiwan 108 curriculum guidelines (Ministry of Education, 2014). For a lifelong learner, CPS also has to consider the skills of spontaneity, communication, and social participation in a technology-enhanced environment. In drone education, challenging tasks make learners use executive self-regulatory strategies in teamwork contexts based on their lifelong competencies.

Since different CPS frameworks have established the fundamentals of assessment, especially in STEAM education, the main approaches utilized in the CPS assessment system have been human-human (H-H) and human-agent (H-A) (Kuo et al., 2020). The H-H approach for predictive learning analytics help understand human interaction processes and outcomes which cope with real CPS learning situations through observation. At the same time, the H-A approach for predictive learning analytics could construct a standardized assessment mechanism for learners to achieve