Rozdział 2.

DRONEaBILITY(TM): A Licence to Fill the (in)Visible Void

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Introduction

After a serendipitous invitation from the BBC to comment on a drone's intrusion in landing paths at Heathrow airport in December 2014, the author identified drone operations and related challenges as a key area of his research interest. So many things had happened since that cold December morning when he spoke to the BBC transport correspondent. Following initial thoughts about the importance of education over regulations, especially for younger Unmanned Aerial Vehicle (UAV) users, the author has extended the research to the application of drones in the KS4 school curriculum (UK Government, n.d.), with results intended to serve as a platform for the delivery of advanced Science, Technology, Engineering and Mathematics (STEM) understanding. This initiative resulted in the Industrial Strategy Seed Fund (ISSF) funding of 15,000 GBP for the project DRONEaBILITY™ (DaB™) in the second half of 2017. The interest of filling in a societal challenge gap was identified by a senior representative from the Civil Aviation Authority UK who emphasised the need "…to stretch (regulations') boundaries to protect general public" (Royal Aeronautical Society, 2017a).

Although once constrained solely to military environments, drones are being increasingly used today in a wide variety of contexts. While their military origin sometimes brings a negative connotation, it does not necessarily follow that drone technology is constrained to a universal negative image. Suppose one remembers the opening of the 2018 Winter Olympics in Pyeongchang, South Korea, or a very early TV commercial when a soccer shoe was delivered in the front yard of that famous TV presenter by a well-known global parcel distribution company. One has to agree on the wide variety of tasks intended and given for drones to accomplish. The intention for UAVs to step in to accomplish "Dirty, Dull and Dangerous" tasks (Marshall, 2011, p. 160) translates into examples of positive stories that change the lives of all kinds of people. From refugee camp mapping or Coast Guard search and rescue, to delivery of medicines to remote communities or even food delivery to offshore yachts (nauticanews, 2021), drones are used to change people's lives.

The expansion of service drones is to support the projected growth of the urban population. At the beginning of this century, 50% of the world's population lived in cities, and this share is expected to grow to more than 60% by 2050 (Zipperer et al. 2020). The value of the drone sales, standing at 8.5 billion USD, was projected to exceed 12 billion USD by 2021 (Joshi, 2017), with the commercial drone market as the fastest growing sector (Goldman Sachs, 2016). Different types of drones range from those that can fit in a backpack and carry a small camera (e.g. GoPro (n.d.)) to those capable of carrying large payloads (e.g. Predator B, General Atomics carries more than 1360kg, Marshall et al., 2011 p.32). The variety of payloads and accessibility of consumer-grade systems has reduced costs for the final user (e.g. researcher, community or a third party). This reduction, along with the accessibility of the equipment and complete control of when and how to use it, make UAVs a significant part of the aviation community today.

Examples of current law enforcement applications in the US (Wolf, 2017) demonstrate that size, environmental and economic impact of drones compared to "regular" aircraft (fixed-wing or rotor regardless) make a case for continued application of UAVs not only in those but in the variety of other cases as well (see Figure 1). Drones are changing science by the cost-effectiveness, adaptiveness and responsiveness of the data captured from this new aerial viewpoint. This phenomenon has resulted in an upsurge in the use of UAVs within scientific disciplines over the last few years. Furthermore, the number of papers published containing the terms 'UAV' or 'drone' in the title over the past 15 years has also increased. This demonstrates how scientists themselves can now become data collectors, rather than relying on third-party sources, by collecting only relevant data at a time that suits their research best.

The progress in drones' use brings both challenges and opportunities. One such challenge is a potential exponential rise in incidents where drones have been flown too close to commercial aircraft. Countries differ in the level of the general requirement for UAV operations. Poland started early to regulate requirements for UAV operations in 2013 (Konert and Kasprzyk, 2020). Examples of self-regulation in the case of gliders or microlight aircraft operations in the United Kingdom can be related to the work of Bartle and Vass (2005), which reviewed the application of various regulatory models in the United Kingdom across several different industries. Although not very common in aviation, initiatives such as the one mentioned might align with the idea that local authorities should be empowered to intervene if a drone is not found to be operating correctly, as per the Drone Bill (Department for Transport, 2018). The development speed of drones and related technology has influenced how local communities think about the future. Initiatives such as "Flying High" (Nesta, 2021) call for drone literate future citizens to shape and develop the way local communities accept and apply drones and their operations as enablers of Urban Air Mobility (UAM).

Use case	Unit cost of business as usual	Unit cost of use case	Difference in unit cost
Powerline inspection	£193,141	£127,856	-34%
Cargo delivery – mail	£1,722	£1,117	-35%
Last mile delivery	£15	£12	-20%
Sub-regional air taxi	£126	£66	-48%
Rural air taxi	£24	£40	67%
Urban air taxi	£31	£38	23%

Figure 1. Benefits associated with the use of drones and advanced air mobility technologies (Source: UK Research and Innovation, 2020)

What are chronic "pains" induced by drones?

