Intellectual Property Education in Australian engineering degree programs: how do we rate?

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Introduction

Intellectual Property (IP) education is slowly becoming an area of increasing interest within engineering education. Equipping engineering graduates with the skills to be able to navigate the area of IP and understand how to protect their work and creations is crucial (Kaplan & Kaplan, 2003). Additionally, new engineers may also be required to demonstrate understanding of how to use commercial databases to search through patents for recent technological developments (Rodrigues, 2001).

Within Australia the number of patents applications filed annually increased from approximately twenty-four thousand in 2009 to thirty-thousand in 2018, while the number of trademark applications increased from approximately fifty-six thousand to eighty thousand annually during the same time period (IP Australia, 2019). Specifically in the field of electrical engineering, during 2017 there were approximately two thousand seven hundred patent applications in each of the areas of 'computing' and 'electronics and communications' (IP Australia, 2018, p. 12).

Within the Stage 1 Competencies set out by Engineers Australia (2017), IP is addressed in section 3.1 sub-point d): "aware of the fundamental principles of intellectual property rights and protection". This highlights that Engineers Australia places value on IP education, but it is imperative to note that inclusion of this sub-element is not mandatory (Engineers Australia, 2017). Therefore, the education which students may receive about IP may vary widely depending on the institution where they are completing an engineering degree.

Reflecting these potential limitations, Kaplan and Kaplan (2003) contend that "Intellectual Property (IP) is rarely, if ever, included in engineering education" while in 2008 the Higher Education Academy (2008) argued that "IPR [Intellectual Property Rights] is not seen as core and can, therefore, be perceived as marginal, within the constraints of the [engineering] curriculum". Reflecting these concerns, a survey completed by sixty-eight postgraduate engineering students from an institution in the UK identified that participants' perception of their understanding of IP protection was quite poor (McLaughlan, Killen, Soetendorp, Childs, & Roach, 2005). On average, students responded that they knew only a little about patents, trademarks, and copyright, but demonstrated mild positive agreement that it was important for engineers to know about these topics (McLaughlan et al., 2005), highlighting that they perceived a shortfall in their education in this area.

This outcome is also reflected within higher education more broadly; a survey of over two thousand higher education students in the UK found that eighty-two percent of participants considered that understanding IP was important for their career, but only forty percent of participants perceived that they had sufficient understanding of IP to support them in their future career (Intellectual Property Office, 2012).

There are challenges to teaching IP-related concepts in engineering education. It has been reported that engineering academics consider that content on IP was not as important as other engineering content, and that there was no space within the curriculum for courses focused on teaching to IP-related content (Ruth Soetendorp, 2004). McLaughlan et al. (2005) report that engineering academics may not know what skills and knowledge students need to learn in IP education. Academics may also feel that they are not appropriately qualified to teach IP (Ruth Soetendorp, 2004).

This study investigated whether engineering syllabi in Australia is conducive to providing engineering graduates with the skills and knowledge required to be able to understand how IP relates to the profession of engineering. Specifically, the following research question was addressed.

Research Question

To what extent is intellectual property education articulated in undergraduate electrical engineering syllabi within Australia?

Study Scope

The scope of this study included four-year single undergraduate degree programs accredited by Engineers Australia (corresponding to a Bachelor degree with Honours component) within the discipline of electrical engineering, offered during 2019. Double or dual degrees were not considered. Only core or compulsory units were considered.

Methodology

Types of Intellectual Property

Types of intellectual property recognized by Intellectual Property Australia include patents, trademarks, registered designs, plant breeder rights, geographical indicators, copyright, and circuit layouts (IP Australia, n.d.). These categories reflect those also recognized by the World Intellectual Property Organization which includes patents, trademarks, industrial designs, geographical indicators, and copyright (WIPO, n.d.). Due to potential issues in trying to identify whether students learn about circuit layouts in terms of IP, this was excluded from the types of IP which were evaluated.

Therefore, this study evaluated whether engineering syllabi articulates ‘intellectual property’, trademarks, registered designs, plant breeder rights, geographical indicators and copyright as course content.

Data Sources

List of engineering units

The list of engineering programs accredited by Engineers Australia (2019) was inspected. A list of all four-year engineering programs which were currently offered and had “engineering” and “electrical” in the title were identified. This identified forty distinct degree programs at twenty-five institutions. So that findings were not biased by institutions which offered more than one degree program in the area of electrical engineering, only one degree program from each institution was selected for further analysis.

If an institution offered a program which only included “electrical” in the title and did not include other associated fields (“electrical and electronic”, “electrical and biomedical”, “electrical and computer”), this program was chosen. Otherwise, the program which appeared at the top of the list for the institution was chosen. This resulted in twenty-five degree programs, one from each of the institutions in Australia who offered undergraduate four-year electrical engineering programs.

