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Drone Edu Challenge IR 4.0: Expanding Skills Sets of Malaysian STEM Talent Pool

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ABSTRACT

As Industrial Revolution 4.0 (4IR) arrived, there is a pressing need to prepare the new generation with skills and knowledge to face the challenges in this era. Programming is the fundamental skills and knowledge that should be introduced and mastered by the youngsters' generation. There is a wide range of educational programs to develop the skills and knowledge among university students, but less effort is given to help school children to learn these skills. Therefore, Drone Edu Challenge IR 4.0 was designed as an educational program to introduce drones to all secondary schools in Malaysia through a competition at the national level. The participants were provided with webinars, online resources, and facilitators to guide them in learning drones and programming under the safe environment at home due to the pandemic COVID-19 lockdown. Despite the challenges of the lockdown, the participants were able to connect socially and get motivated throughout this program because this educational program was designed to be social, interactive, contextual, fun, and relevant to the students through gamification and tournament. To understand the effectiveness of this educational program, interviews were conducted, and the result showed that the participants have achieved more than what the program was designed for. After undergoing the program, some participants are now the drone and programming experts the schools have identified. They lead and teach their peers to learn programming. They show interest and talent to master STEM knowledge and skills. Therefore, more similar educational programs related to technology of 4IR should be organised to develop the Malaysian STEM talent pool.

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1. Introduction

Since the advent of the fourth industrial revolution (4IR), the world has gone through a tremendous change of educational and industrial landscape which has brought vast changes to human's daily life. As an impact from 4IR, the education sector has aligned its teaching and learning, curriculum, and others. Education 4.0 has been seen as a response to the needs to embrace 4IR [1]. One of the benefits for Education 4.0, learning can take place anytime anywhere via several e-Learning tools which offer way for remote learning, self-learning, and a more engaging learning experience [1]. Drones and robots have made their way into schools and co-curricular activities for children [2,3]. Universities and schools are increasing the use of online resources and tools for teaching and learning such as virtual labs, massive open online courses, mobile labs and others to bring the 4IR experience to students [4-7]. This paper reports how drones and related skills such as programming and computational thinking are fostered among school students through an educational tournament – Drone Edu Challenge IR 4.0 (DEC4IR).

2. Literature Review

Recently, there has been an increase in demand on the robot, mobile robot or drone/aerial courses in higher education and also among the school students [8]. Technische Universität München through EDx has offered a course on autonomous navigation for flying robots [9]. This course primarily addressed camera-based navigation of a quadcopter, theoretical concepts such as linear algebra, 2D and 3D geometry, motor controllers, probabilistic state estimation, and visual odometry [10,11]. Besides, University of Pennsylvania also provided a programming course on aerial robotics [12]. It emphasizes 2D and 3D geometry, the mechanical component of flight in micro aerial vehicles and the approach in developing dynamic model, derive controller, and its operation while the MATLAB software is used as programming middleware. While the Stanford University also provided the course on flying cars and autonomous flight engineering nano degree, where it introduced the concept of 3D motion, algorithm controlling with application of Kalman filter and C++ as programming language [13]. It also demonstrated the ability of the drone to fly in the complex city area by loading the real map and no collision occurs between the buildings. In addition, the Udemy platform is also offering the drone programming primer for software development course [14]. It approaches the open-source flight stack based in ArduPilot flight controller, MAVLink, and DroneKit middleware. The ArduPilot software was used in the loop (SITL) simulator that stimulates an ArduPilot-based autopilot and communicates with it using MAVLink through the local IP network.

In Robots Academy, the distance open access drone programming course was introduced, available for everyone and freely accessible at any place [8]. This course also introduced the concept of learning by doing. It also applied the map-based navigation principle and self-localization algorithm that allow the drone with 3D navigation and GPS setting. It focuses on the drone sensor and actuator which describe position and vision-based method. There are several programming courses outlined including theoretical approach and practical exercises. While for the practical approach, there are several practical exercises was outlined focus on the drone itself and computer vision.

