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Droneducation: Empowering Tomorrow's Workforce through IR4.0-based Curriculum

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Abstract
With more jobs being taken over by digital technologies, the major concern of higher education institutes (HEIs) today is to find possible means how to develop future-ready workforces. This study explores the use of drones to enhance university students' knowledge and application within the context of Industrial Revolution 4.0 (IR4.0) education. This research's salient findings are that the students' motivation to enrol in this course is due to their interests, curiosity, and career potential, which entailed a flexible learning process beyond traditional classroom activities. Apart from that, the important synergy between universities and industries was observed to empower students' learning experience. Given the uncertainties ahead, the findings will contribute to HEIs to prepare tomorrow's workforce to meet the IR4.0 challenges.
Keywords: Space Science, STEM Education, IR4.0, 21st Century Education.

Introduction

IR 4.0 will change the future of employment with many current jobs no longer existing in the years to come. The flagship reports of World Economic Forum's Future of Jobs 2018 reported that '*A cluster of emerging roles will gain significantly in importance over the coming years, while another cluster of job profile is set to become increasingly redundant*. The rapid development of IR4.0 has changed the world with various technology-based inventions and innovations.

To better prepare graduates for these rapidly changing industry needs, the HEIs' role is not only to produce graduates to fit in the current job markets and empower them to adapt to future jobs that have not yet existed. The programme, course and teaching approaches offered by HEIs must be agile to instil a lifelong digital skill to create impact and provide solutions for various problems through the digital ecosystem (Ministry of Higher Education Malaysia, 2020; Tapsir & Puteh, 2018). It is no longer the one-size-fits-all approach. The HEIs are now working on possible means to equip their students, not just with academic qualifications but also with hybrid skills. Hybrid skills would encompass qualities such as creativity, problem-solving, critical thinking, and data-driven decisions, thus enabling students to unleash their full potential to stand out and potentially create an impact in an ever-evolving digital industry.

With intensified competition in the IR4.0 global economy, today's students must leave university with a range of new sets of inter-discipline skills and competencies. The HEIs must give greater emphasis to enhancing students' career prospects and pathways that contribute towards nation-building.

In line with current reforms, most HEIs in Malaysia have already restructured their curricula by integrating subjects that are significantly pertinent to the needs of the IR4.0 workplace for their students (Tapsir & Puteh, 2018). This notion has been communicated through the IR 4.0 Education framework to ensure that Malaysian universities' programmes are in line with the global and local changes that have taken place in the IR 4.0 era. This accentuates flexible education that incorporates collaboration with the industry to develop future graduates' 21st-century skills; critical thinking, problem-solving, communication, collaboration, creativity, technological literacy, and digital skills.

While the path of IR 4.0 is still fuzzy, and it is difficult to predict what lies ahead accurately, it also will create numerous new types of jobs that require a different set of skills. Hence, the HEIs have to be ready to prepare job-ready and future-proof graduates and provide opportunities to instil a more flexible delivery of education for future proof-careers.

To unlock big moves towards IR4.0, the HEI must re-design their programmes, nurturing talent for the workforce and becoming a one-stop knowledge for solving industry and the community's problems. Although there are rising calls for HEIs to offer digital-based curricula and skills development programmes, the number remains relatively low; with only a minority HEIs having embraced digital transformation (Gkrimpizi et al., 2023). While the specific requirements for digital skills and proficiencies are still unclear, there is a consensus that the HEIs must adopt a comprehensive digital strategy to prepare future workforces that need to be digitally capable. Nevertheless, there is still a gap in knowledge on how the HEIs should embrace and prepare students for digital transformation. The main concern of the HEIs is how should they enhance the IR 4.0 education to produce future-proof graduates that are ready for digital markets.

In this regard, the Drone for Aerial Photography has initiated a course -, an elective co-curricular course in nurturing, upskilling, and preparing talents and skills for IR4.0. This initiative helps students develop their needed skills to take up the future's high-paid and high-skilled jobs. In line with the IR 4.0 educational approach, this drone course was designed with a multidisciplinary orientation that emphasises collaborative and hands-on experiences that give students a sense of the workplace.

