Drones in Education: A Critical Review

Ou Bai, Hongwei Chu[1], Huili Liu and Guo Hui[2]

[1, 2] **a**Innovation College, North-Chiang Mai University, 50230, Chiang Mai, Thailand
 Corresponding Author

Article History: Received: 11 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 10 May 2021

Abstract: The use of drones in education is growing and has been implemented in various courses as well as in pedagogy development. Using drones in education highly engages students and supports them to develop critical thinking and problem-solving skills, which will prepare themselves in advance to pursue their career. The role of drones in education covers from simple coding for 4–8-year students to much more complex remote sensing for environmental management in higher education and in various fields of academic research. This article aims to review the application of drones in various educational environments and epitomizes the ideas and implementations of drones for educational purposes. Classification of drones of different types used for educational purposes were also outlined. The frameworks proposed for Drone based learning were reviewed and summarized. Further directions of research in this domain were proposed.

Keywords: educational drones; pedagogy; critical review

1. Introduction

Drones, also referred to as remotely operated vehicles (RAV) or unmanned aerial vehicles (UAV), play a crucial role in problem-solving in real-time (Sattar, Tamatea, Nawaz, 2017). Drones are widely used for "video recordings, wildlife monitoring, precision agriculture, disaster management, entertainment, industrial inspections, etc." Beyond this, the emergence of more drone-based solutions makes people's life comfortable almost every year (Canas et al, 2020). Due to the new technological advancements, drones are becoming more popular, accessible, affordable, and easy-to-use (Sattar, Tamatea, Nawaz, 2017). This enables educational institutions to adopt and integrate drones into the educational environment. Using drones is an emerging trend in education (Carnahan, Crowley, Hummel, and Sheehy, 2016) for teaching learners in an innovative, engaging, and effective way.

The drones are available in different types and sizes that possess unique characteristics and capabilities which enable use in all levels of education from primary to high school level (Sattar, Tamatea, Nawaz, 2017) and also from Bachelor degree Doctoral research. Drones are also increasingly used in research settings. For example: In an educational environment, the mapping exercise could be given, in which students can "collect their own aerial images and then interpret them" (Jordan, 2015). The images captured by drones provide more detailed information at a small scale than the regular aerial images and google earth (Helmke, 2007). These types of exercises give good experience to students in technical instrumentation, data collection, data analysis, and interpretation and all critical career skills (Jordan, 2015). Also, in higher education, drones are used in robotics research (Krajník, Vonásek, Fišer, and Faigl, 2011). The ideas of using drones in education mainly focus on three areas, "for teaching science concepts through the construction of a drone, learning through operating (flying) drones, associated again with science subjects but also with art courses, and to explore topics related to legislation, ethical and privacy issues, and security (Fokides, Papadakis, and Kourtis-Kazoullis, 2017). Thus, the use of drones together with other related technologies plays a crucial role in engaging the learners in the classroom.

As the use of drone technology is increasing in the workplace, it is important to use drones in an educational environment, which enables students to be ready to pursue their careers. The integration of drones in the classroom provides wide access to various applications and is highly beneficial to students which supports them to develop critical thinking and problem-solving skills (Carnahan, Crowley, Hummel, and Sheehy, 2016). Integrating drones enables students to critically think about a problem from different perspectives and provide innovative solutions (Sattar, Tamatea, Nawaz, 2017). This provides new teaching and learning experience to both teachers and students and motivates them to highly engage and participate in the teaching-learning process more effectively. Thus, using drone technology in education supports students in developing creative and innovative solutions (Sattar, Tamatea, Nawaz, 2017). Thus, this study aims to review the application of educational drones in various educational environments, different types and sizes of drones used in education, and the frameworks proposed for Drone based learning. Thus, the previous studies were carefully reviewed to serve the research purpose. However, there are limited availability of studies that reviewed or experimented with drones in educational environments.