Game-based learning is a trend that has been introduced in programming lessons. In short, gamification applies game elements or a game framework to existing learning activities while game-based learning designs learning activities that are intrinsically game-like. This gamification focuses on several parameters which include enabling the competition, establishing ranking and scoreboard, providing award and recognition. This implementation was successfully implemented in the classroom, enabled the fun learning environment with total participation from the students [15].

Previous study demonstrated that, gamification approach could be able to attract student's engagement and motivate their attendance's ratio and grade [16,17]. Students receive positive reinforcement both on-site and remotely when challenges with progressive difficulty and gamified step-by-step tasks are used to manage their workload [18]. Moreover, gamification will provide students with instant feedback and graded assignments, which will help them with formative self-assessment and auto-grading [19].

Referring to the Robotics Academy, it has been redesigned to allow for gamified learning in computer vision and robotics through step-by-step updates [8]. This includes (1) competitive exercise. In collection of exercises, students compete against each other to complete tasks within a specified time, increasing their engagement levels, and (2) social interaction. The Robotics Academy has provided students, teachers, and developers with social interaction through a web forum and several accounts across popular social media platforms since 2015, including a YouTube video channel video with more than 300 videos and 40,000 single visits and a Twitter account with more than 200 tweets. A final competition proposed two challenges for programming the autonomous intelligence of vision-assisted mobile aerial robots. In the first exercise, the cat-and-mouse challenge, a quadcopter aerial robot called "cat drone" had to be programmed to search, chase, and stay at a given distance to another aerial quadcopter. In the second challenge, "Escape from the hangar", a mobile aerial robot was required to land inside the hangar and find its way out within 1 minute while avoiding contact with six inner walls, which moved random patterns to increase the difficulty [8].

However, the effectiveness of the competition in learning drones and programming. In-depth and qualitative data is needed to further explain what and how the participants have learnt through this educational program. Furthermore, this competition was designed for university students. Drone and programming should be introduced to school students to develop new and young talent, so that they will be able to strive in the era of 4IR. Therefore, Drone Edu Challenge IR 4.0 was designed as a social educational learning program using gamification through a nationwide competition to develop skills in programming, computational thinking and drone flying.

3. Drone Edu Challenge IR 4.0

Drone Edu Challenge IR 4.0 (DEC4IR) is a fully online-based education program formulated for drone technology learning among school students in Malaysia. This curriculum program is carried out as a project-based learning competition employing heutagogy approach to integrate formal and informal learning experience. The particular of the program is as tabulated in Table 1 follows.

Table 1
Drone Edu Challenge IR 4.0 Malaysia 2021

Item	Description
Date of program	June – November 2021
Total participants	2379
Total finalist	152
Category	1. Primary school (7-9 years old)
	2. Primary school (10-12 years old)
	3. Secondary school (13-15 years old)
	4. Secondary school (16-17 years old)
	5. Primary school (Special Education)
	6. Secondary school (Special Education)
Strategic partners	1. Universiti Teknologi Malaysia (UTM)
	2. Ministry of Education Malaysia (MOE)
	3. Johor State Education Department (JPNJ)
	4. Iskandar Investment Berhad (IIB)
	5. Malaysia Digital Economy Corporation (MDEC)

3.1 DEC4IR Framework

Since the whole program is conducted fully online, an online learning management system (LMS) is developed to facilitate all student's activity remotely. As shown in Figure 1, DEC4IR consists of three phases with its respective activities for the students of different age group.

