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Droning the Pedagogy: Future Prospect of Teaching and Learning

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Abstract**—**Drones, the Unmanned Aerial Vehicles are playing an important role in real-world problem-solving. With the new advancements in technology, drones are becoming available, affordable and user- friendly. Use of drones in education is opening new trends in teaching and learning practices in an innovative and engaging way. Drones vary in types and sizes and possess various characteristics and capabilities which enhance their potential to be used in education from basic to advanced and challenging learning activities which are suitable for primary, middle and high school level. This research aims to provide an insight to explore different types of drones and their compatibility to be used in teaching different subjects at various levels. Research focuses on integrating the drone technology along with Australian curriculum content knowledge to reinforce the understanding of the fundamental concepts and helps to develop the critical thinking and reasoning in the learning process.

Keywords**—**Critical thinking, drone technology, drone types, innovative learning.

I. Introduction

DRONES, are unmanned aircrafts or ships which can be controlled remotely and now becoming popular to solve many real world problems. According to New Media Consortium, drones as an important emerging consumer technology over the next five years [1]. Drone is the most common term, but various other terms are being used inter-changeably such as Remotely Piloted Vehicle *(RPV)* or Unmanned Aerial Vehicle *(UAV)* or Unmanned Aircraft System *(UAS)*. The term drone is being used in this paper due to its familiarity as a common understandable term for general public.

With rapid technological development, ease of use and access, ***drone technology is getting attention and focus of academics and Information Technology (IT) experts*** to create a cost-effective and smart solution for various real-world applications. Affordability and accessibility of drone technology are making them a potential tool for effective teaching and learning practices. Integration of drone technology in education is opening new trends and adding new dimensions to teaching and learning practices.

Drone technology offers various opportunities for students [2] to learn in multiple ways that cause a significant impact on their learning. Use of drones in education provides new learning experiences to students by increasing their engagement and motivation in the learning process, particularly for student's centric learning. Drone technology provides the possibility to create an investigative based learning environment for students by utilizing learner-centered pedagogy [3] to create multiple pathways by which students can move along developmental learning progression rather than following a linear learning path. Drones enable students to visualize a problem from different perspectives and become a better problem analyzer which helps them to think critically. Use of drones in education encourages students to be creative and provide innovative solutions.

This paper aims to explore the different types of drone and their capability and propose their suitability to be used as an effective teaching and learning tool at various academic levels. Research proposes the integration of drone technology along with Australian curriculum content knowledge to reinforce the fundamental concepts and help students to develop critical thinking and promote reasoning in learning process.

II. Use of Drones in Education

Introducing drone technology in education offers enormous benefits and can be used in a number of educational settings.

A. Develop Deep Understanding

Cognitive sciences describe the term deep understanding as far how concepts are represented in student's mind and how these concepts are interconnected with each other [4]. Deep understanding develops the ability to understand individual concepts and connecting many concepts at once which lead towards deep thinking and construction of new concepts. Drone technology can be used to represent the same problem in different contexts so students can see the multiple aspects of a problem which help them to construct their understanding, development of thoughts and encourage making sense of their thoughts which adds up to create new knowledge.

B. Motivation and Engagement through Hands-on Practice

Integrating drone technology in tasks designing for students have the potential to stimulate motivation and engage Students. Involving students in hands-on experience kind of activities with drone technology develop their interest in the topic and add the aspect of enjoyment so learning takes place in a light and pleasant environment and leave long lasting impacts. Student's confidence increases as they rely less on their teacher and more on their own initiative for knowledge-creation and play an active role in their learning process and determine how to reach their desired learning outcomes independently. Through established motivation and

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engagement students become active knowledge creator and learner. Hands-on practice with drones will promote a future of innovative and socially beneficial uses of this technology.

C. Technical Knowledge and Skill

Technical knowledge and skill have been identified as one of the most important components to succeed in work and life in a 21st century global society. These include information, media, and technology skills; learning and innovation skills; and life and career skills [5].