Drone Applications in Education

Drones (or unmanned aerial vehicles) are designed with aerodynamic forces instruments, including robotic arms or high-definition digital cameras, to improve and optimize industrial processes. Though they initially seem to be more of a niche hobby, extensive growth in the applications and technology developments make drones an important emerging technology to enhance operational efficiencies for many industries.

Several studies on drone technology (such as Sanfridsson et al., 2019; Corrigan, 2020; Poikonen & Golden, 2020) and its application in various industries (such as Dugdale et al., 2019; Gschwindt et al., 2019; Huang et al., 2019; Kavoosi et al., 2020) have captured great research interest from a wide range of disciplines in recent years. From fighting in wars to improving the teaching and learning processes, drones' possibilities to create real value are endless (refs).

For example, in an initial exploratory study, Brunner et al (2019) deployed a Drone prototype in a real-world environment to tackle autonomous last-mile issues delivery in urban environments using an off-the-shelf drone. To improve the hyper-realistic maps and simulation components of drones race, Spica et al (2020) recommended a novel receding horizon planning algorithm that allows each player to estimate its opponent's relative position for Autonomous Two-Player Drone Racing.

Drones also become an innovation for wildlife monitoring and conservation. Lyons et al. (2019), for example, used drones to monitor large and complex wildlife aggregations, while Kays et al (2019) utilized drones with mounted thermal infrared radiometric sensors to detect and map the wildlife. Moreover, Kelaher et al (2019) used the drone to assess variation in assemblages of large marine fauna of the ocean and Kelaher et al (2020) used aerial surveys to improve the sampling precision of nearshore marine wildlife. In mitigating traditional tracking and monitoring issues, Weston et al (2020) provided an excellent overview of how laws and codes of practice can be applied to reduce negative interactions with wildlife for the recreational use of drones.

Also, drones provide a relatively accurate and reliable methodology for capturing building images for heritage buildings' conservations. In a recent study to assess the stability and the seismic vulnerability of the bell tower, Micelli & Cascardi (2020) have developed an innovative approach of the drone-based survey to reduce the time-cost expenditure of the structural assessment for a heritage building. As part of emergency disaster response, by using the advancement of deep-learning models for natural disaster surveillance, Mishra et al (2020) developed an autonomous drone for search systems that contains more than 30,000 human instances of different actions. During the tsunami disaster at Tokyo Electric Power Company in Fukushima in 2011, a UAV was used to quickly assess the damages by the emergency responders Irizarry et al (2012) as often practised in the industry for building safety inspection purposes (Alizadehsalehi et al., 2018). All these studies reveal that drones have already attracted researchers' attention, opening up new opportunities to unlock a wide range of industries' productivity and efficiency.

With the sophisticated design and wide range of drone applications, many educational practitioners have begun to integrate drone technology to enhance teaching and learning processes.

For example, some educational practitioners have promoted drones as a platform to enhance teaching and learning processes (Norman et al., 2018). By using drones, Chou (2018) has established a comprehensive curriculum to investigate the impacts of using drones on the development of cognitive skills and sequencing skills (Bermúdez et al., 2019). The finding revealed a significant relationship between drone application and students' learning improvement Nordin & Norman (2018) in both skills.

In fact, with the growing importance of Science, Technology, Engineering and Mathematics (STEM) skills for the future, many educational practitioners have started using drones to engage their students in STEM Education. By promoting computer programming and robotics, Bermúdez et al (2019) initiated a Drone Challenge in which students had to program the navigation system for drone operations. Yousuf et al (2019) integrated exciting hands-on activities and enhanced students' interest in robotics and critical thinking using drones. Using the Python programming language, Bhuyan et al (2020) suggest that Drone education helped students improve their critical thinking and motivated them to pursue careers in STEM-related disciplines, specifically in information technology and cybersecurity areas. This view is reflected by Farr & Light (2019), who suggest that the 'The Sky's the Limit: Drones for Social Good' programme allows students to identify the connections between drones, particularly engineering concentration and social reflection.