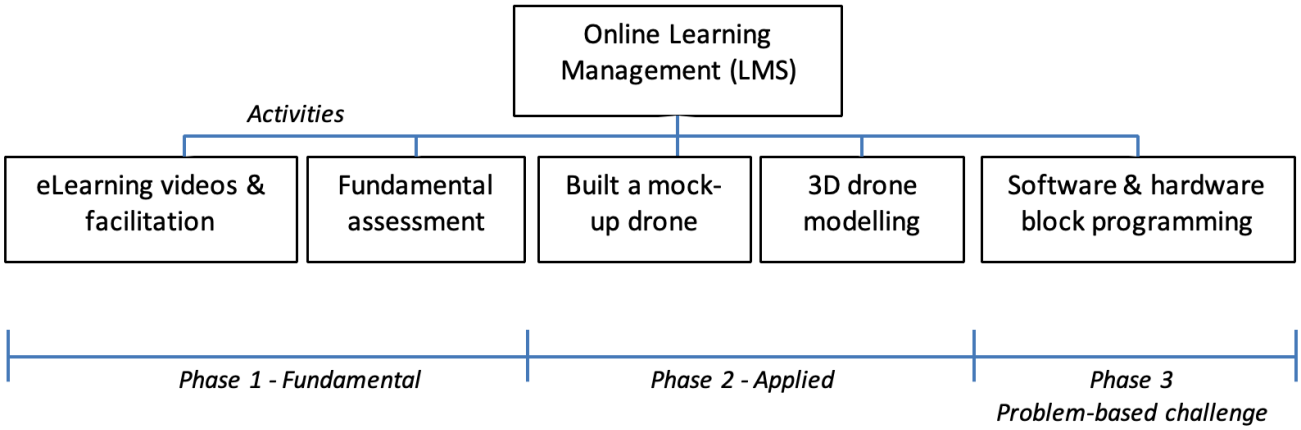


Fig. 1. Overview of Drone Edu challenge IR 4.0 activities

Phase 1: All students are formed into a group of two students and one teacher or facilitator. Recorded videos on the fundamentals of drone technology are prepared within their signed-up account at the LMC system as in Figure 2. Students will need to complete a total of 120 minutes video lecture series and followed up with an online quiz assessment.