Equip students with necessary skills to perform better in work and life in a 21st century global society must be the aim of the educators. Technology should be used in a way which enhances student's competency in their professional and everyday life in addition to the fundamental knowledge of the subject. Drone technology will be one of the major consumer technology in near future, therefore, considering the future technological requirements it would be timely decision to prepare and equip students with technical skills and expertise which will be in demand in future. Using drone technology in a purposeful way in education can enhance student's technical knowledge and problem-solving skills and make them competent to cope with the future technical and professional requirements.

D. Critical Thinking

Drone technology offers the possibility to design the tasks in an innovative way by which students can be challenged to develop skills in *problem-solving*, *analysis, creativity* and *critical thinking* in their work and are encouraged to learn more about their subjects. Use of drones in education can foster the critical thinking because as students are involved and engaged in an activity where they can apply content knowledge and skills which place them in a position to develop arguments, do reasoning and logically evaluate the problem.

III. Drones Types and Characteristic

Drones are part of this new generation's technology. They ae made of a light material to increase their flying maneuverability and to reduce weight. Drones vary in size, shape, payload (the equipment attached to it) and range and pose various characteristics. The size of a drone can be of an insect to the size of a commercial airplane. The weight of drones can vary from several grams to hundreds of kilograms.

Main drone categories based upon their working and lift mechanism include **fixed wing, multirotor,** and **Hybrid/ other systems**.

As the name describe *Fixed-wing* systems has static wings and their lift mechanism uses the forward airspeed e.g. traditional airplanes, kites that are attached to the surface, gliders like hang gliders or paragliders. Fixed-wing drones can fly faster and are more suitable for long distances.

Multirotor use rotary wings to generate lift e.g. traditional helicopter. Rotorcraft can have one or multiple rotors. Drones using rotary systems are almost always equipped with multiple rotors. A number of rotors suggest name for each type e.g. tricopter, quadcopter, hexacopter and octocopters are names of three rotors, four rotors, six rotors and eight rotors drones respectively. Multirotor drones do not need a landing strip, make less noise and can hover in the air. *Hybrid* systems integrate the characteristics of both multirotor and fixed-wing systems e.g. hybrid quadcopters. These drones use multiple rotors to take-off and land vertically but also have wings so it can fly longer distances [7]. Other systems include drones which are neither fixed-wing nor multirotor systems. These drones are of type ornithopter e.g. DelFly Explorer which is the first flapping wing Micro Air Vehicle *(MAV)* that is able to fly with complete autonomy in unknown environments. This drone is of the shape of an insect or bird, weighing just 20 grams and with a wingspan of 28cm, it is equipped with an onboard stereo vision system [8]. T-Hawk drone is another example of other drones' category that uses a turbofan, making the drone look more like an unmanned (hydro) jetpack [9].

A classification based upon *size* and *weight* distinguishes drones as **large** and **small** drones. Lower weight limit for large drones is 150 kg and for fixed wing drones and 100 kg for multirotor drones [6]. Term large drones refer for fixed wing drones between 20 and 150 kg and multirotor drones between 25 and 100 kg while Small drones are fixed-wing drones up to 20 kg and multirotor drones up to 25 kg. Small drone category can further be sub categorized as **nano** and **mini** drones which can vary in weight from several grams up to several kilograms. *Nano drones* are quite small and can fit in your palm, while *mini drones* are about the size of your hand. These drones are mainly suitable for indoor applications and recreational applications.

Considering the energy sources, drones can also be classified into four categories; **traditional airplane fuel**, **battery cells, fuel cells**, and **solar** [10]. Large fixed wing such as military Predator drones use airplane fuel (kerosene). Military Predator drones can be equipped with a number of different sensors and rockets. Multirotor drones use battery cells because they are short range and requires less time operating time, therefore, rechargeable battery cells are practical for them. *Fuel cells* convert the chemical energy from the fuel directly into electrical energy. Fuel cells are heavy and have the benefit to be used for long hours without recharging. Fuel cells are suitable for drones which are capable of covering long distance and carrying weight. For example, Stalker drone uses a fuel cell that has a flight time of 8 h. Currently available *solar cells* are low in efficiency which makes them suitable for many multirotor drones. Solar cells are also suitable for small ornithopters.