From the above review, drones' utility is already an essential part of the curriculum in higher education institutions. The consulted literature works also revealed that introducing drone education can provide an exciting and valuable experience to students to foster a technical career path in engineering or drone-related fields. Using this as a starting point, some issues in designing IR 4.0 education through drone application warrant further discussions.

Methodology

This study investigated the use of drones to enhance university students' knowledge and application within the context of IR 4.0 education.

A survey was conducted amongst 84 students who enrolled as the first batch of the Drone for Aerial Photography. This elective co-curricular course is offered to all students regardless of their discipline (or main bachelor's program).

The students were given exposure to the complex and challenging drone industry scenario that required novel solutions. For that, students were taught six components of drone application in industry, ranging from:

i. theoretical (such as types of drones, fundamental uses of drones, and drone operation techniques), to
ii. practical drone applications (such as drone application in the industry, professional drone-related careers, and drone entrepreneurship).

At the end of the course, an online questionnaire was distributed to the students to assess how far the course has achieved its presumed objectives. The questionnaire's objective is to gather the student's opinions on their learning experiences and perspective. Before the session, the students were briefed about the questionnaire's objective. They were required to fill in the consent form to indicate their willingness to contribute to this study and pledge honesty and sincerity in providing information and responses. Ethical practices such as the anonymity and confidentiality of respondents were guaranteed throughout the questionnaire. Reflection on results and feedback provide significant insight for improvement in the course delivered in the subsequent semester.

Demographic Data

The students' complete demographic profile comprising gender, year of study, faculty, and permanent residential areas were presented in Table 4.1.

Table 4.1
Demographic Profiles of the Students

Respondents' Characteristics		**Percentage (%)**
Gender	Male	74
	Female	26
Year of Study	Year 1	26
	Year 2	26
	Year 3	39
	Year 4	9
Faculty	Faculty of Information and Science Technology (FTSM)	22
	Faculty of Science and Technology (FST)	39
	Faculty of Social Sciences and Humanities (FSSK)	22
	Faculty of Engineering and Built Environment (FKAB)	4
	Centre for Liberal Studies (CITRA-UKM)	13
Permanent Residential Areas	Urban	70
	Rural	30

The result shows that male students mostly favour the Drone for Aerial Photography course. This significant pattern could very well be that male students prefer technology-based courses rather than female students. This finding is consistent with the previous study conducted by Cheryan et al (2017) which demonstrated females' underrepresentation in science, technology, engineering and mathematics (STEM) fields as a worldwide phenomenon. Stoet and Geary (2018) also reported that males expressed greater interest, higher self-efficacy and more satisfaction in science, technology and mathematics while females are relatively better at social science.

The course's enrollment is explicit that the course was favoured mainly by the third-year students recording the highest enrollment rate (39%). The course was quite a popular choice among the first and second-year students, given the equal portion of 26 per cent as presented in Table 4.1. Surprisingly, the lowest number of students taking the course less than 10 per cent suggests that the final year students less favoured the course.

Data on the faculty to which the students belonged were also analyzed. The results indicate that the highest number of students were from the Faculty of Science and Technology (FST) with 39.13%. Furthermore, the results exhibit that most of the students who took up the course were those from the science and technology disciplines comprising the Faculty of Science and Technology (FST), Faculty of Information and Science Technology (FTSM) with a total of 22% and Faculty of Engineering and Built Environment (FKAB) with 4%. There are smaller numbers of students from the social sciences and humanities disciplines combined, with 22% from the Faculty of Social Sciences and Humanities (FSSK) and 13% from the Centre for Liberal Studies (CITRA-UKM).

The findings also show that many students (70%) reside in urban areas.

Analysis

Drone Applications

The students were asked to indicate their opinion on how they had perceived drone application as highly applicable and which industry they were interested in exploring more.

Table 5.1 shows that most students perceived the construction (building, infrastructure and real estate) industry with a score of 16%. This is perhaps because drones are being utilized widely in the construction industry in multiple aspects around the world.