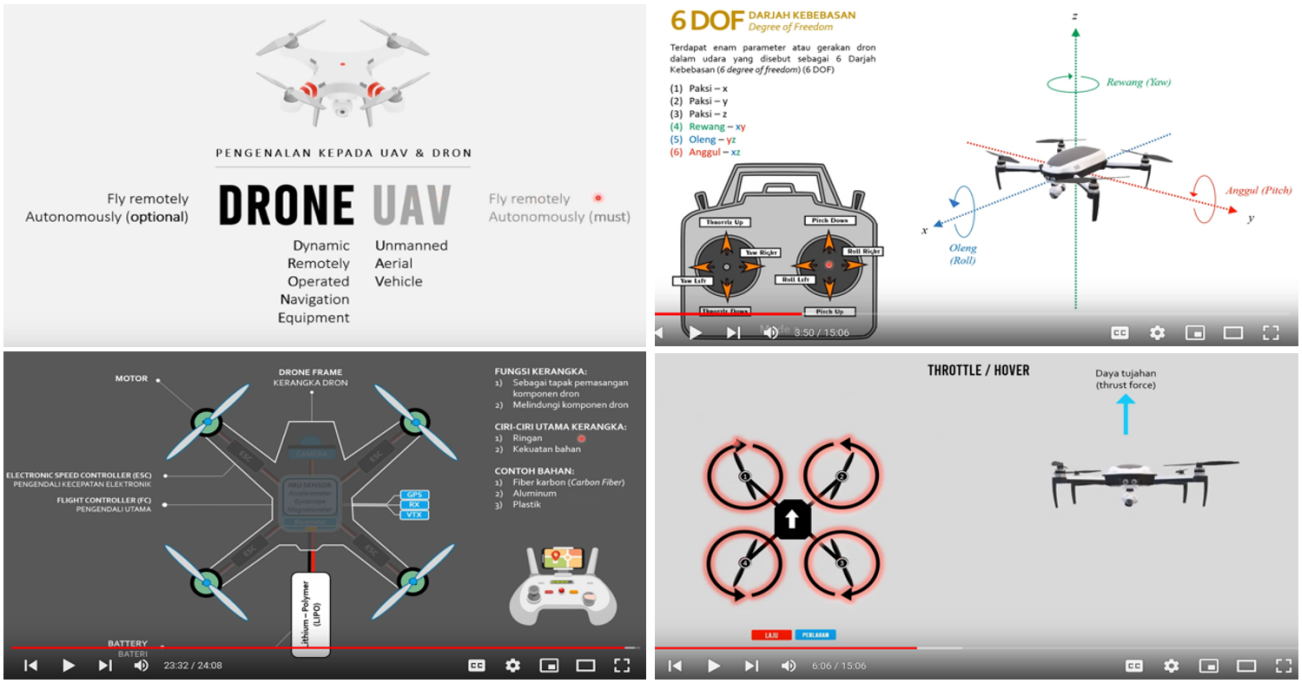
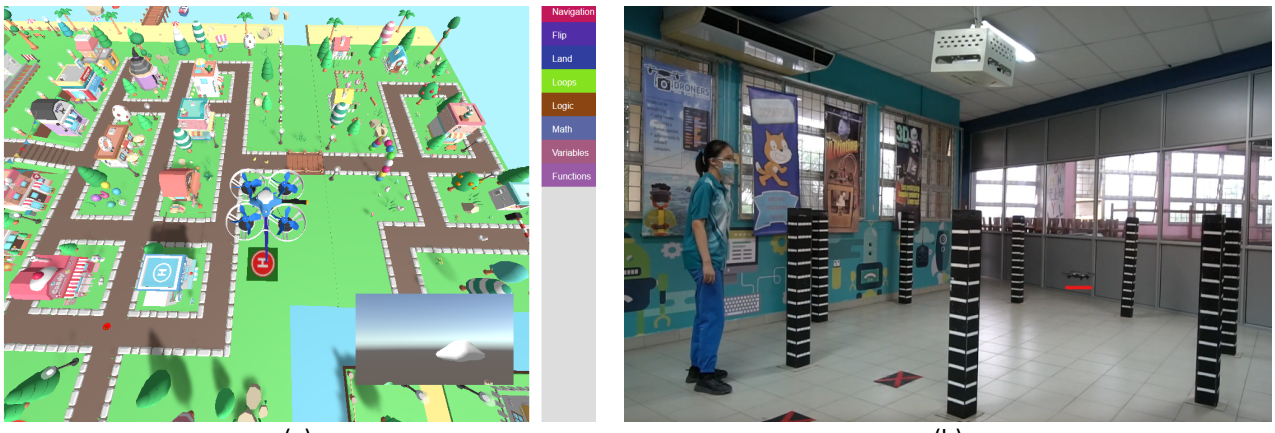


Fig. 2. Online eLearning video

Phase 2: Upon completion of the fundamental study, they are required to apply their knowledge to build a drone model. For safety purpose, the built model is not meant to be fly but as a mock-up model resembling a real drone setup and configuration. As for the secondary school students, a 3D drone modelling is assigned using a computer aid design software (CAD) of their choice.

Phase 3: The key activity of DEC4IR is to enhance programming skill among school students which is focused on the phase 4 of the program. Realizing the challenges for students to gain interest to learn programming, a heutagogy approach is implemented. The groups are given four project themes to choose only one: medical, engineering, security, and agriculture. As shown in Figure 3(a), they are required to investigate the real problem according to the chosen theme and to use virtual software for 'block programming' to design an autonomous drone flight to address the stated problem. Subsequently after the validation of the simulated flight, the students are provided with a DJI Tello drone unit to apply their designed program code on a real drone flight as shown in Figure 3(b).



