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Future-Proofing Students in Higher Education with UAV Technology: A KM Case Study

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Abstract: In this paper we report experiences in implementing a new course 'Understanding Drone & Robotics Technology – History, Usage, Ethics & Legal Issues' at the Singapore Management University (SMU) framed as a strategic knowledge management initiative in an institution of higher learning aimed at capturing, sharing and creating new knowledge about disruptive technologies such as unmanned aerial vehicles (UAVs). We posit the new course as a knowledge innovation initiative (similar to a KM-enabled business case in a corporate setting) in support of the university's mission and vision so as to deliver new value to students and to stay ahead of the latest technological developments. In line with a 'normal' KM initiative, we examine how the new learning and teaching initiative was conceived, pushed forward and eventually launched, creating a new multi-disciplinary learning experience for students, instructors and other stakeholders. We explain the knowledge strategy of the course and use the SECI framework to shed light on selected aspects of the pedagogical approach towards achieving the desired learning outcomes. Overall, the paper intends to make a case for more collaborative knowledge leadership as a strategic enabler of knowledge innovation in a rapidly changing higher education landscape.

Keywords: Drones, UAV technology; Higher education; Multi-Disciplinary Teaching and Learning, Knowledge Transfer

1. Introduction

The idea for the course 'Understanding Drone & Robotics Technology – History, Usage, Ethics & Legal Issues' course came up as a response to the increasing use of drone technology and 3D robotics in business and society. Drones are unmanned, multi-purpose tools. Their history can be traced back to World War I when the US army experimented with unmanned aerial torpedos. Nowadays, drone technology belongs to the military arsenal of many nations. Drones serve many purposes (intelligence, surveillance, reconnaissance, traffic and crowed management etc.), and they can be deadly. In business and society, drones are utilised to capture images of people and/or buildings, to monitor agricultural conditions, to take pictures from (or of) hard to reach places, to assess the impact of climate change on rainforests, to film events, to deliver parcels, to survey real estate, to deliver help to heart attack victims in remote areas via a flying defibrillator or to fly life-saving kits to swimmers in emergency situations. In view of their increasing importance in terms of commercial value creation, R&D (it is estimated that about $6.4 billion is spent annually for R&D on drones), job creation, innovation (e.g. Internet of Things), new forms of warfare as well as legal/moral-ethical/regulatory concerns, it is imperative that students learn to critically appreciate the multiple and often conflicting implications and consequences of this technology for business and society.

The curriculum of the drone course features eight broad topics: (i) an initial introduction into the evolution of the course, incl. structure, learning objectives, outline specifics and deliverables; (ii) a critical discussion about the social impact of these technologies with reference to industrialization, militarization, urbanization, labor markets etc.; (iii) an overview about the history of automation and drone technology from the industrial revolution and early robots to autopilot features in commercial airliners, factory automation and artificial intelligence in various fields (e.g. medical diagnosis); (iv) a deep dive into the business side of drones and how they are used in smart logistics, agriculture, 3D modelling, security, environmental analysis, news reporting, filming, human rights monitoring etc.; (v) several sessions on the legal & ethical issues of drone technology such as regulatory frameworks and stakeholder-specific policy imperatives, incl. safeguards for dealing with newly emerging/disruptive technology; (vi) a deep dive into the technological modus operandi of driverless vehicles, industrial/home robots and love robots as well as drone related apps and functionalities (e.g. extended camera function); (vii) a hands-on 'Flying Drones' session with a team coordination perspective (hands-on) where student teams need to master a timed indoor obstacle course and a timed team coordination activity; and (viii) a future outlook session with special emphasis on the critical analysis of these futuristic new technologies (Ball, 2015; Birtchnell & Gibson, 2015; Graves, 2016; Lawson & Holton, 2016; Mirot & Klein, 2014; Morris, 2015; Zuger, 2016). Selected learning objectives include:

- To explain the disruptive potential of drones and robot technologies in business and society, e.g. with reference to logistics, supply chain management, transportation etc;
- To gain practical experiences in piloting mini drones on campus and grow their problem-solving, collaboration and team-building skills on the basis of hands-on user operations while mastering an obstacle course;
- To articulate some of the legal, regulatory & ethical-moral issues of deploying drones and robots in business and society.