At present, the availability of UAVs in different sizes is quite prominent. In addition to widening the base of potential private well-intended drone users, this situation has brought the challenge of drones straying in the airspace, causing frequent problems to civil aviation operations. According to the UK Airprox Board, 92 instances of drones coming close to aircraft were observed in 2017 alone (See Figure 2). Incidents range from the drone being flown directly over the wing of an aircraft approaching Gatwick Airport in the summer of 2017 to another instance where a drone was flown within 30 m of a Boeing B787 landing at Heathrow airport (Howard, 2020). Figures appearing in this latter report are within the 5 km proximity to a runway and higher than 400 ft (121.9 m). As a result, the incident could have called for an arrest and a jail sentence of up to five years for the drone operators in question if they had been located. Passengers in Canada were not that lucky. Their aircraft's wing was hit by a drone later in 2017 (BBC, 2017). They managed to land safely, but the drone operated well beyond the no-fly zone defined by the Canadian Transport ministry.

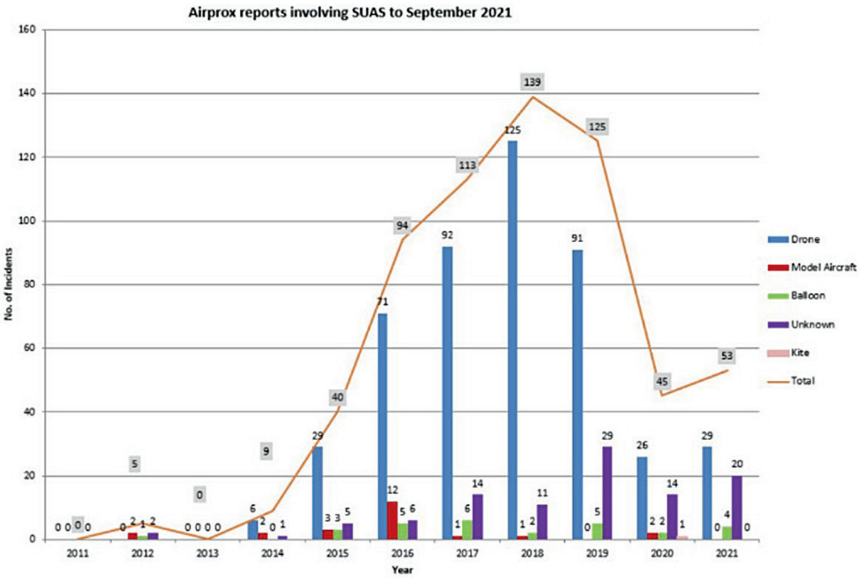

Figure 2. The trend in Drones' Incidents
(Source: Airprox Board, n.d.)

However, is that all new? Today, trying to introduce drones to our air space, airways and awareness, we face a lot of things that aviation has seen before. If we rewind just approximately 100 years back, we would have seen similar problems. Newspaper headlines on the first commercial application of aircraft; efforts to organise their commercial operations in an orderly and efficient way; registering and managing aircraft in the least possible intrusive manner to the society and the world below were similar issues seen then. So how to go about all of this when we face some of the challenges mentioned above with drones?

If one thinks about learning from the past, one can remember how the private automobile, “the beast” as they have called the new invention at the time, was introduced on roads during mid-19th century in some of the early-adopting countries in the past (Simona et al., 2021). If we move on to the present times, we see road mobility as a prerequisite for everyday living. Depending on the country we refer to, young adults are allowed to participate in road transport from an early age because bicycles, motorcycles and automobiles are nowadays generally accepted as a mode of transport. So, the gap has been closed between acceptance and the level of risk caused by the system.

Reflecting on the reason for this advancement, we can assume that early awareness of the nature and risks involved in the system would be one of the reasons for progress. Therefore, why not use the same approach when integrating UAVs and their operations in our society? The author has been thinking and referring to initiatives such as BIKEABILITY, a programme whereby the community enables children to learn about bicycles and their use as a means of transport (Bikeability Trust, n.d.). It enables them to take responsibility while using them appropriately, obeying the road rules, and being healthy, independent, and socially responsible. It also empowers them to be good members of the society (see Picture 1).

Picture. 1. Initial BIKEABILITY™ Training
Source: own work

In a situation when the profession of drone operator is not an easy market to get into, it is crucial to start early to gather the relevant knowledge to accept, understand and operate UAVs. The present situation of drones' diffusion and usage in schools is not ideal. The most visible civilian drone research focuses primarily on their design (Imperial College London, 2018). The major part of academic effort is intended to overcome the apparent disconnect between encapsulated military ecosystem and developing a civilian application – including the training (SESAR, 2018). As per recent interaction with significant stakeholders, aerospace and aviation industry awareness demonstrates the need for a more diverse representation of underrepresented groups (Rolls-Royce, 2018).