(a) (b)

Fig. 3. Autonomous drone flight (a) droneblock & simulator, (b) actual flight test

3.2 Student's Assessment

DEC4IR practice a quadruple helix model involving experts from the governance, academia, industry and community. The expert representatives are being invited as interviewers for a virtual interview session with the student groups as in Figure 4. Students are being interviewed about their basic understanding of drone, programming, and computational thinking skills. The interview sessions took place via virtual platform using Google Meet for 4 hours, with 56 participants. Qualitative inquiry is used as the research framework. The interview protocol was developed and checked by drone experts. All the participants are asked for their consent before the recording of the interview sessions.

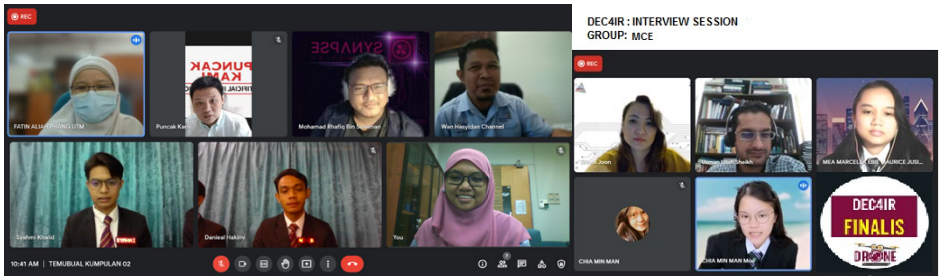


Fig. 4. Virtual interview assessment with industrial experts

4. Results and Discussion

The data was analysed using qualitative data analysis [20]. The participants showed that they understand how drones' function, identified problems that can be solved by using drones and exhibit their programming skills in providing the solution to solve the problems that they identified. Figure 5 shows some of the drone designs by the participants as a result of this educational competition. The drone designs were evaluated by experts and almost all the designs show functioning drones.

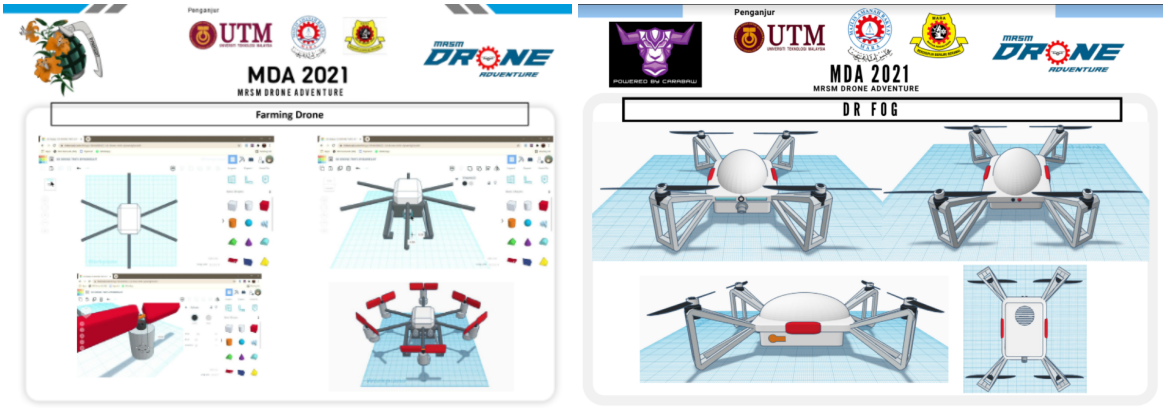


Fig. 5. Drones designed by the participants using 3D computer aid design software (3D CAD)

From the interviews, it was found that the participants have now become experts in programming for help their peers. Their teachers acknowledged the participants' expertise in programming and asked the participants to teach or lead their peers in similar projects such as robotics. One of the participants said, *"…basically maktab kami ni, pelajar baru kenal pasal drone. Jadi kalau ada apa-apa event mereka akan minta saya buat persembahan drone sebab drone ni salah satu asset juga di maktab kami…",* [Basically at our school, students only start to know about drones. So, if there are any events at my school, the school will ask me to fly drones as a performance because now drones

have become the school's asset] - Participant R. *"And macam biasa kalau maktab ada program berkaitan dengan drone mereka akan minta bantuan saya dalam dua minggu awal."*, [and as usual, at our school, if there is any program related to drones, the school will ask my help, usually 2 weeks before hand] - Participant I.