Table 5.1
Application Drone in Industries

Industry	%
Construction (Building, Infrastructure and Real Estate)	16
Entertainment (Advertising and film making)	15
Oil and Gas	15
Sport	11
Manufacturing	9
Geology	9
Agriculture	5
Food Services	4
Tourism & Hospitality	4
Forestry	3
Aviation	3
Maritime	3
Insurance	2
Healthcare	1
Total	100

It is not a surprise that the students chose the entertainment (advertising and filmmaking) industry as the second most industrial application in which drone was utilized. It is undeniable that drones have become popular tools utilized by directors and cinematographers to film stunning vistas, exciting aerial shots of actions and overhead crowd shots in a wide range of media. Besides their reasonable cost compared to cameras mounted on a helicopter, drones are more convenient and reliable as they help film directors save a significant amount of money for movie production (ref).

The application of drones in the insurance and healthcare industry was placed at the bottom of all the students' choices list. This seems to suggest that most of the students were not aware or had limited knowledge of how drones can provide services for the insurance and healthcare industry.

Industrial Uses of Drone

Table 5.2 indicates that out of 12 drone applications, the majority, 20% of the students, showed their interest in exploring drone applications in the aerial photography and video industry motivating them to enrol in the course. This manifests that aerial photography and video are significantly valuable for producing aerial footage and photogrammetric techniques in innovative ways for their class presentations, class projects, student campaigns, social media and environmental monitoring for study purposes.

The students also showed relatively high interest in 3D surveying and Geographical Information Systems (GIS) mapping (15%), with Game trailing closely behind at 14%. Engineering applications were also favoured by the students (12%). Unmanned cargo systems urban planning, and Non-Descriptive Technique (NDT) inspection were also popular (both at 8%). Meanwhile, in general, the students indicated their less interest in the type of drone used in natural science and wildlife study and preservation.

Despite Malaysia's position as a biodiversity hotspot with rich, charismatic wildlife, the study reveals that most students were not aware of the fact that Drone is significantly applied in many studies on natural science and wildlife preservation. This also points to the need to conduct more studies on drones' application in natural science and wildlife preservation as a new niche area for future exploitation.

Table 5.2
Industrial Uses of Drone

Industrial Uses of Drone	**%**
Aerial photography & video	20
3D Surveying & GIS mapping	15
Game	14
Engineering applications	12
Unmanned cargo system	8
Urban planning	8
Nature science	2
Non-destructive testing (NDT)	7
Safety surveillance	3
Shipping and delivery	5
Emergency & disaster response	4
Wildlife study & preservation	2
Total	100

Students' Perspectives on the Course

Before their enrolment in the course, more than half of the students (61%) reported that they already had some basic knowledge of digital literacy including the basic use of drones. More than two-thirds of the students are aware of drones' basic uses, drone applications in the industry, types of drones in the market, drone entrepreneurship, and professional drone-related careers. One out of five (20%) students also possess enough knowledge of drone operation techniques, as illustrated in Table 5.3.

Table 5.3
Students' Knowledge: Pre-Course and Post-Course

Topic	Pre-course Knowledge		Post-course Knowledge	
	None	Yes	None	Yes
Basic Uses of Drones	39%	61%	0%	100%
Drone Applications in the Industry	52%	48%	0%	100%
Types of Drones in the Market	61%	39%	0%	100%
Drone Entrepreneurship	61%	39%	0%	100%
Professional Drone-Related Careers	70%	30%	0%	100%
Drone Operation Techniques	78%	22%	0%	100%

At the end of the semester, students gained more knowledge through drone assignments and other related activities using drones. The students could use their knowledge whilst completing the tasks given to them to fulfil the course's requirements. It is evidenced that the students were forced to demonstrate computational thinking (Amenyo, 2018; Bermúdez et al., 2019) while programming basic tasks using the drone to achieve given objectives for classroom projects and activities. This supports Piaget's constructivism theory (Piaget, 1968) that contributes to students' scaffolding knowledge based on their learning by doing activities.