Therefore if young people and other enthusiasts could receive training in responsible drone flying, this could reduce the risks to aviation infrastructure, open up possible new career paths and even help schools with means of enlivening the STEM curriculum (NATS, 2018). STEM-related subjects are the foundation blocks of any organised thinking in natural sciences. The earlier young people see the connection between the subjects and their practical applications in life, the easier it is to motivate and keep them interested in the topic.

How our DRONEaBILITY™ research can provide effective "pills"?

Having won a grant from ISSF, the author started the Proof-of-Concept phase for DRONEaBILITY™ (DaB™) project working with non-academic users (i.e. teaching staff) in a secondary school. This phase drew on the idea of cycling proficiency. DaB™ proposed a solution where the syllabus was aimed at Year 10 and 11 students (Key Stage 4 (KS4) during years before and when having General Certificate of Secondary Education (GCSE) exams (Hartpury College (n.d.)) and delivered in two stages. The initial stage would have been theory-based, with a compulsory element covering awareness of regulations and best practices in drone operations. Following this, a practical stage would have been on-site and could be tailored to the needs of each school.

In order to create an effective syllabus, we needed to move from the basic premises of knowledge along the line of different cognitive domains, i.e. thinking skills. Within six major cognitive domains (see Figure 3) ranging from the most simple to the complex ones, each category is built upon the other as one moves upwards the pyramid. Higher order thinking skills are at the foundation of the majority of Higher Education systems in the world. For example, UK Quality Assurance Agency (n.d.) builds its structure of different levels of higher education qualifications based on them. Additionally, the Federal Aviation Administration early pilot's training programmes and current Evidence Based Training (EBT) initiatives contain elements of this system.

Following the structure of the 'system of categories of learning behaviour', introduced by Dr Benjamin S Bloom (Allyn and Bacon, 2016) in mid-20th century, the author used them to inform the design and assessment of educational approach in DaB™. The structured definition and explanation of the hierarchy of thinking skills helped harness the power of formal knowledge and its comprehension (i.e. current curriculum in STEM) towards creating interest and new knowledge (i.e. UAV related knowledge).

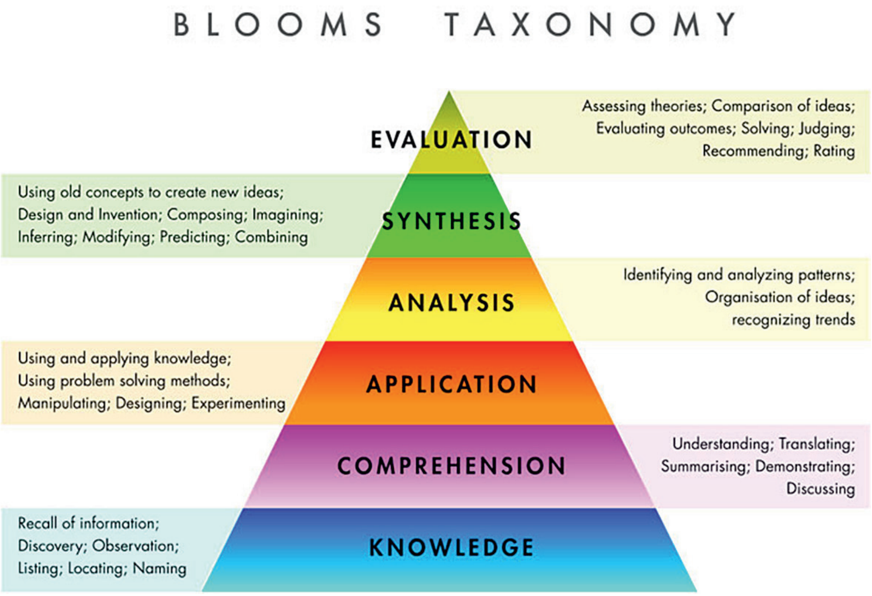

Figure 3. The Cognitive Domains
(Source: Alford et al., 2006)

The past ten years have seen a noticeable decrease in the numbers of young adults who eagerly embrace education in STEM subjects. Formal reports suggest that attributes and tools developed by studying these subjects help current and future employees (CBI/ Pearson, 2013). Aviation has witnessed less actual flying and subtle moves towards remote operated aerial systems, including UAM (Kim and Yoon, 2021) and mainstream commercial operations.

Therefore, future employees could benefit from encouraging STEM learning by making it more attractive (Coventry University, 2015). Hence DaB™, as a part of the STEM learning ecosystem (National Academies Press, 2015), intends to expose them to the professional knowledge and a path of potentially becoming the operator of drones in the future.

The activities in the Proof-of-Concept phase of DaB™, funded by the ISSF grant, were projected to end at the point when demonstration STEM classes, together with hands-on practical sessions in drone operation, were delivered to a target audience in partnership with a selection of secondary schools. Being just one part of a "diverse setting where learning occurs", DaB™ intended to offer a network of people (i.e. teachers and young adults) everyday encounters with STEM (through formal lectures and practical UAV-related applications) in schools and in a virtual community setting. Young adults' learning supported by such an ecosystem would meet their evolving cognitive, emotional and motivational qualities (National Academies Press, 2015). Therefore, official school STEM practice enriched by DaB™ broadens its reach and supports young people's learning (Calabrese Barton and Tan, 2019).