Course design, teaching and learning approach as well as normal class proceedings are conceptually informed by the integrated curriculum model based on an instructional method centreing upon a multidisciplinary team of instructors from three different areas (business, IT and law/ethics) as well as multidisciplinary learning materials aimed at enabling learners who belong to the digital natives category (Bennett et al., 2007; Gan et al., 2015) to connect knowledge from various relevant subject areas (Steinberg, 1997). In line with media richness theory (Daft & Lengel, 1986) and the theory of student centred learning (McCombs & Whisler, 1997), we added a ‘drone flying practicum’ conducted by students under the supervision of the instructors so that the learners would appreciate some of the drone-related course contents, internalizing important course aspects such as ethical concerns (e.g. privacy matters) or safety considerations. Students who do crash a mini drone themselves experience first-hand what regulators have to deal with when makers of innovative ‘flying cars’ or established firms such as Amazon apply for drone flying permits. In this sense, a personal drone flying experience is highly effective in communicating and appreciating important lesson contents.

Eight Parrot (‘Mars Airborne Cargo’) minidrones were purchased (one drone for altogether 8 groups which were divided into 2 larger groupings with one classroom allocated each) at a cost of about S$ 1,000. These smaller Parrot drones are ‘ultra-compact and easy-to-pilot vehicles which can be controlled with a smartphone or tablet via Bluetooth. The Airborne Cargo drone weighs 1.9 ounces and boasts superior flight stability because of its 3-axis gyroscope and accelerometer. It flips forward or backward and makes agile turns on a dime. It’s designed for safety, so students can fly them indoors or outdoors thanks to its propeller circuit breaker which automatically shuts things down in case of a collision’.

Before the ‘formal’ flying session, students were briefed about legal-regulatory cum safety matters and had the opportunity to watch introductory videos about set-up etc. provided by French min drone maker Parrot on YouTube. Groups were then given ample time to experiment with the drones in class and to beef up their flying skills. After these segments, each group was asked to nominate ‘their best pilot’ to become the designated pilot for that group for follow-up, competitive flying activities. The next step included the mastery of three exercises to showcase and further improve one’s flying competencies. If they managed to complete these (three) exercises within the time given, they were entitled to further practice with the drone.

In line with the theory of student centred learning, the (1st run of the) drone course turned out to be heavy on essay writing. Individual assessment made up 60% of the final grade, comprising (i) class participation (15%); a research paper on the historical and sociological impact of technology (10%), e.g. the role of robots in Japanese society and business systems; a term paper (20%), e.g. to explore how drone delivery systems will shape a smart city by 2025; and a MCQ test (15%). Group assessment made up 40% of the final grade, comprising (i) a minor group project plus presentation (15%); e.g. reflecting about the historical development and future impact of love robots vis-à-vis their general risks, incl. ethical-moral issues; and a major group project plus presentation (25%) such as an in-depth, critical discussion of the business and legal implications of selected UAV-related technologies.

1.1 Problem and KM Challenge Statements

The core ‘problem’ the course attempts tries to address can be summarized as follows*:*

How do disruptive technologies such as unmanned aerial vehicles and robot technologies affect business and society – broadly speaking?

The associated teaching and learning challenge addressed in this paper is as follows:

Given the disruptive change in the global economy and job markets, how can universities better prepare graduating students and future-proof them?

The core 'knowledge management challenge' this paper attempts to examine is:

How best to capture, share, create and use relevant knowledge and information about the complex subject matter in order to achieve both learning and organisational objectives?

