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Practical Pedagogy for Embedding Drone Technology into a Business and Computing Curriculum

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Abstract

This paper outlines the design of an undergraduate module in 'Applied Drone Technology' to enhance student engagement and learning of a new technology within a business school curriculum. It focuses on the development strategy and issues the team encountered when trying to create something outside the usual core computing and business curriculum. Although there are barriers and issues to integrating drones into a curriculum, it can be accomplished with proper planning and a strategic vision. The result was a module that can be used by students in a business school, but with the capability of being used by students in other academic units.

Keywords: drone, UAV, UAS, curriculum development

1. Introduction

The recent introduction of unmanned aerial vehicles (UAV), more commonly known to the public as 'drones', has resulted in more opportunities for businesses to incorporate this technology into their operations and long-term growth., The rapid growth of this technology has kept firms scrambling to keep with hardware and software transformations. They find it increasingly difficult to find skilled employees who can operate and implement drone applications, and understand this technology from a business point of view.

Universities have recently started to engage with this technology, but mostly at the post-graduate level in the science areas, or for research purposes. In the UK, this is especially problematic at the undergraduate level, where universities have not embraced drone curriculum, especially in the business area. This paper highlights a project to develop an undergraduate drone applications technology module under a business school curriculum at a UK university. The project started with applied drone technology into some post-graduate research aspects of the university, and progressed to some incorporation of drones into a few seminars at undergraduate level. At that time, interest in drones within the industry and among students was growing, and it was imperative to build an applied module for undergraduates. The project continues with the process and procedures the module team followed to successfully create an effective module specification.

2. Literature Review

2.1 Drone Marketplace

According to Atanasov (2016), the use of drones has grown outside of military uses into a significant number of business applications crossing a range of industries.

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A European Commission (2015) impact assessment report on UAV growth estimates that about 10 percent of civil aviation will be unmanned by 2025 compared to a miniscule amount today, and drones will become an important tool and part of many businesses, supporting the competitiveness of various industries. The impact report states worldwide forecast of market growth and jobs, where the world forecast on drone applications is expected to double by 2022 and represent about 4 billion Euro per year. European drone employment by 2050 in manufacturing is expected to increase to 150,000 jobs. The number drone jobs in the USA for 2025 is estimated to exceed 100,000, with an economic impact of more than $13.6 billion.

According to a report by IBISWorld (as cited by Canis, 2015), the largest market for UAS U.S. sales is still military, but civil and commercial segments will be at $125 million in 2015 employing 8,300 U.S. workers. The study predicts that by 2020, the U.S. commercial market will grow to $4.3 billion with 10,000 jobs. Another study by Teal Group (as cited by Canis, 2015), predicts that over the next 10 years worldwide UAS production will rise from $4 billion to $14 billion. A more recent and optimistic study by The Association for Unmanned Vehicle Systems International (AUVSI) estimates that $13.6 billion and 70,000 jobs will be created in the by 2020 (Solomon, 2016).

The growth of the drone market has created business opportunities for many industries. Currently, the civilian drone market is comprised of entrepreneurs and small companies, although large global firms like Amazon, Google and Wal-Mart Stores have been testing drones for warehouse inventory, curb-side pickup and home delivery, and waiting for USA regulators to weigh in on commercial use of UAVs. The biggest challenges in the commercial market will be the ability to adapt to government regulations (Weissbach and Tebbe, 2016).

Liu (et. al, 2011) mentioned surveying firms could use UAVs to acquire high quality terrain images of the areas of interest, particularly when such a task could potentially risk human life. The geo-referenced images can be used for various engineering or business activities, such as urban and road planning, the site selection of factories and bridges. Cope (2016) states that photography and filming for wildlife projects or for TV and cinema is a popular application. The author also mentions that emergency services workers and engineers can use drones in a variety of ways and make their jobs much safer.