The plan was for the practical stage to be delivered wholly online, including synchronous, mobile-friendly web conferencing tools for live sessions, enabling learning through students' own devices (or school-provided ones). This type of delivery aligned with the prevalent thought (Royal Aeronautical Society, 2017b) that recognised the benefits of efficient content delivery for students and young professionals (e.g. based on digital devices, the Internet, apps and social media) at the time the author started working on DaB™. After 18 months of life driven by the pandemic that started in the first quarter of 2020, society and education got used to attending meetings, musical concerts, and even birthday parties online. The abundance of channels and the perceived ease of applying online tools for teaching led the author to recently conclude that "…Blended Synchronous Learning can bring significant advantages to a variety of educational contexts" (Pates and Sikora, 2021).

Following the Proof-of-Concept phase, the author and DaB™ team planned to start the project's next phase, called DRONEaBILITY™ Gamification

Exploration Phase (DaBGEP). DaBGEP was aimed to generate a contemporary, gamified interface that would generate interest and maintain the positive behaviour of drone users, as introduced by the initial stages of the DaB™ project. Access to the interface was intended to promote and reinforce desired behaviour and the Community of Practice (CoP) among the users. Generated and supported by the databases on DaB™ computer servers, this community was intended to keep track of operations and desired behaviour of the young adult UAV operators.

A Community of Practice (CoP) is, according to Ghimiși (2016), "…a group of people who share a concern, a set of problems or a passion about a common topic, a passion for a professional or personal activity". The CoP is a notion that originated early in human history (e.g. apprentices and teachers, shipmates and masters) but has drawn the focus of interest recently with the advent of online communities (e.g. computer game players or enthusiasts (Schiavone and Borzillo, 2014.) or online education delivery (e.g. Massive Open Online Courses (MOOCs) (Philpott and Pike, 2013)). The characteristics of CoPs can differ depending on the topic they cover (Lave and Wenger, 2014). Towards the end of the last century, the research was focused on understanding how CoP influences and formulates learning (Vygotsky, 1978; Cole, 1990; Rust et al., 2005).

In the case of DaB™, it is intended to help build performance expertise through participants support (see Figure 4). Beginner users joining the community should become more involved in the community as their learning increases (Walton, 2009). Alongside the examples where digital literacy in an office environment is improved through the interaction with more experienced colleagues (Iosad, 2020), DaB™ users would improve their skills by exchanging feedback and questions between fellow users and the Community's administrators. Although already discussed and applied in areas of vocational teaching in aviation (O'Brien, 2013), this CoP will bring novelty to our project as it is applied at a relatively young age of participants developing their UAV skills and their identity as future responsible society members.

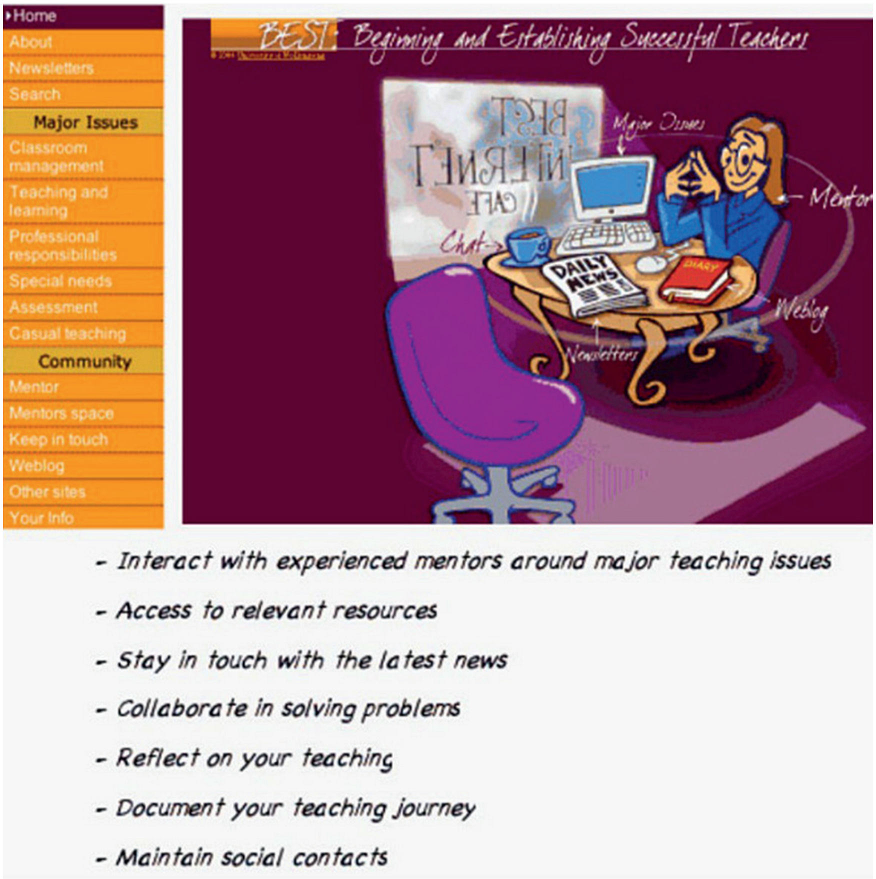

Figure 4. Community of Practice Idea in Action
(Source: Herrington et al., 2006)