2. Application of Drones in Educational Environment

This section summarizes the studies that applied drones in the educational environment from primary level to higher education research and also noted few studies that measured the attitude of students towards drones. Drones

are used widely in educational settings and offer numerous benefits to teachers and students. The authors Bermúdez, Casado, Fernández, Guijarro, and Olivas (2019) described the drone challenge event as a platform for developing programming and robotics competitions for young students. The authors suggested it as a suitable tool for practicing various aspects of computer programming and aerial robotics at the K-12 level. Fokides, Papadakis, and Kourtis-Kazoullis (2017) examined the use of drones for teaching primary school students. They selected the students from Mathematics, Physics, and Geography courses. The target group consisted of 40 fifth-grade primary school students, and they were divided into two groups. The first group was taught using drones and the second group was taught using traditional methods. The data were collected using questionnaires and evaluation results. The results of their study revealed that the student group taught using drones outperformed the student group taught using conventional methods (Maths evaluation sheet and in all the delayed post-tests). While in the other two cases (Physics and Geography evaluation sheets), there is no difference in the results. Thus, the authors found that the students' attitudes toward drones were highly positive. The authors (Krajník, Vonásek, Fišer, and Faigl, 2011) stated that drones are used in robotics research in higher education. Jordan (2015) proposed that micro drones/UAVs could be used in geologic fieldwork and education, especially very useful in undergraduate research. Fung and Watts (2017) studied the use of drones and their application in chemical education for analytical environmental chemistry. Their study also reported the perceptions of students towards using drones in their course. The authors Palaigeorgiou, Malandrakis, and Tsolopani (2017) examined virtual drone-based virtual field trips (VFT), and their study found that the undergraduate sustainability education students felt an enjoyable and intriguing learning way in drone-based VFT, which offered the same value as actual field trips. Molina et al (2014) encouraged the use of drones in developing interdisciplinary engineering projects, and such projects would help students to pursue graduate school for further development in the specific area of research. Zwaan and Barakova (2016) investigated the integration of drones into the context of sports, particularly in boxing, and reported that drone technology lacks in agility and speed of a human boxer. The study of Smith and Mader (2018) concluded that the use of drones in the classroom for science courses can help to explore new areas and connections between science and nature. The study results of Chou (2018) found that drone programming significantly improved third-grade students' learning of spatial visualization and sequencing skills. HOLOTESCU et al (2020) mentioned in their study that students from a few schools in the Orastie Mountains participated in online class lessons using drones/technologies with the coordination of their Geography, Biology, and History teachers (https://www.youtube.com/watch?v=zJ8LFzuoRQ). The study by Jovanović (2019) also stated that at Old Dominion University the drones are used in a STEM-related residential education program for high school students that focuses on mitigating the impacts of climate change, and building resilience to sea-level rise. Özden and Atasoy (2019) analyzed the students' expectations towards the technology and design course of 7th-year students in state secondary schools and found that in the design needs the students mostly mentioned "making robots, drones; mechanical design; and design of a desirable product."

3. Different types of drones used in education

This section summarizes the most popular types of drones used in education. Most of the drones can be used from young ages 7+ years as they are usual mini-drones which could be used from primary school to higher education research.

3.1 Aerial Drones

The below drone (Figure 1) is used to present the students about the basics of mathematical modeling, aerodynamics, control inputs and the flight simulator to be prepared for capturing images for photogrammetry (Luque-Vega, Lopez-Neri, Santoyo, Ruiz-Duarte, and Farrera-Vazquez, 2019)

.

Figure 1. Aerial Drone Prototype (Luque-Vega, Lopez-Neri, Santoyo, Ruiz-Duarte, and Farrera-Vazquez, 2019).

ROBOlink CoDrone

This drone is developed by the Robolink company, which mainly focuses on coding and programming. It is just 37g, lightweight and durable. The coding can be done in an Ardino or Python environment (ROBOlink, n.d.).

Figure 2. ROBOlink CoDrone (Source: https://shop.robolink.com/products/codrone)**.**

3.2 Tello EDU Drones

Tello EDU Drones are created for educational purposes by Ryze technologies jointly with DJI and Intel Processors. This drone has advanced flight control technology which allows it to fly easily. It helps to learn programming languages such as Python, Swift, and Scratch. This drone can be used for commanding multiple Tello EDUs to fly in a swarm by writing code, and developing AI functions. This drone realizes AI functions such as object recognition, 3D reconstruction, and deep learning technologies (RYZE, n.d.).