2.2 Drone Employment

The number of jobs in the UAV industry is expected to grow significantly during the next decade. Cope (2016) quotes a U.S. Federal Aviation Administration prediction that there will be 70,000 jobs created in the drone industry by 2018, and that qualified UAV operators should be highly sought after by many companies. Currently, rates for drone operators are very good. In the UK, £350-£500 daily rate is the industry norm (Dronesafe 2016). In the UAV industry, consultants are the highest paid professionals (70,500-145,500), followed by systems engineers ($72,350-$127,000), UAS pilots ($85,000-$115,000), instructors ($74,500-$93,000), payload operators ($74,500-$93,000) and imagery analysts ($57,350-$84,600) (UAVCareers.org, 2016). There are a variety of careers in the UAV industry, which includes pilots, programmers, camera operators, imagery analysts and technicians (DroneTrainingHQ.com, 2016b).

2.3 University UAV Programmes

Because of the current and projected increase in the drone market and employment opportunities, universities are looking to add drone technology to their curriculum. This would provide graduates with various technical and professional employability skills for future careers in various industries. There are now 21 U.S. community colleges and universities that offer degrees in drone technology at both the undergraduate and post-graduate level (DroneTrainingHQ, 2016a). In the UK, at the time of this research project, there are no undergraduate programmes focused on UAVs. Three programmes exist at the MSc level: Cranfield University offers a MSc in Autonomous Vehicle Dynamics and Control (Cranfield University, 2016), Liverpool John Moores has an MSc in Drone Technology and Applications (Liverpool John Moores, 2016), and Southampton offers a MSc in Unmanned Aircraft Systems Design (University of Southampton, 2016). These degrees are heavily based on engineering and systems. According to Al-Tahir (2015), most UAV-related university programs are within mechanical engineering, aerospace engineering or robotics departments. Most fall into the following typical levels:

Certificate programme in UAV pilot and operations

- Minor in UAS systems specializing in navigation
- Undergraduate degrees that prepare graduates for jobs in operations, sensing and administrators
- Masters and PhD programs in UAS specializing in engineering aspects.

Although current university curriculum are aimed at operations and engineering aspects, this may be shortsighted in terms of industry needs. Pezeshki et al. (2016) claim that UAV faculty are often poorly equipped to facility student groups and tend gravitate towards intense disciplinary specificity. As UAV ventures are high risk, it would be problematic for any one person to have the knowledge to implement an integrated project. The authors suggest curriculum have an interdisciplinary effort.

Few colleges and universities have attempted to venture outside the scientific or engineering aspects at this point. One early exception was the University of Missouri and University of Nebraska, which attempted to start drone journalism programs. In 2013, both universities received a letter from the U.S. Federal Aviation Administration requesting that it cease all outdoor flight, and required that they receive Certificate of Authorization (COA) before they could resume outdoor flying. Even with the COA, it would restrict where the university could fly drones, thus affecting their learning programs (Davies, 2013). After a hiatus of several years of indoor flying, the Missouri program was restarted after the FAA's new Part 107 regulation came into effect in August 2016, which allowed "student use of unmanned aircraft in furtherance of receiving instruction at accredited educational institutions" can fly under the "recreational/hobby" (non-commercial) classification and does not require FAA authorization. This allows students at educational institutes to fly, but under the direct supervision of a trained UAV pilot (Shaw, 2016).

In the UK, there are no dedicated undergraduate drone degrees, although some programs do include aspects of the technology within other courses. In 2015, the University of Hull implemented drone applications to logistics and supply chain management teaching at the Business School, where it was well-received by the students (University of Hull, 2015).

2.4 Pedagogical Approach to Drone Use in the Classroom

Technology enhanced learning approaches can be an effective way to deliver appropriate education to students. As technology advances, the pedagogy approaches within technology and business programs must also change. Carnahan et al. (2016) state that the inclusion of drones in instructional activities yields increases in student motivation and engagement. An example is the use of robotics to allow students to have concrete examples of how STEM concepts are applied and used in business, thus allowing students to pursue complex careers.

According to Schmitt et al. (2012), technology becomes a medium through which educators can instruct and students can learn. In the UK, curriculum standards are being revised to include more technology competencies into curriculums. For example, in the UK, there is a new Environmental Science A-level starting in 2017. Students will fly drones and will learn about the use of drones to monitor crop pests and track wildlife poachers and satellite surveys to monitor water resources (Espinoza, 2016). The course has been assembled by exam board AQA, and is submitting it to educational standards watchdog Ofqual (Cutlack, 2016). As UK students studying at A-level do gain experience in drone technology, these students will progress to university level degrees expecting advanced UAV topics. Thus, it is imperative that universities do begin to implement drones topics into their curriculum.