2. Instructors as Innovative Knowledge Champions

2.1 Leadership as enabler of knowledge innovation

We look at the development and implementation process of our course as one of knowledge innovation, i.e. we utilized existing research and our combined teaching and learning experiences as well as interests to generate new knowledge (= learning contents) that students need in order to meet the overall course objectives.

Table 1: Enablers of Knowledge Management (KM)

Leadership Practices and Strategy	• Leadership support and strategic alignment • Critical: capability to leverage on knowledge assets to reinforce org. core competencies
Culture Practices	• Critical: a robust culture of knowledge sharing and innovation that endorses communication, learning, collaboration, k-reuse and k-creation in ways that enhance value
Human Capital Management Practices	• Impact of human capital management functions (e.g. performance appraisal system and reward & recognition policies) on sustainable buy-in and effectiveness of (new) KM tools and systems
Technology Practices	• KM tools and systems (IT) used to collect, store, disseminate and share information • Critical: seamless communication within the organization, user inputs and usability
Knowledge Management Processes	• Policies, rules and procedures (action steps) used to identify required knowledge assets and how they are collected, adapted and transferred across the organization (e.g. content submission process)
Measurement Practices	• Capturing, measuring, tracking and quantifying the value of knowledge assets • Performance usage metrics such as number of ideas generated in one part of the org. and adopted somewhere else

We believe that IDIS103 is critical for future-proofing our students. We also created new practice activities (e.g. the drone flying practicum) for the students in support of the envisaged learning outcomes. From a *knowledge leadership* perspective (Von Krogh, Nonaka & Rechsteimer, 2012), we perceive 'us instructors' as knowledge leaders and innovation champions (see Table 1).

Having taught knowledge management electives at university level for more than 10 years, two of the three inventors and instructors of IDIS103 were aware of the importance of collaborative leadership (De Meyer, 2011) as an enabler of managing knowledge and *championing* the idea for a new multi-disciplinary teaching and learning opportunity. The champion concept can be traced back to MIT professor Donald A. Schoen (2005) who observed in a 1963 study on radical military-related innovations that they were often driven by extraordinarily engaged persons who played a key role throughout the entire process from ideation to implementation. Champions are the individuals who emerge to take creative ideas (which they may or may not have generated) and bring them alive. Their role is critical as innovation implies change, insecurity, resistance and risks.

2.2 Leveraging a community of instructors across different disciplines to cope with new disruptive technologies

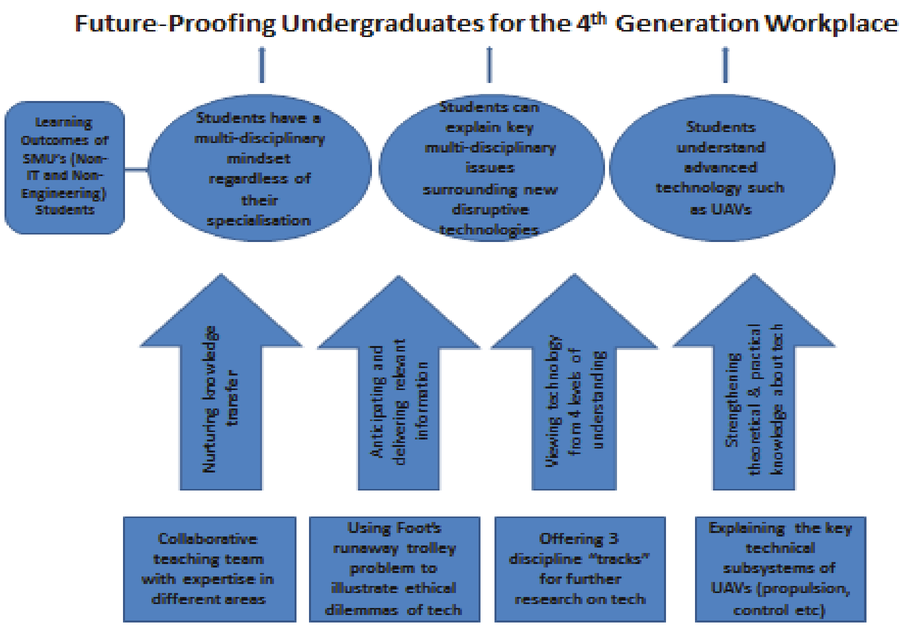
One novel element of the new course initiative IDIS103 is the fact that it is taught by a multidisciplinary team of trusted colleagues from different disciplines (business, IT, law). The development process was straightforward and relatively issue-free once approval had been obtained from the mighty curriculum committee of the university and the funding approach had been sorted out. The IDIS103 teaching team can be regarded as a *community of interest* whose members are passionate about disruptive technologies such as UAVs and who wish to expand their knowledge base by interacting with each other regularly, including students and external subject matter experts. Depending upon the intensity of the exchange, COIs can help to advance knowledge and create new opportunities for value creation, e.g. at the intersections of different disciplines – something which has been termed 'intersectional innovation'. Today, there are many innovation challenges which cannot be solved by one scientific discipline alone. Many questions relating to health, energy, climate change and others require thinking across different fields.