Drones can also be distinguished by their range and can be grouped into **very close range**, **close range, short range, mid-range** and **endurance drones**. *Very close-range* drones have a range of about 5 km and flight time bout 20-45 minutes. *Close range* drones can be controlled within 50 km of range. These drones have relatively high-power battery which enable them to fly from one to six hours. Short *range* drones have the 150km range and have a flight time of 8-12hours. *Midrange* drones are comparatively high-speed drones that have a range of 650km. due to their large range midrange drone are suitable for surveillance purposes. *Endurance* drones have flight time for 36 hours and have the capability to fly at an altitude of 30,000ft.

IV. Existing Drone Models

Many drone models are available in the market. As the aim of this research paper is to explore the appropriateness and feasibility of different types of drones for educational purposes, therefore, this section provides an overview of some popular drone models which are available for governments, industry, and citizens and have potential to be used as an important educational tool.

A. Cheerson CX-10C RC Quadcopter RTF Drone

This is little nano drone built with strong material with size 1.5 x 1.5 inch. This model has a 0.3MP camera to take pictures and videos. LED lights in front and back that look great in low light flying. Charging time is 15-20 min and flying time is 5-8 min. Their 6 axis gyro systems make it possible to throw in air and start flying. Controller has three modes, i.e. beginner, intermediate and expert mode which is helpful for user with different skills to fly to quadcopter[1].

Fig. 1 Cheerson CX-10C RC quadcopter [14]

B. Syma X12 Drone

Syma X12 is a little nano drone with size 2.8 x 1.1 x 1.8 inch, equipped with the latest 6-axis flight control systems. The X12 can perform continuous 360-degree barrel rolls for great action and offers wonderful performance with 30 minutes charging time and 6-8 minutes flying time[2].

Fig. 2 Syma X12 drone [15]

Syma X12 drone has two modes to control high and low speed flight. A small button on right side of the controller generates flips. This quadcopter can be oriented in the air smoothly due to its 4 LEDs on top and bright white LED on the front.

C. Delfly Explorer Drone

The Delfly Explorer is the first flapping wing *MAV* ornithopter drone that flies like a dragonfly. This drone is developed by the Delft University of Technology in the Netherlands. The drone is capable of take-off and fly fully autonomous within a closed environment. It can avoid obstacles by due to its stereo vision system. The drone has a weight of 20 g and can currently operate for only nine minutes because of the size and weight constraints of the battery. In the future, these models could be used for reconnaissance and air photography, but also for applications like greenhouse inspections to check if the fruit is mature [8].

Fig. 3 Delfly Explorer drone

D. Blade Nano QX RTF Drone

Blade Nano QX RTF is a mini drone best known Quadcopters for flying fun. Easy to use characteristic enable it appropriate for beginners. Anyone can pick up the controls and experience RC flight with minimal effort and even less experience.

Fig. 4 Blade QX RTF nano drone [16]

E. Hubsan x4 Drone

The Hubsan x4 is a small multirotor drone, simple in design and operation, developed by the Chinese company Hubsan.

Fig. 5 Hubsan x4 Drone [17]

The mini drone has a weight of 30g, a radius of around 100 m and flight time is 7 min. Some models of the x4 drone come with a built-in camera for making pictures and recording video. The drone is currently a popular and relatively cheap alternative for the more advanced drones. This drone was built for recreational purposes.

F. Parrot AR Drone

The Parrot is one of the most popular drone types that was mainly built for recreational purposes. This quadcopter can be controlled by a smartphone or tablet. The drone can operate for 12 to 18 min and weighs about 400 g with speed of 18 km/h and it has a range of about 50 m. The drone has two cameras, Bluetooth and WiFi technology and uses GPS-waypoints to fly a preprogramed route. This drone is suitable for photography and video.

Fig. 6 Parrot AR Drone [18]

Parrot AR drone is equipped with gaming software which includes racing game and augmented reality driven shooter games in which a real-world environment is augmented by computer-generated graphics and/or sound. Tasks can be preprogramed with Parrot AR drone like maintaining a particular altitude.