Figure 3. Tello EDU Drone (Picture Source: https://www.ryzerobotics.com/tello-edu).

3.3 Sky Viper Drone

This drone can be used by students from a young age. The main features of this drone are hands free position hold, return to home, flyaway prevention, follow me mode, and auto-launch, land + Hover (Skyrocket LLC, n.d.).

Figure 4. Sky Viper Journey GPS Video Drone (Source: https://sky-viper.com/journey/).

3.4 Parrot MAMBO Educational Drone

This drone is designed especially for education to drone revolution in academic institutions from primary level to Ph.D.'s. This drone provides aerial perspective across disciplines film, journalism, and Media, and most

importantly STEM (Science, Technology, Engineering, and Mathematics) education. The students can learn block coding (Tynker and Blockly) and text coding (Javascript, Python) (Parrot Education, n.d.).

Figure 5. (Source: https://edu.parrot.com/index.html)

3.5 Frameworks proposed for Drone-based learning

This section summarizes the studies that proposed a framework for integrating into curriculum, course, training, and open/distance/online learning. The study by Sattar, Tamatea, Nawaz (2017) focused on integrating drone technology along with Australian curriculum content knowledge. Their study argued that drone technology has a good potential for integration with curriculum content knowledge to reinforce the understanding of the fundamental concepts and it helps in the learning process to develop the students critical thinking and reasoning. The authors (Canas et al, 2020) proposed a course for autonomous aerial robotics and presented an open-source drone programming course in Robotics Academy, which is an open-access educational platform for robotics distance learning. The primary goal of the course is to provide an open-access platform for facilitating drones' programming in different situations and applying concepts that are related to artificial intelligence, computer vision, automation, autonomous navigation, or control algorithms. From the course, few exercises were validated in three aerial robotics competitions. Thus, their proposed course of drone programming distance learning is ready to be used in higher education in engineering. Similarly, there are many online platforms such as Udemy, EdX, and Coursera that provide distance learning in drone programming. Fernández, Guijarro, and Olivas (2019) stated that the drone challenge event is a platform for developing programming and robotics competitions for young students. Joyce, Meiklejohn, and Mead (2020) presented a structured approach for using drones to teach geospatial technology fundamentals in a STEM framework covering primary/elementary, middle, secondary, and tertiary education. Tezza, Garcia, and Andujar (2020) supported using drones as a STEM teaching tool. The authors recommended guidelines to design curriculum and using drones in their lectures. Also, they designed a 5-session intensive course (15 hours) to introduce students to drone technologies and encourage them to continue further studies in the STEM field. They tested this with 15 middle-school and 15-high school students during a summer camp and found that the students are interested in pursuing an education and career with drones or STEM. Bryans-Bongey and Rosen (2019) found that the middle school and high school teachers were able to incorporate UAS in creating their lesson plans on numerous STEM topics and also, they increased their access and practical use of UAS in the classroom. The authors Olds, Dahlman, Mooney, and Russell (2017) conducted a sponsored three-half day workshop to motivate using drones in STEM, UNAVCO, and NOAA. The participants of the workshop were practiced with UAV flying skills, experimented with lightweight sensors, and learned current drone-enhanced research projects. The small groups were tested on existing activities and designed student-focused investigations. The project examples included measuring aeromagnetics, developing 3D topographic models, creating vertical profiles over various land surfaces at different temporal intervals, and developing a multi-semester drone-focused curriculum. Sattar and Nawaz (2019) stated that drones can be used for integrated STEM education using inquiry-based and experiential learning approaches to cope up with 21st-century skill requirements. Ware (2017) stated that their military academy focused on "incorporating drones in the curriculum and where it created career options for our graduates". And their graduates learned the geospatial skills. Bertrand et al (2018) pointed out the job trends in next few years related to UAVs. Hence, the authors emphasized the integration of drones in educational curriculum and aim to offer the course through MOOC related to drones and aerial Multi-Robot Systems (MRS). Brand et al (2018) introduced the PiDrone, along with an associated college-level introductory robotics course to form the core of the curriculum. They stated that the students were able to build, program, and test their own robots.