3. Knowledge Strategy of IDIS103

Besides Big Data Analytics and the Internet of Things, drones, robots and Artificial Intelligence (AI) are the new technologies that are taking businesses by storm. With the dawn of the Fourth Industrial Revolution, much job disruption has taken place around the world. UPS has prototyped a drone-enabled truck that can deliver parcels that used to require two delivery trucks, and are now driven by one delivery person (Kastrenakes, 2017). Some technology-industry luminaries have openly called for countries and governments to start addressing the negative impact of disruptive technologies on society to properly balance the positive impact of drones and robots on business bottom-lines; Bill Gates has called for a "robot tax" to be paid by robot-owning companies, and Elon Musk has suggested to provide an universal basic income as a form of society safety net for people who lost their jobs as a result of these new technologies. Recently, the European Union has built upon Asimov's Three Laws of Robotics, and pushed forward a new legislation initiative that mandates a "kill switch" for robots (CNA, 2017).

Given such tectonic shifts in the global economy and job markets, how can universities better prepare graduating students to learn using a multi-disciplinary approach rather than further relying on the tradition of subject-based learning with a single focus on Literature, History, Law, Architecture, Science, Medicine, Economics, Engineering, etc.? How to successfully convert students so used to subject-based learning into competent graduates who are relevant and ready for the Fourth-Industrial-Revolution workplace? Our course IDIS103 addresses this issue and provides a knowledge-based solution (see Figure 1).

Figure 1: Knowledge Strategy of IDIS103



To achieve the learning outcomes of IDIS103 such as the development of a multi-disciplinary mind-set amongst students regardless of their specialisation as illustrated in Figure 1, the course is built upon a particular *knowledge strategy* with four thrusts: (i) nurturing knowledge transfer amongst students (and instructors) through project works, (ii) anticipating and delivering relevant information to all users, e.g. through lectures, (iii) helping learners to view technology from different levels of understanding, and (iv) strengthening learners' theoretical and practical knowledge about IDIS103-relevant technologies through external expert presentations.

Key propellants included (i) a collaborative, multi-disciplinary teaching team (COI) from three different schools with expertise in business, law/ethics and technology, (ii) the use of relevant pedagogical approaches such as Foot's runaway trolley problem to illustrate the ethical dilemmas of advanced technologies such as autonomous UAVs or cars, (iii) the availability of 3 different discipline "tracks" for further technology research, and (iv) technical explanations pertaining the key technical subsystems of UAVs such as propulsion or control.