G. DJI Phantom Drone

The Phantom 4 drone is most popular multirotor drone that is being used for various applications. DJI phantom 4 has advanced stereo *Vision Positioning System (VPS)* which enables phantom 4 to fly even without the global positioning systems. Phantom 4 can hover in the air quite smoothly and *VPS* helps to control the Phantom 4's movement and bring it back to the home position in case of hazardous situations. Using ActiveTrack, the Phantom 4 will recognize your subject, follow them naturally, and keep them in the frame[6]. This drone is equipped with front obstacle sensors combine with advanced computer vision and processing to give the Phantom active obstacle avoidance that allows it to react to and avoid obstacles in its path.

DJI Phantom 4 has multiple flight modes which offers the possibility to fly in a simple or intelligent navigation. This drone can be controlled through DJI go 4 app using a smartphone or an ipad. The smartphone can also control the camera to move and make pictures or record video. Just by programming the flight altitude and certain waypoints the drone can take-off, land, make recordings, and return automatically The Phantom 4 have 3.1mi (5km) of range, can fly for about 28 minutes with complete control and a live 720p HD view of everything the camera sees.

Fig. 7 DJI Phantom 4 drone [19]

H. Aeromao Aeromapper EV2 Drone

The Aeromao Aeromapper EV2 is fixed wing remote controlled drone. It can be controlled remotely or preprogrammed for autonomous operation. The Aeromao Aeromapper EV2 has a width of 1.56 m, weighs about 22.7 kg and can stay operational for 60 minutes within a range of 20 km. The Aeromapper EV2 is ideal for surveying large sized areas and to generate 2D orthomosaics, 3D terrain models & Digital Elevation Models *(DEM)*. This drone model is also suitable for application such as; crop management, research and forestry, wildlife monitoring, oil & gas pipeline and for topographic surveys.

Fig. 8 Aeromao Aeromapper EV2 Drone [20]

I. ScanEagle Drone

The ScanEagle is a fixed-wing drone dating from 2004 and is mainly used as a surveillance tool. ScanEagle can operate above 15,000 ft with a flight of up to 20 hours, depending on system configuration. The Scaneagle is 1.5 meters long with 3-meter wingspan.

Fig. 9 ScanEagle Drone [21]

It can operate in land and maritime environments. Its modular design allows integration of new payloads and sensors and ensures the vehicle will be able to incorporate new technology as it becomes available [21].

TABLE I
DRONE TYPES, MODELS AND SUITABILITY FOR EDUCATION

Drone Size	Model	Suitability for School /Level/Application
Small (Nano)	Cheerson CX-10C	Primary School
	Syma X12	Primary School
	Delfly Explorer	Primary School
Small (Mini)	Blade nano QX RTF	Primary/Middle School
	Hubsan x4	Primary/Middle School
	Parrot AR	Middle School
	DJI Phantom 4	Middle/High School/
Large	Aeromao-Aeromapper EV2	High School/ Research and Surveying
	ScanEagle	Military/Survillance

Review of drone types, characteristics and models suggest that drones have great potential to be used as an effective creative tool for learning and experimentation. Some drone model has excellent features which offer flexibility to be used at primary, middle and high school level (Table I) but the real challenge is how these tools should be used in an innovative way in classrooms activities that are aligned with subject content knowledge. Nano drones; such as Cheerson CX-10C, Syma X12 and Delfly Explorer are suitable to be used at primary level due to their various functions and characteristics. The size of these nano drones are perfect for little hands and their joysticks are easy to manage. Mini drones also offer a range of possibilities to be used at primary and middle school level, e.g. Parrot AR drone which can be linked up with WiFi Bluetooth and gives the possibility to add the other technological platform such as augmented reality, game-based learning making it a suitable tool to be used at different school levels. DJI Phantom 4 can be used at high school level as well as to solve many relay world problems due to its high quality and easy to use features. Fixed wing drones are not suitable to be used at school level because they were developed mostly for surveillance purposes however they may be used for the studies that include the border security and safety issues.

V. Drone Integration along with Curriculum Content Knowledge

The Australian Curriculum at Foundation to Year 10 revolves around three important areas; disciplinary knowledge, skills and understanding; general capabilities and cross-curriculum priorities. The Australian Curriculum aims to set out the knowledge, understanding and skills needed for life and work in the 21st century and establish common standards and high expectations of achievement across the nation [11].