Soft skills development, such as teamwork and presentation skills are important to employers. Teamwork can be used as a pedagogical tool, and students working together on drone projects can gain valuable employability skills to aid them in their careers. Band (et al, 2013) explain how they implemented a drone class where students gained project management and team-building skills. Carnahan et al. (2016, p. 8) explains that the goal of successful technology integration in education is to drive a student-centered, investigative based learning environment. The use of drones in the classroom can yield an increase in student motivation and engagement, and they can gain a broad range of skills. Carnahan et al. (2016, p. 12) have devised a SOAR module for drone usage in the classroom, which focuses on the user experience, while providing research-based foundations for ethical, legal and pragmatic uses of drone technology. The components of the SOAR module include:

1. **S**afety – ethics and legal issues
2. **O**peration – flight, maintenance and trouble shooting
3. **A**ctive learning – engagement in solving problems
4. **R**esearch – practical applications

The authors explain that the SOAR model has been successful in K-12 US education (Carnahan et al., 2016, p. 12), but this could be applied to other educational endeavors.

3. Case Study

3.1 Current Implementation of Drones

The use of drones in the current University of Worcester curriculum encompasses some limited use across several Institutes in both undergraduate and postgraduate programs. In 2014, a lecturer in the Institute of Science secured a €100.000 Marie Curie Career Integration Grant (CIG) to use a drone for developing mathematical models that describe movements of biological material in the air. The award will therefore both enhance basic understanding of bio-aerosols and improve existing forecasting of pollen and fungal spores: a major cause to hay fever in the UK (University of Worcester, 2014). Another researcher is using drones image processing techniques for mapping the physical conditions within rivers (University of Worcester 2015).

The Worcester Business School began some limited applications in two modules for spring 2017. For the Level 5 and Level 6 e-business modules, tutors created video lectures on business uses of drones in the commercial market. They also created three seminars of drone flying and implementing marketing campaigns using drone footage. This allowed students to have the option of using this footage for their assignment, or using a non-drone method of collecting videos. Drones were also used in the Level 4 'Creative Computing' module. Students spend two seminar sessions collecting drone videos and images, and then used Adobe to edit what they had collected. For both modules, drone topics were incorporated into existing learning outcomes. For example, one of the learning outcomes for e-business was 'assess the effectiveness of information technology innovation and emerging Internet technologies on various business functions.' Implementing a new and innovative technology into this module thus met learning outcomes. However, having only two or three seminars in drone technology could only expose students to a very small 'taster' of what this technology could actually do, thus necessitating the need for an entire module.

3.2 Evaluation of Need

In the spring semester of 2016, informal discussions among colleagues in several Institutes recognized the need for more inclusive inclusion of drone technology into courses. The major reason for this was the recognition of industry needs and employability of UAV pilots and surrounding jobs related to drones, as discussed in the literature review. In September 2016, UoW lecturers and the Head of UAS for a local UAV firm gave a presentation entitled 'Drones in Business: Can your Organisation Capitalise on this New Technology?' Over 20 members of various local firms who were interested drone implementation attended the presentation. Firms were interested in hiring drone graduates as well as working closely with UoW on various UAS projects. Interest by students to include this technology into the curriculum was very high. To prepare to module approval, the Computing Department completed a survey of Level 4 (L4) and Level 5 (L5) Computing students to just the interest of creating a new drone technology module. Of the 195 students at L4 and L5 students, 94 took the survey. Table 1 shows the results of the survey with five levels of interest in signing up for a drone applications module. Thirty percent of students were very interested in attending a module, while 44 percent were fairly interested. Interesting, only 15 percent were neutral while 10 percent would not sign up. In order to create a new module, the general policy is that a module needs at least 15 enrolled students to be viable. The results of this survey showed a remarkable interest by the students in learning this technology. We anticipated therefore, a viable number of students to run several occurrences of a module.