3.1 Examples of Pedagogical Knowledge Transfer Strategies Used

3.1.1 Project work

Group projects represent a core element of the knowledge transfer process in IDIS103. Group assessment makes up 40% of the final grade, comprising (i) a minor group project plus presentation (15%) and a major group project plus presentation (25%). Each project group comprises between 5-6 students. The topics are to be taken from the following "vertical" domain areas:

Table 2: Vertical Domain Areas for Group Project Topics

Home/Companion Robots	Driverless Cars	Robots (space exploration)
Robots (automobile factories)	Robots (car & bike parking)	Robots (intelligent speech)
Robots (other industries)	Military Drones	Robots (recreation)
Love Robots	Commercial Drones (**)	Robots (journalism, events)

For their minor group projects, students are requested to do research into the assigned topic (one of the "vertical" domain areas) and elaborate on the following areas: (a) historical development, (b) overview of the technology used (for the layman), (c) examine what can go wrong with the technology and the impact, and (d) explore the legal and ethical-moral issues. A simple example is shown in the table below.

Table 3: Examples of Minor Group Project Topics

Vertical Domain Area	Historical Development	Technologies Used	Tech Failures & Impact	Legal, Ethical, Moral Issues
Driverless Cars	Cruise control Proximity warning (for parking)	Digital image processing Electronic throttle control Proximity Sensors	Objects wrongly identified – e.g. side of white truck confused to be sky Impact: car crashes	Trolley problem – crash into child or old person? Legal: sue the car owner or the car manufacturer?

Each group is given 15 minutes to do a presentation in class. No report is necessary. However, the Powerpoint file should contain brief speaker notes of about 50 words for each slide with content (i.e. minus the separator slides).

While Project #1 (minor) covers the "vertical" domains, the focus of Project #2 (major) is on the "horizontal" considerations. Students are requested to select three "vertical" domains, and choose ONE of the following "horizontal" areas to focus on technology, business applications, social issues, legal issues and ethical-moral issues. A simple example is shown in the table below. During their final presentations, students are expected to explain each item in detail, e.g. by answering questions such as: *How does touch-friendly e-skin work? What does understanding human speech involve? How to achieve real-time uninterrupted video transmission?*

Table 4: Examples of Major Group Project Topics

Horizontal Domain Area	Home / Companion Robots	Military Drones	Love Robots
Technology	Accurate speech to text conversion Understanding human speech	Very accurate positioning Real-time video transmission	Touch-friendly e-skin

Each team is required to do a 15-minute presentation in class in Week 13. No report is necessary. However, the Powerpoint file should contain brief speaker notes of about 50 words for each slide with content (i.e. minus the separator slides).

3.1.2 Ethical thought experiments

A key pedagogical approach utilized in IDIS103 to shed light on the multi-disciplinary issues surrounding new technologies in an era of the Fourth Industrial Revolution such as advanced driverless vehicle technologies (when mature and fully deployed, they will take over the role of the human driver) and associated ethical issues centres around the *Trolley Problem* (see Table 2). A typical related scenario discussed in class includes a driverless vehicle with a hardware failure that has totally lost control of the brakes; a young child which throws a tantrum, breaks away from her parent and dashes across the road five metres away from the driverless car; on the kerb next to the car is a group of five elderly persons having al fresco afternoon tea at a sidewalk café table. In such a situation, should the car go straight and knock into the young girl, or should it swerve and crash into the group of five elderly persons? One might argue that the car should go straight because the young girl is at fault; another person might propose to give the little girl a chance at life and program the computer to swerve the car since the five elderly persons have lived quite long lives. Before the computer controlling the driverless car can be programmed to “make such a decision”, human society must first agree to a solution. The ethics debate is still on-going, and a solution is not going to be found any time soon because the ethical dilemmas are complex (MIT, 2017).

Is the scenario presented above a social science problem only? Certainly not! Is it a computer science problem only? No. Or think about the case of a severe injury involving a driverless car, and the victim who wishes to take legal action? Should the victim sue the owner of the driverless car, the car manufacturer, or the company that produced the software that drives the car? That we can not sufficiently answer these questions at this point in time is not surprising. Regulatory and legal-ethical solutions almost always lag behind risky technological developments.