The Australian Curriculum incorporates the key learning outcomes of the national Early Years Learning Framework [12]. Learning areas of foundation years focused on the development of sensory, cognitive, exploratory, analytical and creative practices in arts, technologies and language. The Australian Curriculum across Years 3–6 assists students to develop their ability to solve problems; independent decisions making and show responsibility. It emphasizes to engages students with discipline knowledge, understanding and skills of the eight learning areas of the Australian Curriculum; Literacy and numeracy, English, mathematics, Science, humanities and Social Science, Health and Physical Education, Arts, Technologies and Language. At the primary level of Australia curriculum drone technology can be integrated along with content knowledge and basic concept understanding. Basic tasks with drone technologies can be designed such as simple flight, route planning, concepts of direction, angle, height, weight and speed. For example; if the speed of the drone is known then time and distance can be calculated. The key idea is to reinforce the content knowledge with drone technology. In early years, students can develop their skills to maneuver a drone and apply the concepts of angles, rotation and height by exercising relevant activities. Drones provides the possibility to design interactive collaborative group activities in different learning areas defined by Australian curriculum that offers a chance to quiet and introverted students to collaborate and communicate with their peers and actively participating in group activities.

In Years 7-10 the Australian Curriculum supports the deep understanding of the contents knowledge and skill development in all eight learning areas. Australian curriculum at middle to high school level emphasise the specialise in learning and to equip the student for senior secondary schooling, including vocational pathways. This is important to note that numerous learning areas of Australian Curriculum are underpinned by an inquiry-based approach [13] to learning particularly, The Humanities, Social Sciences and Science suite of learning areas. Drone technology offers a range of possibilities in education to drive a student-centered, investigative based learning environment by which students actively develop their understanding of science and social science by combining scientific knowledge with reasoning and thinking skills. In this connection, drones have tremendous potential to help students learn science, technology, engineering and math (STEM) concepts in an interactive and fun way.

Students can be the creator of the technology by applying concepts of engineering and can create their own drones. Students can target some real-world problems and can alter or modify the existing drone model. This exercise can enhance their critical thinking and inspire them to generate solutions for real world problems.

Programming and coding are other areas where students can learn how to write a program and control a drone. Programming concepts like sequencing, repetition, events, conditional logic, problem-solving, and debugging can be applied. The tickle app uses the Block coding principles and provides an easy to use the platform to do programming and write codes for drones. Drone Blocks app also works using block programming principles and work very well with the DJI Phantom 3, DJI Phantom 4, and Inspire 1 drones. Users can plan the drone flight path by dragging and dropping blocks onto the canvas to command their drone. This app is suitable for beginners, even can be used for year 4-8 students. The Drone Blocks App makes programming drone missions accessible through a familiar, easy-to-use "block" programming interface.

In addition to programming, students can learn how to do remote sensing and fly a drone to acquire spatial data by applying concepts of mathematics to rectify errors and get geo-corrected images which can be used in a number of learning areas to investigate and analyze real world problems. Furthermore, techniques and skills related to filmmaking and photography can be learned using drones. Students can excel in photographic techniques. Spatial data and relevant photos and video taken from drones provide a sound base for Project Based Learning pedagogy that can be applied in several Australian curriculum learning areas. For example, in Geography problem related to geographic phenomena such as earthquake, cyclone, flood, and bushfire can be used as a context for problems based learning.

Students could be challenged with a problem of assisting human well-being, environmental management or economic/social management.

VI. Conclusion

We argue that drones have immense potential for integration as technology with the curriculum content knowledge to reinforce the understanding of the fundamental concepts and helps to develop the critical thinking and reasoning in learning process. Drones are available in various types and size which enable them to be used in different educational context. Although this technology is still developing, it has a heap of potential for improvement in the near future. Currently the use of drones in schools is on positive side and general thinking of the teachers about drones is positive too. Drones along with other related technologies can play an important role to better engage the learners in classroom. Drone technology can be better embedded with Australian curriculum which aims at developing successful learners with particular attributes of being confident, creative, active an informed individual.

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