The participants are also explained that, initially they were not interested in programming. However, after undergoing DEC4IR, they started to like programming and could master the skill. *"Secara jujurnya, apa-apa tentang ASK saya memang tak minat. Complicated. … Daripada tak tahu apa-apa sekarang sudah pandai"*, [Honestly, I have no interest about anything in "Basic of Computer Science" (a school subject on programming). It's complicated. … (after participated DEC4IR), from knowing nothing (about programming) now I am good at it] - Participant R.

Learning programming is difficult, even for university students. For school students, it is even more difficult. However, DEC4IR has proven to be effective to make learning programming seems easy. This is because DEC4IR was designed to motivate students through the use of competition, gamification, contextual and social settings that allow students to interact with each other during the learning even though during lockdown.

The participants also garnered praises from the industry experts who interviewed them. They were praised for their presentation, designs and proposed solutions. Below is an excerpt of the interview between A (industry expert) and M (participant):

00:17:29 A: *M, perlu tak membina penghadang angin sebab tengok ka nut sesuai untuk indoor tapi tadi M buat dekat outdoor so ada ke letak penghadang angin ke kalau angin datang, kerusi itu memang habis kan*
[A: M, do you need to make a partition to stop the wind because it seems like more suitable for indoor use but you want to use it outdoor, so will there be a partition to prevent the wind blowing the chairs away]
00:17:50: M: *yes, itu kena tahu berapa kali percubaan sebab untuk saya ia kan tepi sahaja and di depan dan belakang buka so angin sentiasa ada tapi saya buat tu tunggu angin adalah. Better kita buat dalam dewan sebab memudahkan. Sebab belon memang sensitive kalau ia terkena angin sikit, ia auto terlari apa yangg kia agak, pastikan kita punya battery drone itu atas 30%*
[M: Yes, we need to know how many trials because it comes from all directions. It is better that we use it in a hall, it is easier because the balloons are sensitive if there is wind, the wind will disturb the drone, and we have to make sure the drone battery is above 30%]
00:18:36 A: *di atas 30%*
[A: above 30%]
00:18:42 M: yes, bawah daripada 30% ia tidak akan buat
[M: yes, below 30% will not make it]
00:18:46 A: Okok. Terima kasih M, awak akan menjadi engineer yang hebat. Mantap ini.
[Ok, ok, thanks M, you will make a great engineer, great job]

From the interviews above, DEC4IR is a very effective educational program to develop future engineers who will be able to strive in the 4IR era. The learning activities are fun and contextual which make the participants learn while going through the activities that make learning programming and drones easy and motivating. The competition and gamification of DEC4IR is also a part of a very important element to motivate participants to learn new knowledge by themselves, with guide from the speakers, facilitators, their teachers, peers and experts. The social context provided in DEC4IR is similar to that of Robotic Academy, only that DEC4IR is designed for school students and is proven to be effective [8].

5. Conclusions

In summary, DEC4IR has successfully organised nationwide to disseminate knowledge and understanding of drone. This is very important to prepare students to face the new era of 4IR and to foster their interest in STEM. Furthermore, DEC4IR not only is a success as a national competition for schools' students, but it also develops future engineers and STEM talent that are gravely needed by the country which is now facing severe shortage of STEM talent [21,22]. DEC4IR can be considered as one of the lifelong learning in STEM education, especially as a form of informal STEM education [23]. It has been expanded to primary school students and university students' service-learning projects [3,24,25].

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