Ethical dilemmas pertaining new technologies as outlined above are traditionally studied by social science and law students only. They are usually not well covered in computer science or IT schools. Engineering and IT schools typically cover driverless-car related topics like LIDAR, signal processing, and pattern recognition (which are usually not covered in law and social science classrooms). Business students are used to calculating the ROI that results from the deployment of drones, robots, and driverless-truck technologies, but they may not be deeply familiar with how the safety software works or how onboard computers can be protected against hackers. And what about the Accountancy and Economics undergraduates enrolled in our IDIS103 class (see Table 5)? Designing 12 weeks of meaningful learning activities about drones, robots and AI aimed at engaging a group of very diverse students and better prepare them to face the uncertainties of their future workplace was a key challenge the instructors faced when IDIS103 was first taught.

3.2 Facilitating Technology Learning in a Diverse Classroom

Table 1 shows the diverse student profiles according to their major specializations for the first and second runs of this new module.

Table 5: Student Profiles

	RUN 1 (JAN-APR 2017)	RUN 2 (AUG-NOV 2017)
Total Class Size	**45**	**44**
Accountancy	5	4
Business	15	10
Economics	6	4
Law	5	9
School of Info Systems	12	11
Social Science	1	3
Exchange	1	3

Students who chose to study non-IT and non-engineering disciplines do so for a variety of reasons – they are stronger in English, they do not have a strong Mathematics foundation, or they simply have a better aptitude for other subjects. Given this backdrop, instructors must facilitate learning about advanced technologies without using jargon so as to succeed in tickling the imagination of a group of undergraduates most of whom do not major in IT and engineering. How can the learning gaps for each category of students be bridged so that they get maximum value at the end of 13 weeks? How to make technology jargon understandable to the layperson and to transfer important knowledge without frustrating them?

One approach we used at the beginning of the course (week 1) in order to tackle such issues was to explain to the students in class that technology can be viewed from four levels of understanding as indicated in Tables 6 and 7 below.

Table 6: Levels of Understanding of Technology

LEVEL	**WHAT THE LEVEL MEANS**
CLUELESS	I don't know what it Is / what it is used for
BLACK BOX	I know how to use it but do not know how it works
HOW IT WORKS	I know how it works, but do not know how to build it
HOW TO BUILD IT	I know how to design and build it

Using the analogy of a motorcar, students with driving licenses were asked which level of understanding they had; and most arrived at the conclusion they understood the motorcar at the Black Box level – how to pump fuel, turn on windscreen wiper, change a flat tyre. We next went on to explain the four levels as applied to common technologies.

The Instructor used the Mobile Phone example to explain to the class in detail "How it works" – how limited frequencies resulted in the design of the cellular system, cell towers and base stations, why sometimes phone calls are dropped when cell capacities are exceeded, how mobile phones can still work when the user is in an underground road tunnel, or in the basement of a shopping mall, how Telco A's subscriber was able to connect and talk to his friend who subscribes to Telco B. He summarized the explanation by highlighting that at the 101-level of how it works, it is more enlightened common sense rather than rocket science; that all one has to do is to do some Internet research and watch relevant YouTube videos. Regardless of their academic backgrounds, this helped put most students at ease and comfortable with handling technology knowledge for the next 12 weeks.

For the individual Term Paper assignment, students were given a choice of three tracks (Business, Legal/Ethical and Technology) in order to their preferred Term Paper research topic. Three quarters of the class of 44 students choose the Technology track even though only 25% of the students were from the School of Information Systems (SIS). This is a proxy for the comfort level of the non-technology students when faced with a technology research topic. Table 7 shows samples of the topics chosen by the technology-track students who did not come from SIS.