Alford et al. (2006) argue that higher cognitive thinking invites a further understanding of content such as problem-solving, making judgments, evaluation and reflection. If that is the case, one must try to kindle and sustain the interest in the topic for participants by progressing from the basic to higher cognitive domains. One possible way to do this suggested in the literature is by using game elements (i.e. feedback, rewards and relationship) in a non-game context as described in the "Gamification" approach (Werbach and Hunter, 2012). Figure 5 presents a design framework conducive to the development of the gamified system.

Figure 5. Gamification Design Network
(Source: Adapted by the author from Werbach and Hunter, 2012)

Lieberoth (2015) emphasises that games are an important way of engaging with school children. Despite constant tension when discussing the benefits or harmful effects of computer games when encouraging learning (Strong, 2020), authors have praised adaptive functions of play (Bjorklund and Pellegrini, 2010) and their benefits for psychological development (Piaget, 1962). Starting as a simple, playful interaction, a play can become more than that by introducing rules and objectives (Detering et al., 2011). Serious games like simulator-based training and operational preparation in aviation (Hugos, 2012) or desktop simulations like 'The Beer Game' (Senge, 1991) or pendulum behaviour simulator (Figure 6) are at the other extreme of the spectrum of games. They are intended for education and training mainly.

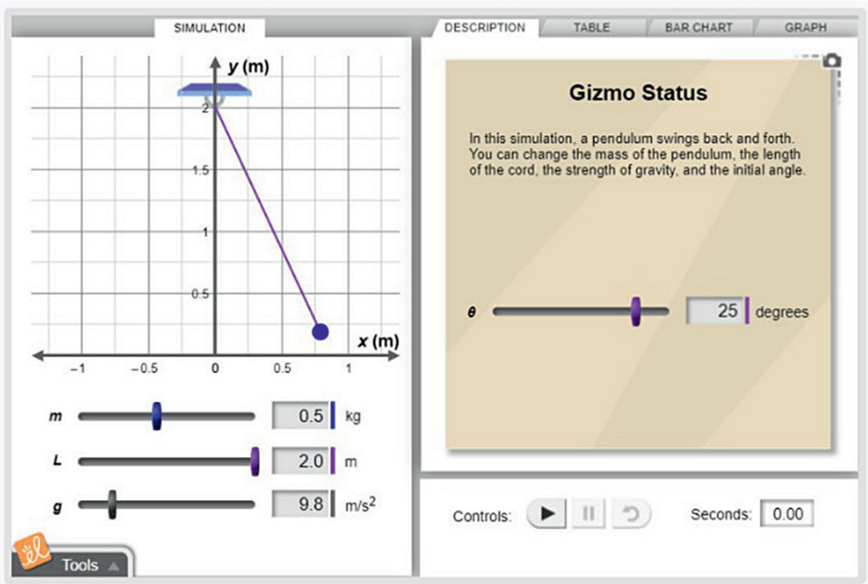

Figure 6. Pendulum Energy Web Simulation
(Source: ExploreLearning, n.d.)

Therefore the author and DaB™ decided that young adults in Years 10 and 11 would benefit from exposure to new challenges and objectives while stimulating their interest and engagement aligned with the need of "digital natives". With this in mind, our objective was to create a gamified interface to support the community of practice among them and motivate their regular/ desired/ legal use of drones (compared to rogue uses mentioned already).

A DaB™ interface is intended to support communities of drone users, teachers, form administrators and students within the participating schools initially. In the same way as 'Lose It' (n.d.) (a smartphone application that supports users during weight control attempts), our gamification system will implement points, badges, leader boards and challenges (see Figure 7). Those mechanical elements of the game framework (Hunicke et al., 2004) will be complemented by its dynamics and aesthetics to trigger participants' engagement, teamwork and competition through feelings and behaviours. Lasting behavioural change in a non-game context (Wu, 2011) is the final goal of DaB™.

When referring to UAV usage and related STEM curriculum, gamification can be twofold. At one level, the more obvious one, it would incentivise young adults to engage in a kinesthetic and hands-on activity different from a relatively "dry" learning of STEM-related subjects in school. Emotional disengagement and boredom of studying these subjects provide an ideal area where adjusting gamified elements as closely as possible to the target audience (Zichermann and Linder, 2013) can create a related positive outcome. Stirring fun elements into the gamified system would motivate students on a physiological level. Therefore, releasing dopamine (Werbach, 2016) encourages participants to continue, transforming tiring and unexciting tasks into enjoyable activities.