The Drone for Arial Photography course also impacts the students' learning, literacy and life skills, i.e., critical thinking, technology literacy and creativity that add value they gained from this course. This course has compelled the students to apply higher-level thinking, i.e., problem-based learning, since exploring various trial-and-error measures to accomplish the given tasks. At this point, the lecturer's role is essential to present learning objectives that correspond with Oakley & Sejnowski's (2019); Vygotsky's (1994) methods.

The findings also demonstrate that the student's prior knowledge and enthusiasm for using drones have led to their motivation and interest in learning the content. This also enhances the students' full engagement in learning activities.

Enriching Students' Learning Experiences

Despite the students' varying percentages of knowledge on drone education before the course, the students, in general, were positive and satisfied with the theoretical and practical knowledge of the drone they obtained by taking the course (Figure 5.3).

In enriching students' learning experiences during the course, several guest speakers from the industry were invited to interact with the students in a series of collaborative drone activities for each topic on drone applications in the industry, types of drones in the market, drone entrepreneurship, professional drone-related careers and drone operation techniques. Students were exposed to real-world practice and open-ended problem-solving activities.

During the session, the guest speaker shared his practical knowledge and real industry examples of drone application and implementation. This facilitates the students to integrate theory and current best practices in the industry. By utilizing experiential learning approaches, nearly all students (96%) were relatively satisfied with the guest speaker's forum. This manifests that the students enjoyed the real-world knowledge-sharing session that enhanced their knowledge and learning experience.

Table 4.5 shows that the lecturer's presentation and assignments provided for the students and group teamwork scored relatively high (85%), followed by assignments (91%) and group cooperation/ teamwork (91%). The students also found the course content (87%), the course management/conduct (82%) and the number of students per classroom relatively satisfactory, as shown in Table 4.5.

Table 4.5
Students' Perspectives on the Course

Category	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied
Course content	0%	13%	61%	26%
Lecturer's presentation	0%	4%	52%	43%
Series of collaborative drone activities with the industry	0%	4%	48%	48%
Assignments	0%	9%	52%	39%
Group cooperation/ teamwork	0%	9%	43%	48%
Students' satisfaction with the number of students per classroom	13%	9%	48%	30%
Course management/ conduct	4%	13%	43%	39%

It is evidenced that important approaches such as inviting speakers from the industry, lecturer's presentations and assignments play a vital role in the student's enthusiasm for drone education. It is safe to conclude that the Drone for Aerial Photography course effectively enhanced students' knowledge with regard to both theory and the practical applications of drones. Subsequently, the knowledge gained would help broaden the students' perspective on using drones professionally for business or future careers.

Discussion

The main rationale behind deploying drones in an educational context is that the apparent and increasing usage of drones in industries has broadened in recent years.

Through this course, we instil digital knowledge based on students' interests, equipping them with the right digital skills, enriching digital experience, and transforming them to strive for jobs that have not existed. The teaching and learning process was based on the real drone-related business case studies that the industrial expert guided. This is to prepare them to make significant contributions to the industry immediately upon graduation. This also ensures graduates who enter the workforce are equipped with the right skills and attributes to succeed in a globally competitive employment market.
The main challenge in developing this '*Droneducation*' is to break down the boundaries between disciplines. The design of this course structure must be fluid, flexible, and organic to

cater to the co-curricular course and offered to all students regardless of their discipline. Rather than 'mere passive listeners' graduates, it is challenging to develop broader generic attributes of students who possess not just deep disciplinary knowledge but a keen ability to strive effectively across disciplinary, social and cultural boundaries. This ensures our graduates can adapt to IR4.0 revolution challenges to respond effectively to the dynamic career demands after graduation.

Rather than the "one programme fits-all-approach", this drone course encourages students from different profiles to individually develop both depth and breadth skills and abilities as part of academic achievement in the various drone-related knowledge.