Table 7: Examples of Term Paper Topics (Technology Track)

Student's Specialisation	**Term Paper Topic**
Law	Explosive Ordnance Disposal (EOD) Robots
Social Science	Smart Speaker systems (e.g. Google Home)
Business	Unmanned Aircraft Systems (UAS) Traffic Management
Accountancy	Security patrol robots

Table 8 presents some of the strategic pedagogical k-transfer activities of IDIS103 with particular reference to students' project works and the 4-level tech framework discussed earlier in form of Nonaka's SECI framework (1991). It sheds light on how knowledge was acquired, transferred and newly generated amongst the course participants.

Table 8: Use of SECI Framework in IDIS103

SOCIALISATION	**EXTERNALISATION**	**COMBINATION**	**INTERNALISATION**
Tacit → Tacit	*Tacit → Explicit*	*Explicit → Explicit*	*Explicit → Tacit*
Within the social setting of the team project, they	For their respective sub-topics, each student had to	To ensure coherency, each project team had to	Majority of the students were able to translate new

SOCIALISATION	EXTERNALISATION	COMBINATION	INTERNALISATION
Tacit → Tacit	*Tacit → Explicit*	*Explicit → Explicit*	*Explicit → Tacit*
each used their prior knowledge to share with other team members to "put everyone on the same page".	do basic research and draft the presentation materials.	appoint one or more information integrators to ensure a seamless final product. These integrators had to read everyone's explicit contents to combine them into the final set of (explicit) materials for presentation.	knowledge obtained from Internet and other sources into credible term papers.

3.3 What Do Students Think about IDIS103?

The following student comments may be helpful in further assessing the plausibility of the arguments made above:

"Should be made compulsory to all students".

"Course is very interesting and effective in enabling me to understand more about Drones and Robots …".

"The component of flying the drone physically was a great experience. Also the trip organised to .. was very informative and useful in helping us understand AI better".

"The best module I have taken in my 4 years here in SMU".

"Love the course though slightly heavy on the assignments and projects required".

"This course is fun and exciting, exposing SMU students to very different learning concepts and ideas. This is a good start for SMU and more modules like this should emerge in the near future".

"Gives an insightful view of what students can expect in the near future. Too rigorous for a GE module".

4. Conclusion

In this paper, we shared experiences in developing and implementing a new knowledge-intensive course with emphasis on disruptive technologies such as UAVs. Framed as a case of strategic knowledge management in an institution of higher learning, we argued that new course initiatives which focus on new technologies can be instrumental in helping students to appreciate what it takes to cope with the 4^{th} Industrial Revolution and to internalise the importance of a multi-disciplinary outlook in a VUCA world. The innovative course initiative IDIS103 helped both students and involved Faculty to capture, share and generate important new knowledge about emerging technologies such as UAVs which in turn helped both sides to better appreciate how these technologies actually function and impact business and society at large.

Increasingly and especially with the Fourth Industrial Revolution gathering speed, universities are well advised to ensure that students acknowledge the importance of having a multi-disciplinary mindset regardless of the school / discipline they belong to. This requires that students force themselves out of their comfort zone into areas they may not be familiar with or may initially not be interested in. We believe that more emphasis on multi-disciplinarity can buffer them from future job disruptions after they have graduated, helping them to embrace a lifelong learning mindset. Failure to do this would have dire consequences for the university, its graduates and external stakeholders.

The IDIS103 experience has shown that any new pan-university knowledge innovation initiative (similar to a KM-enabled business case in a corporate setting) in support of the university's mission and vision requires the right KM enablers, especially if the initiative relies on the inputs of different disciplines. Besides supportive leadership and a robust innovation culture, it is critical that the multi-disciplinary teaching and learning vision is effectively aligned with appraisal and reward mechanisms (incl. KPIs).

Limitations encountered while embarking on the case study research presented above include the small response rate that may limit the generalization of the findings, the bias that results from an unrepresentative, opportunistic sample (selection bias) and (iii) lack of causality.

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