Table 1: Student interest in drone module

	L5 students	L4 students	total
Very interested – will definitely sign up	14	14	28
Fairly interested – might consider signing up	17	25	42
So-so, may or may not sign up	5	9	14
Not very interested, probably will not sign up	3	7	10
Definitely not interested – won't sign up			0
	39	55	94

The Worcester Business School runs the Media Lab, a university laboratory where students can gain real-world employability skills on client projects. Firms with projects (web site creation, mobile app development, and others) contact the university to arrange for student teams to implement a variety of projects under direct supervision of a university lecturer. Students gain project implementation and development skills, the firms benefit from a completed project at a fraction of the cost of developing the application themselves.

There have been several requests for development of video applications using drone technology. As more of these are requested, it would be imperative that students do gain some knowledge of drone development in their modules as well as Media Lab projects.

3.3 Preliminary Assessment

In order to gain approval over where to fly within university property UoW's insurance company required a site risk assessment of drone flights anywhere on university grounds. The risk assessment consists of the following parts:

1. Drones that will be flown
2. Safety plans
3. Site survey
4. Risk rating matrix
5. Activity and site specific location

A separate risk assessment document was completed for each indoor and outdoor site areas where drones could possibly be flown for classes or other public activities, such as Open and Visit Days. Some of the indoor rooms that were accepted were the gym and some large classrooms (with limited audiovisual equipment that could be broken). The team had some trouble with some outdoor venues initially chosen as potential flight zones. For example, one of the outdoor playing fields had overhead utility wires that were too close to the field. This was based on CAA flight rule 3.23 (over or within 50 meters of any vessel, vehicle or structure, which is not under the control of the person in charge of said aircraft) (Civil Aviation Authority, 2015). There was a practical reason too; high voltage lines are a source of radio interference that can affect the data links between the controller and the drone. One area the development team had to consider was the CAA rule about aerial work and if the operations were considered 'commercial' or not, which would mean more restrictions on flying. ANO 2009 Article 259 'Meaning of Aerial Work' details that a flight is for the purpose of aerial work if valuable consideration is given or promised in respect of the flight or the purpose of the flight. Flying operations such as research or development flights conducted 'in house' are not normally considered as aerial work provided there is no valuable consideration given or promised in respect of that particular flight (Civil Aviation Authority, 2015). According to SUAS Global (2016), "in most cases, self-funded or research drones developed by institutions such a Universities or private businesses can be regarded as non-commercial as long as they are not employed in providing a paid service to a third party." Thus, as long as UoW used these drones for educational or research purposes, they did not have to fly within 'commercial' guidelines.

It was deemed necessary to have a CAA certified UAV pilot present for any university sponsored event on university property, including class seminars, Open Days, research activities. Originally, three university lecturers had completed UAV pilot training (all in Institute of Sports & Science). To grow the drone program at the university, it was thus necessary to have more CAA trained drone pilots. After liaising with colleagues from other Institutes, we researched several firms that provided UAV training where CAA licensing could be completed. We found that it was sometimes difficult to determine from a firm's web site whether their 'UAV training' was actually certified by the CAA, so it took several weeks of additional email and phone communication to review companies. A UAV training firm in Wales was chosen where our lecturers could receive a combination of online training and an additional several days of flight training and testing. We finally decided to send six staff through this training (5 from the WBS and 1 from Institute of Science). Training sessions started in October 2016, and is anticipated that pilot licenses will be obtained by early spring of 2018 for staff.

Cross-institute communication was a large part of this development effort. A university-wide 'drone' team was convened with representatives from across four Institutes that were interested in incorporating drone technology into the curriculum or looking at it from a research perspective. Several meetings were held to discuss topics ranging from risk assessment, university process and procedures, Open Day coordination and potential module development.

Colleagues from the WBS, Institute of Science and Institute of Sport met in October 2016 to finalize development of a drone applications module. There was an initial thought that we could develop two modules: a drone applications module and a 'flight' module. However, we concluded that we would initially start with one 15 credit (semester-long) module that concentrated on applied drone applications that also included flying time. However, for this module, students would not have enough flying experience to actually be qualified as a CAA certified pilot.