As noted in the findings, before enrolment in the course, more than half of the respondents reported that they already had the literacy of the basic use of drones. Furthermore, more than two-thirds of them have sound knowledge of basic uses, types, applications, drone entrepreneurship and drone-related careers. It can be asserted that most of the students who participated in this course due to their interests, curiosity and career potential. This finding supports previous studies by Jean Piaget, which proposed that knowledge is not simply transmitted from teacher to student but actively constructed by the learner's mind (Piaget,1968). Accordingly, the students' perceptions of drones are gradually extended from theoretical knowledge to practical applications.

In this course, lecturers did not directly feed the students' information; instead, they facilitated the students with a 'Discover-Explore-Experiment-Experience' (DEEEs) approach. While doing the learning activities, this study observed that students' past experiences, working on real-life problems, and outside classroom activities were considered. As a result, the findings showed that most students could customize their learning pathways depending on their interests, style, pace, and learning orientation. In this context, it requires a flexible learning process that goes beyond traditional classroom activities.

In this course, the industries actively designed the curriculum, such as holding in-class workshops, participating in professional development activities, hiring interns, sponsoring capstone projects, and providing job placement. It is imperative to note the overwhelming positive responses from students on a series of collaborative drone activities. This finding is congruent with several recent studies on infusing industry-based skills into education by (Alexander et al., 2020; Leischnig & Geigenmüller, 2020; Rybnicek & Königsgruber, 2019). The inclusion of industry engagement activities as part of active pedagogical tools for this course was a platform to enhance the student's learning experience and build essential linkages between university-industry-community settings. The integration of the student into early career development would enable them to quickly demonstrate their value and potential and enhance their competitiveness for IR4.0-related careers. This also revealed that direct engagement from the industry provides students with different perspectives, as well as enables them to more clearly understand the demands of the job and the skills required by the industry when they enter the job market.

Like many new and contemporary technologies, drones are another engaging tool for students to prepare themselves for IR 4.0. By bringing students to the real world and the natural world to the students, this course gives them opportunities to develop their versatile experience, creativity and desirable attributes for the IR4.0-related career. In this measure, the Drone for Aerial Views course appears to have achieved its key objectives.

Conclusion, Limitation and Recommendation for Future Research

For most HEIs, the IR4.0 is sometimes described as an incoming thunderstorm - visible in the distance, arriving at a pace but with little time and resources to prepare. When considering future-proof strategies, this unevenness leads to these concerns - Where are we? Where do we want to be?, How do we get there?

By engaging the Drone for Aerial Photography course as the context and students as the unit of study, this study revealed that despite academic experience, the Drone for Aerial Photography course was a practical approach to instil the need for solid talents for tomorrow's digital future. By bringing students to the real world and the natural world to the students, this course nurtures and cultivates students with the proper knowledge, skills, attitudes and values for the future. This requires a flexible learning approach that requires collaboration and synergy from governments, industries, and society.

Given the nature of this research design, a few research limitations emerged from this study's findings. First, 84 students in the first batch of students who enrolled in the Drone for Aerial Photography course participants of this study might pose generalisability and external validity issues. The findings of this study may not be generalized to students with different demographic qualities. A more significant number of participants, including different demographic profiles, might generate more diverse demographic patterns to address this need. In this direction lie potential future lines of research relative to the futuristic curriculum design.

Preparing the HEIs to engage with the future IR4.0 skill demand is a crucial strategic task. In the context of drone education, further empirical research needs to be conducted to examine drone education's potential as a platform to prepare students for IR4.0. In addition to deploying drone applications and their impact on preparing future-proof graduates, longitudinal studies are needed to fully understand future skills, HEIs readiness, and industrial readiness. However, given that a longitudinal study will usually require a long duration and funding, our work provides a baseline study for stakeholders. Nonetheless, we also recommend conducting additional research to understand better the dynamics of student preferences for drone technology-related activities with other pedagogical approaches.

Finally, we reiterate that more efforts should be made to develop an IR4.0 graduate competency readiness model in measuring and benchmarking the HEIs's maturity in producing and preparing students for IR4.0.

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Availability of Data and Materials

De-identified data and study materials are available by request from the corresponding author.

Consent for Publication
Individual data use was approved by study participants in accordance with local and federal guidelines.

Competing Interests
The authors declare that they have no competing interests.

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