Figure 7. "Lose It" Gamified Interface
(Source: Loce It, n.d.)

On a more profound and subtle level, gamification would include using game elements to promote and sustain a desired positive behaviour once they qualify to use drones alone or in a group. It is the intention of the DaB™ project to keep participants motivated to perform as desired or regulated. Maintaining the focus on design, distribution of appropriate tasks, challenges, objectives and unexpected events of the gamified environment will positively influence young adults' motivation and objectives (Burke, 2014). Computer databases and network resources behind DaB™ gamified interface will serve as a tool for monitoring ideal target behaviours through quantitative and measurable software algorithms. This objective, originating from applicable UAV regulations and best practices, will be accessible and easy to understand by our young adult participants.

What has been done so far?

DRONEaBILITY™ is an idea and project that was started in May 2017 and has been developed since then. During this time, circumstances around the project and society have been more or less in favour of the idea and the project. In the former case, the author has changed his professional affiliation, while for the latter, regulations applicable to UAV operations have been changed since the start of the project and affected some aspects of it. Results presented here cover the time from the start of the project to the completion of the initial ISSF funding in March 2018. It is worth noting that the time that has passed since then, and changes in the authors' circumstances, have affected some of the results (i.e., access to physical assets and original IT infrastructure). Nevertheless, when the need comes to secure them again, it will make them easier to obtain once it has been already accomplished.

After initial ISSF funding (i.e. 15,000 GBP), DaB™ has achieved the following:

- Created an outline and rationale for the syllabus as proposed in the application for the original funding,
- Secured IT infrastructure and software to pursue proposed online delivery of theory-based drone-related knowledge integrated with Year 10 and 11 STEM curriculums,
- Generated knowledge and expertise critical for the selection of drones appropriate for the practical session in drone operation as foreseen by the initial project plan,
- Secured physical assets (drones and related equipment) suitable for inducing young adults to possible new career paths in STEM careers,
- Established contacts and explored ideas of further external engagement with civil aviation regulators, related professional associations, private entities and education providers,
- Secured collaterals related to practical drone operations stage and any other potential DaB™ engagement internally or at the venue of proposed education providers.

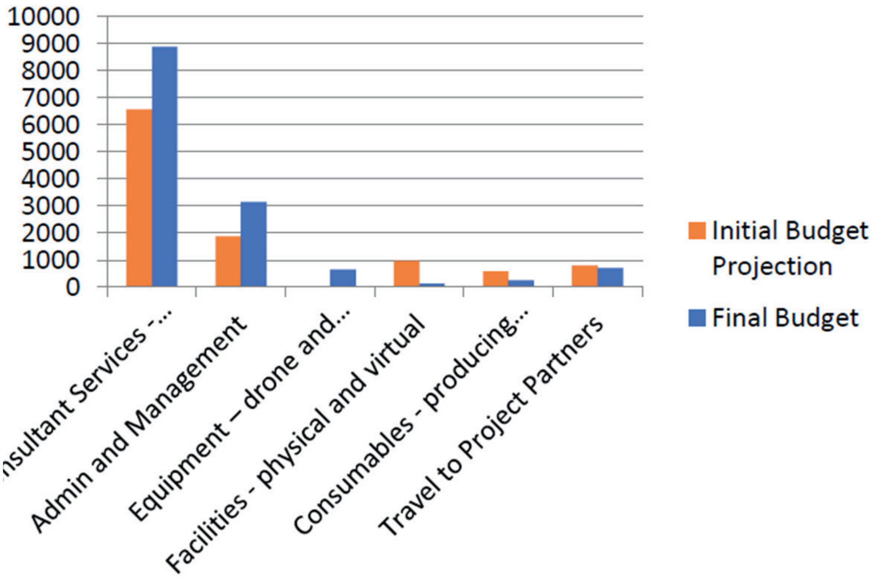

Figure 8. Initial and the Final Budget Categories Split [GBP]
Source: own work

Presenting the above listed activities concerning the initial fund of the project, the author had an initial budget split, foreseen at the onset of the project spread as shown in Figure 8. Please note that quantitative data in this report come from the project's internal budget tracking. It is worth highlighting that the share of funds spent on consultancy by external Subject Matter Experts (as seen in Figure 9) has been quite significant. That reflects the need of identifying the equipment that was best fit for the project and a steep learning curve for DaB™ academic members, including the author. It is worth emphasising that the initial budget projection did not contain the amount for drones and related equipment, as its definition was one of the outcomes sought from the project itself. Subject Matter Experts' (SMEs) inputs have enabled DaB™ to assess and decide the requirements needed to inform the future course of action while developing the project's content in a relatively short amount of time.