The module would be developed from a generic applied focus, which meant that students from applicable degrees in four of the Institutes could enroll in the module as long as it was approved for their degree of study. Initially, most of the Institutes were going to include this new module in their 2017/18 plan for some degrees. However, by mid-November it was getting late to include new modules in the 2017/18 plan, as any new additions for a degree had to be approved in the January 2017 school approval meetings.

At the time, WBS still was able to take this forward. The team felt that a test of this initial module would be conducted by WBS Computing students for 2017/18, and then open up to other Institutes in 2018/19.

3.4 Module development and Pedagogical Approach

The Computing team met to finalize the module specification, and named the module COMP3305 – Applied Drone Technology. Idries et. al. (2015) mentions that several technical and non-technical challenges face a UAV development process, including business challenges and lack of project management. This module aims to address these issues with first addressing the use of drones from a business applications point of view (i.e. imagery, video, fieldwork planning, sensor and data analysis, and mapping). Second, students will learn project management aspects such as risk management, operations and scheduling. Third, they will also participate in drone flying to gain piloting skills. The final learning outcomes for this module were:

1. Display knowledge of the legal framework in which drones operate.
2. Complete risk assessments and site surveys to industry standards.
3. Demonstrate confidence in operating a drone safely.
4. Successfully implement a practical project using drone technology.
5. Discuss potential future applications for drone technology.

There will be two assessments for this module:

1. Planning document worth 50% of the module grade.
2. Practical project worth 50% of the module grade.

Part of the pedagogical approach to this module development was a strong emphasis on students developing 'soft' skills, as well as the technical and business skills. The team reviewed literature from Band (et al, 2013) who used presentations as part of their grading in their UAV class. Although they concentrated on the computer science aspects of drones, the team used the idea of incorporating presentations in a lecture theater so students can learn from each other and see what experiences others have gained. Band (et al, 2013) also opened up the final presentations to any other students so students from earlier semesters could get a glimpse of what to expect. The team will be taking this approach and attempt to have the students present during Open Days and Reading Weeks to other students, thus benefiting current and future students. Part of the pedagogical approach to this module was based on the SOAR module developed by Carnahan and Zieger (Carnahan et al., 2016, pp. 11-13), discussed in the literature review.

1. **S**afety is covered in learning outcomes 1, 2 and 3, which cover legal and ethical issues with UAV technology, as well as safe flying.
2. **O**perations is the flying and maintenance, covered in learning outcomes 2 and 3. They will gain project management skills and create a flight plan. This will also help with their analytical skill building.
3. **A**ctive Learning will be covered in learning outcomes 3 and 4. Students will solve practical problems in flying and creating applied projects (assignment 2).
4. **R**esearch is covered in learning outcome 5, which requires students to keep abreast of changes in the technology and legal aspects of the UAV industry.

Although WBS will teach the module in 2017/18, it was designed that lecturers and students from other Institutes could participate in the future. The assignment could be adapted by students in various degrees of study. For example:

1. Constructing a 3d model of a building using aerial footage and photogrammetric techniques could be a project for students in Institute of Science
2. Constructing an annotated panorama for use on social media or developing a video presentation of a property for estate agent use could be projects for students with an interest in Marketing, Social Media or Web area
3. Capturing high quality video footage for use in a film drama could be geared towards students in Graphic Arts or Media Design

4. Exploring the potential for drone delivery of small packages would be of interest to Computing students interested in developing their programming ability
5. Using drone photography and panorama stitching to assemble an isometric map of a large area could be a project for students in Science
6. Using drones as an educational tool for primary school students would appeal to Education students.

3.5 Logistical and Practical Approaches

Before completing the module spec, the team had to overcome several practical and logistical issues. First, they had to consider an appropriate level for module development, either Level 5 or Level 6. Due to the constraints of just having the WBS trial a module, the team decided to offer the module to L6 students initially.