5. Conclusion

This study reviewed the application of drones, different types of drones, and frameworks for drone-based learning. It is obvious that drones play a very important role in education and various sectors. The STEM (Science,

Technology, Engineering, and Mathematics) or STEAM (Science, Technology, Engineering, Arts, and Mathematics) education and the integration of drones in the curriculum is essential. Because implementing drones in education can provide more practical knowledge to students and develop their critical thinking skills. Examples: Using drones in mathematics courses can help to calculate the speed and distance. Similarly, the mass and weight of the drone can help to understand physics and know how it works. The design of the drone is part of mechanical engineering. Drone programming and coding require knowledge of science and mathematics. That's the reason the majority of the studies emphasized integrating drone education in the STEM framework. However, based on the review it is understood that drones are integrated into education across the fields like geology, aerodynamics, robotics, marketing, social arts, visual arts, journalism, visual field trips, and including STEM. The academic institutions are offering drone-based education in offline, online, or open access platforms like MOOC. The drones will rule the world with its AI function, thus, it is essential to inculcate drone education from the primary level/middle school level itself, so that the younger minds will have creativity and problem skills, with that more research ideas would evolve during their higher education and also make themselves more eligible in the job market.

order to affect the high quality of the papers, the authors are requested to follow the instructions given in this sample paper. The regular length of the papers is 5 to 12 pages.

Reference

1. Bermúdez, A., Casado, R., Fernández, G., Guijarro, M., & Olivas, P. (2019). Drone challenge: A platform for promoting programming and robotics skills in K-12 education. International Journal of Advanced Robotic Systems, 16(1), 1-19. https://doi.org/10.1177%2F1729881418820425
2. Bertrand, S., Marzat, J., Maniu, C. S., Makarov, M., Filliat, D., & Manzanera, A. (2018, September). DroMOOC: a Massive Open Online Course on drones and aerial multi robot systems. In 2018 UKACC 12th International Conference on Control (CONTROL) (pp. 434-434). IEEE.
3. Brand, I., Roy, J., Ray, A., Oberlin, J., & Oberlix, S. (2018, October). Pidrone: An autonomous educational drone using raspberry pi and python. In 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 1-7). IEEE.
4. Bryans-Bongey, S. E., & Rosen, C. (2019). Strategic Professional Development for Busy Teachers: Profile of a High-Impact Instructional Design. International Journal of Learning, Teaching and Educational Research, 18(10), 220-232.
5. Carnahan, C., Crowley, K., Hummel, L. & Sheehy, L. (2016). New Perspectives on Education: Drones in the Classroom. In G. Chamblee & L. Langub (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 1920-1924). Savannah, GA, United States: Association for the Advancement of Computing in Education (AACE). Retrieved March 30, 2021 from https://www.learntechlib.org/primary/p/171951/
6. Cañas, J. M., Martín-Martín, D., Arias, P., Vega, J., Roldán-Álvarez, D., García-Pérez, L., & Fernández-Conde, J. (2020). Open-source drone programming course for distance engineering education. Electronics, 9(12), 2163. https://doi.org/10.3390/electronics9122163
7. Chou, P. N. (2018). Smart technology for sustainable curriculum: using drone to support young students' learning. Sustainability, 10(10), 3819.
8. Fokides, E., Papadakis, D., & Kourtis-Kazoullis, V. (2017). To drone or not to drone? Results of a pilot study in primary school settings. Journal of Computers in Education, 4(3), 339-353.
9. Fung, F. M., & Watts, S. (2017). The Application of Drones in Chemical Education for Analytical Environmental Chemistry. In Teaching and the Internet: The Application of Web Apps, Networking, and Online Tech for Chemistry Education (pp. 155-169). American Chemical Society.
10. Helmke, M. F., Coughlin, M. F., Potter, N., & Sevon, W. D. (2007, March). Hickory Run Boulder Field (2): Collecting high-resolution, low-altitude aerial photographs by UAV. In Geological Society of America Abstracts with Programs (Vol. 39, No. 1, p. 43).
11. HOLOTESCU, C., GROSSECK, G., ANDONE, D., GUNESCH, L., CONSTANDACHE, L., NEDELCU, V. D., ... & DUMBRĂVEANU, R. (2020). ROMANIAN EDUCATIONAL SYSTEM RESPONSE DURING THE COVID-19 PANDEMIC. eLearning & Software for Education, 3.
12. Jordan, B. R. (2015). A bird's-eye view of geology: The use of micro drones/UAVs in geologic fieldwork and education. GSA today, 25(7), 50-52.
13. Jovanović, V. M., McLeod, G., Alberts, T. E., Tomovic, C., Popescu, O., Batts, T., ... & Louise, M. (2019). Exposing Students to STEM Careers through Hands-on Activities with Drones and Robots.
14. Joyce, K. E., Meiklejohn, N., & Mead, P. C. (2020). Using Minidrones to Teach Geospatial Technology Fundamentals. Drones, 4(3), 57.