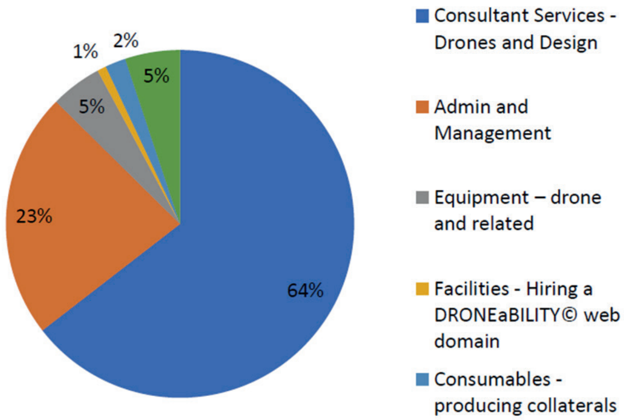

Figure 9. The Share of Specific Budget Categories Spent
Source: own work

Material presented and discussed in this paper so far has the purpose of providing the necessary components and infrastructure to continue DaB™ beyond the partial completion of the DaB™ Proof-of-Concept phase covered by the initial ISSF fund that ended in March 2018. Summarising the future actions that the author has identified as necessary, they are as follows in the sequential order:

- To design and create syllabus aimed at Year 10 and 11 students potentially (the year before GCSE exams) delivered in two stages. The initial stage is theory and STEM curriculum-related, with a compulsory element covering awareness of regulations and best practices in drone operations;
- To create and test the practical stage of the syllabus on-site at one of our educational partners so it can be tailored to the needs of each school;
- To capture critical parameters originating from the syllabus related and practical stages using appropriate research instruments (qualitative and quantitative survey);
- To facilitate educational partners' (2 to 3) and drone experts' consultations when brainstorming the architecture for gamified interface and gamification requirements that are relevant for the intended audience and realistic outputs from drones used

DaB™ project experience so far indicates the potential financial share and duration of each of these activities in the total budget, as shown in Table 1.

Table 1. Projected Budget Share and Duration of DaB™ Gamification Exploration Phase (DaBGEP)

Item	Resource	Share of the Total Budget	Activity Duration and Justification
		Consultation Services	
	Consultation Services – Education Content Delivery	17.3%	Staff in one of the partners who will help brainstorm sessions and feed into the software's design (1 hour/ week) for 14 weeks.
	Consultant Services – Drones	17.3%	Consultant fee for non-academic partners providing information on practical aspects of drone operations. Engagement might be irregular depending on the project progress and demands (1 hour/ week for 14 weeks).
	Consultant Services – IT and programming	23.4%	Consultant fee for a rigorous and methodical assessment of different requirements and aspects of the interface, its backbone requirements and architecture. It will include testing, streamlining and integrating the resulting software and hardware requirements in the application (i.e. iOs and Android App) with web server usage (1.5 hours/ week for 14 weeks).
		Equipment	
	Equipment – tablet iOs/ Android	10%	Equipment purchase to control drone, facilitate brainstorming sessions and test app on iOs/ Android platform.
	Travel:		
	Travel to a Conference	10%	Publication of data for a wider audience – stay, airfare and conference fee for (2-day conference in Europe/ UK).
	Travel to Project Partners	3%	Managing face to face contact in critical moments of the Project development local travel within the UK.
		Consumables	
	Consumables varied	1%	Stationary, printing of materials, other consumables.
	Publication	0%	Publication in relevant journals by academic partners in the DaB™.

Item	Resource	Share of the Total Budget	Activity Duration and Justification
		Administrative Cost	
	Programme Administration	18%	Managing a project for the duration of the project once. Budgeted for 5 hours a week for 15 weeks.

Source: own study

Drawing on the subject matter and educational development expertise in the DaB™ project will close with the platform ready to be released to a broader audience and relevant knowledge disseminated.

On the one hand, and in terms of societal benefits that DaB™ intends to generate, the project aims to create financially effective delivery for schools, communities and the society. It endeavours to fill the gap when UAV beginners' practical flight training, although very valuable, is not mandated in some aspects of the regulations. On the other hand, and as regards the commercial application of the project, it should generate an online service that schools would pay a licence fee to run (less than fees for services such as "Kerboodle", for example (Oxford University Press, 2018), and which could be applied both in the UK and overseas.

The delivery of a complete package (both stages) could be offered to interested entities (for example, schools, County Councils, Air Cadets (n.d.)). The mode of development and deployment needs to be investigated and this can be done in collaboration with appropriate partners. In addition to the commercial application in education enhancing their STEM curriculum, DaB™ can see a potential to create a "lite" online training version complementing UK Civil Aviation Authority (CAA), UK National Air Transport Services (NATS), and European Aviation Safety Agency initiatives to inform and educate the general public.

Why our DRONEaBILITY™ research removes current "pains"?

Drones are a platform able to facilitate direct and collateral knowledge creation, transfer and application for aviation and other related disciplines. While the most visible civilian drone research focuses mainly on their design, the aerospace and aviation industry is aware of the need for a more diverse representation of underrepresented groups of users and their involvement in drone usage. With dissonance between encapsulated military ecosystem and developing civilian applications, there is a need to introduce drone usage topics in schools as part of the general and STEM curriculum. When there is no enhanced and UAVs' STEM curriculum for the target age group, DaB™ has a robust, Unique Selling Proposition for schools that can use this as an edge against their competition.