One major logistical issue with running this module is the staff-intensive hours it takes to run compared to other similar Computing modules. An average Computing module would have 30 students in an occurrence, with one lecturer and possibly one lab demonstrator. However, we would have to limit the number of students in one occurrence. Flying too many drones at one time could be problematic with the number of radio frequencies used at once. In addition, flying in a gym would present a limited number of drones being able to safely fly at one time. Therefore, the team felt that a maximum of 20 students in one occurrence would be acceptable. The second issue is that we would need more staff compared to other Computing module sessions. To meet safety requirements and due diligence with safety, the team wanted to have a trained CAA pilot and an assistant for each flying session. This would make this module more expensive from a staffing point of view. However, we could use a Sessional Lab Demonstrator instead of two CAA pilots during flying time.

The Computing Department would run three difference occurrences, each with 20 students. To trial the module, the team would run the first occurrence in fall semester 2017 in order to test the module and make adjustments. Then two occurrences could be run in semester two. Room and timetabling are other logistics to consider. Any outdoor flying must be done during daylight hours. Therefore, the team requested that timetabling schedule the occurrences between 9:15 and 15:15 in order to ensure proper daylight hours, even during the short UK winter daytime.

During the risk assessment phase of this project, the team identified indoor and outdoor areas we could fly. Although it would be most beneficial to have wide-open outdoor fields to fly, the weather in the UK can be a problem for flying. Therefore, the team had to book both indoor flying space and outdoor fields at the same time. If the weather would be inclement, the students could go inside to a gym to fly. However, this did cause some issues with timetabling in that a single module appeared to be ‘double-booked’ for a specific date/time.

Another issue to resolve was how long the teaching session would be each week. Normally, Computing modules are held in a three-hour lab session each week. However, the content of each week could be adjusted accordingly. Some weeks might require a 2-hour lecture on drone laws following by a 1-hour workshop. The following week might be a dedicated 3-hour flight session. As weather conditions could change, the team would need to be flexible on changing weekly content.

The team submitted a draft of the module specification to the External Examiner who questioned the relevance of the module for students in the BSc Games Design & Development degree. The team answered that there were several areas it was a fit: drone racing, gamified flight with virtual reality, programming skills development. The second external commended the university on introducing an innovative module. The module specification was approved at a quality meeting in January 2017. At this point, further development of the module outline and module materials could begin.

3.5 Key Challenges and Lessons Learned

Several key challenges emerged from this development project. First, because this technology goes across many different business and technical areas, it is critical to develop a cross-Institutional approach to development and running this type of module. Experts from across business, science, graphics, sports need to be involved in the entire process. We had a very congenial group of colleagues who saw the vision for the future growth in this field and were willing to push for the development. Nonetheless, there were issues in a cross-Institute approach. Due to busy teaching schedules, it was nearly impossible to get all members of the team together for meetings.

Several decisions had to be made with key colleagues from various Institutes, who then disseminated the information to team members who could not attend meetings.

A second challenge the team faced was getting the financial buy-in from university management to run the module. Purchasing drones is not inexpensive, with the costs ranging from the actual drones, batteries, extra blades, cones for safety, netting and other anticipated equipment costs. There was also the cost to send several lecturers to CAA training to earn their drone license.

All of these tangible costs had to be approved by management before the module was approved. It was also important to secure the approval of management in all Institutes for this new degree. Presentations on the positive educational and employability aspects of the module were presented at senior management team meetings.

3.6 Future Development and Impact

Although this module is geared towards L6 students, there was a great deal of interest by students to also allow L5 students to take it. In addition, several Institutes felt the module would better fit into their curriculum at L5. Therefore, future development may be the addition of a similar module for the L5 students. Although it was too late for other Institutes outside the WBS to include the module for 2017, future plans are to allow students from specific degrees within the Institute of Humanities & Creative Arts, Institute of Science and the Environment and Institute of Sports and Exercise Science to take this module or a L5 module in 2018. This module creation project has shown that inclusion of drone technology affects most of the educational areas in some capacity.

4.0 Conclusion

In this paper, we have described the process of developing a drone module for UK higher education. This project has proven valuable learning experience for a variety of stakeholders. The process shows how a cross-institutional collaboration can be effective in developing a module that encompasses a variety of cross-functional areas to meet the increasing demands of businesses to employ well-rounded graduates. There are numerous benefits of other global universities in adopting this approach to developing a new module that encompasses technology within a business application setting.

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