15. Krajník, T., Vonásek, V., Fišer, D., & Faigl, J. (2011, June). AR-drone as a platform for robotic research and education. In International conference on research and education in robotics (pp. 172-186). Springer, Berlin, Heidelberg.
16. Luque-Vega, L. F., Lopez-Neri, E., Santoyo, A., Ruiz-Duarte, J., & Farrera-Vazquez, N. (2019). Educational Methodology Based on Active Learning for Mechatronics Engineering Students: Towards Educational Mechatronics. Computación y Sistemas, 23(2), 325-333. https://doi.org/10.13053/cys-23-2-3196
17. Molina, C., Belfort, R., Pol, R., Chacón, O., Rivera, L., Ramos, D., & Rivera, E. I. O. (2014, October). The use of unmanned aerial vehicles for an interdisciplinary undergraduate education: Solving quadrotors limitations. In 2014 IEEE Frontiers in Education Conference (FIE) Proceedings (pp. 1-6). IEEE.
18. Olds, S. E., Dahlman, L. E., Mooney, M. E., & Russell, R. M. (2017, December). Using Recreational Drones to Promote STEM Learning. In AGU Fall Meeting Abstracts (Vol. 2017, pp. ED13E-01).
19. Özden, C., & Atasoy, R. (2019). Determination of Educational Needs of Technology and Design Courses in Secondary School Students. International Online Journal of Education and Teaching, 6(3), 511-523.
20. Palaigeorgiou, G., Malandrakis, G., & Tsolopani, C. (2017, July). Learning with Drones: flying windows for classroom virtual field trips. In 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT) (pp. 338-342). IEEE.
21. Parrot Education. (n.d.). Retrieved from: https://edu.parrot.com/index.html
22. ROBOlink. (n.d.). Retrieved from: https://shop.robolink.com/products/codrone
23. Ryze. (n.d). Tello EDU. Retrieved from: https://www.ryzerobotics.com/tello-edu
24. Sattar, F., & Nawaz, M. (2019, June). Drones and STEM Education for the 21st Century. In Canada International Conference on Education, 2019.
25. Sattar, F., Tamatea, L., & Nawaz, M. (2017). Droning the pedagogy: Future prospect of teaching and learning. International Journal of Educational and Pedagogical Sciences, 11(6), 1632-1637.
26. Skyrocket LLC. (n.d.). Sky Viper Retrieved from: https://sky-viper.com/journey/
27. Smith, B., & Mader, J. (2018). Drones for the science classroom. The Science Teacher, 85(2), 16-16.
28. Tezza, D., Garcia, S., & Andujar, M. (2020, July). Let's Learn! An Initial Guide on Using Drones to Teach STEM for Children. In International Conference on Human-Computer Interaction (pp. 530-543). Springer, Cham.
29. Ware, J. (2017). Teaching with Drones: The Challenges and the Opportunities. PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING, 83(12), 807-808.
30. Zwaan, S. G., & Barakova, E. I. (2016, June). Boxing against drones: Drones in sports education. In Proceedings of the The 15th International Conference on Interaction Design and Children (pp. 607-612).