Initially, DaB™ fitted Industrial Strategy funding to minimise the impact of drones (a vehicle of the future) on society when potential students understand and apply knowledge of manufacturing and operating practices relevant to drones' purpose and nature. Award funds allowed DaB™ initial and rapid generation of knowledge related to appropriate hardware selection and procurement. The DaBGEP phase will test and streamline the project's ideas and elements with backbone requirements, architecture and different interface aspects. The resulting software and hardware will provide a robust, deployable, gamified DaB™ platform with all elements needed for commercial development and deployment. This change supports students' needs for efficient content delivery (e.g. based on digital devices, the Internet, apps and social media).

Managing risks bottom-up by comprehending STEM foundations and fostering the desired behaviour through a gamified Community of Practice participation prevents problems later on. Taking the opportunity to learn lessons from manned aviation and applying them to desired drones' operations through DaB™, we acknowledge that young adults are entering the new operating environment using different tools. Once deployed, the DaB™ syllabus would reduce the risks to aviation infrastructure by offering young adults the foundations for responsible drone flying. Education before regulations that the author stated in his BBC interview, supported by the result of the DaB™ project, can eventually enable the introduction of next-generation driverless vehicles assisted by Artificial Intelligence that will influence, positively and negatively, global societies.

Finally, through DaB™, we want to create droneworthy young adults, people ready to participate in hobbyist activities but whose initial hobbies can grow into a career valuable for the society. On the one hand, this potential transition is critical when the industry faces a projected shortage of pilots and the need to induce people into the profession at an early stage. On the other hand, the current perception of potential UAV passenger operations is not optimistic despite the public initiatives and projects. Research by the author and his graduate students found that neither the general public nor professionals are happy to go onboard UAVs. When there is no pilot, there is no trust in a drone operation. DaB™ can give confidence to young adults as future UAM users or operators to participate in the system in both roles, alleviating problems such as congestion in megacities and the anticipated lack of future operators in the system.

Conclusion

Having identified drones as an addition to the author's research areas of interest and recognising his passion for technology-enabled academic practices, the author can see that DRONEaBILITY™ is an ideal platform to motivate research and enhance his contribution to the society, industry and academia. The initial ISSF Award was critical in developing an idea to the point where its completion is more than a wish. Award funds allowed DaB™ initial and rapid generation of knowledge related to appropriate hardware selection and procurement. The synergy of the project's members and SMEs enabled exposure and effective communication between all related stakeholders resulting in the generation of intellectual capital that, together with hardware acquired, has been critical in the first phase of the project development.

The idea of gamification in DaB™ is to implement game design principles, game design thoughts and game mechanics (e.g., levels, goals and missions) in a UAV users Community of Practice environment. Young participants need attentiveness, acknowledgement, acceptance and rewards. Gamification can fulfil those needs and support STEM and practical UAV operations' objectives that are otherwise doomed to fail without participants' engagement. This approach will guide specific behaviour, solve problems, engage the participants (i.e. young adults in Year 10 and Year 11 of secondary education in the UK or globally – 14 to 16 years of age) and increase their motivation to study STEM subjects. Additionally, playful elements can support, measure and reward their compliance with UAVs' regulated and effective use. So, when we said this, the drones themselves are something that we had to take advantage of in secondary education and academic education. DRONEaBILITY™ and drones in and for society and citizens of the (Near, Very Near) Future.

Summary

This paper aims to fill the gap of organised thinking about an effective way to motivate young adults (14–16 years) in secondary education to learn about Science, Technology, Engineering and Mathematics (STEM) topics while using Unmanned Aerial Vehicles (UAV) in a responsible, informed and effective way. The growing record of close encounters between UAVs and other aircraft has prompted the author to think of a possible way to introduce drones' and their operations to the general public and social knowledge. Driven by the example of the Bikeability project in the UK and the recent growing accessibility to UAVs, this paper presents the premises, experiences and projections/ aspirations for an effective, initial, societally-accepted drone education. The idea is to present the background thinking and challenges that the introduction of UAVs in society creates. Using information gained from academic and professional resources and primary data collected while developing the Proof-of-Concept phase of the project DRONEaBILITY™ (DaB™), the author will set the stage for this project's introduction. Following this, ways in which the author can see DaB™ meeting various challenges are presented. The subsequent section will present the work done using primary quantitative data from the project's Proof-of-Concept phase and secondary data from academic resources. The final section discusses the results and draws significant conclusions and possible implications. The paper is intended for relevant managers, school administrators and teachers, as well as drone practitioners to adopt an informed approach when including UAVs in the curriculum of secondary STEM education.

Keywords: drone; Unmanned Aerial Vehicle; UAV; STEM; education; safety.

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