Following this, the publicly accessible program structure of all units for each program was accessed from the respective institutions’ website. The total number of units per degree program ranged between thirty to thirty-six units. Following this, the core or compulsory units from each program were identified. This identified six hundred and thirty-nine courses across the twenty-five programs, a mean of 25.6 units per program.

A spreadsheet was created to record unit information. Using the publicly accessible unit outline of each unit from the respective host institution’s website, the following information was recorded each unit: the host institution, unit code, unit name, year level when the unit is expected to be completed, and website link to the publicly accessible unit outline.

Unit outline content

Unit outlines were analysed using document analysis (Bowen, 2009), combining aspects of content and thematic analysis. Unit outlines typically describe the intended focus of the unit, the intended content of the unit, the intended learning outcomes for the unit, and possibly the types of assessment tasks for the unit. Unit outlines and handbooks have previously been used in a range of studies to evaluate information about engineering syllabi, such as inclusion of creativity in engineering education (Marquis, Radan, & Liu, 2017), inclusion of ethics in engineering education (Stephan, 1999), and a comparison of electrical engineering programs at various institutions within the Gulf Cooperation Council (Memon, 2007).

To be able to analyse the content of the unit outlines in an efficient manner (using keyword search for the first stage, discussed below), and to ensure that website data was captured in case the content of websites changed in future (which may inhibit reproducibility), it was necessary that the text of each respective unit outline was scraped and recorded. To do this, a Python script was created which allowed the text content of each unit outline to be automatically extracted and saved to a separate text file. However, it was necessary to record only sections of the websites which were the unit outline itself. It was imperative that non-unit outline material on the website such as text in website headers, text in website footers, text in navigation bars, HTML tags and JavaScript code were excluded.

To do this, the webpage(s) which displayed the unit outlines on the website of each institution was inspected (using Developer tools in Google Chrome). The HTML element which encompassed the entire unit outline was identified, and the respective details (such as HTML element type and name) were recorded alongside the other details for the unit in the spreadsheet. When the Python script was executed it accessed the website of every unit outline, and the recorded HTML element details allowed the script to access only the text relevant to the unit outline, and record this to a file. This created a set of six hundred and thirty-nine text files, each containing the text of an entire unit outline. Files were named using a convention which allowed each file's content to be readily identified.

Data Analysis

Data analysis took stage in two stages. NVivo was used for analyzing the unit outlines. During the first stage, unit outlines were evaluated for inclusion of keywords regarding all types of IP described above. The purpose of this was to limit the course outlines which would be manually evaluated during the second phase to those which included keywords specifically relevant to each respectively type of IP. Keyword searches were performed on all unit outlines in NVivo using the Text Search Query function with the find settings set to 'With stemmed words (e.g. "talking")' (Table 1). This allowed similar words of interest in the unit outline text, such as 'patents' or 'patenting' for the keyword 'patent' to be identified. Using the keywords shown in Table 1, there were 44 course outlines which included keywords related to intellectual property, 9 course outlines which included keywords related to patents, 406 course outlines which included keywords related to designs, and 112 course outlines which included keywords related to copyright.

During the second stage, unit outlines which had been selected for each type of IP using the respective keywords, were evaluated to see whether the unit outline did in fact articulate information relevant to IP education. Unit outlines were coded as either articulating information relevant to IP education, or not, based upon the content in the unit outline.

The manual analysis demonstrated an important limitation of the keyword search from the first stage. The vast majority of hits for 'design' referred to the act of designing a problem solution or engineering design, and did not refer to a registered or design within the context of IP. In a similar vein, the vast majority of hits for 'copyright' and 'intellectual property' were links within unit outlines to the respective institution’s policies on these topics. Therefore, exclusion criteria were inductively created for these cases as the unit outlines were analysed.

Findings

Table 1: Number of Unit Outlines which articulate Intellectual Property Education at each stage of analysis, and reasons for exclusion

Types of IP	Search Terms	Keywords in Unit Outline (N = 639)	Excluded During Manual Evaluation	Reasons for Exclusion (Can be multiple per outline)	Unit Outlines which Articulate IP Education
Intellectual Property	“intellectual Property” intellectual-Property IP	44 (6.9%)	30 (4.7%)	Links to institution’s policy on IP - 25 IP refers to Internet Protocol - 6	14 (2.2%) (11 institutions)
Patent	patent	9 (1.4%)	0 (0.0%)	N/A	9 (1.4%) (7 institutions)
Trade mark	“trade mark” trademark trade-mark	0 (0.0%)	0 (0.0%)	N/A	0 (0.0%)
Plant Breeder Rights	plant breed	9 (1.4%)	9 (1.4%)	Referring to electrical plants - 9	0 (0.0%)
Geographic Indicator	geographic	0 (0.0%)	0 (0.0%)	N/A	0 (0.0%)
Registered Design	design	406 (63.5%)	404 (63.2%)	Refers to the process of design - 404	2 (0.3%) (2 institutions)
Copyright	“copy right” copyright copy-right	112 (17.5%)	108	Links to institution’s policy on copyright - 108	4 (0.6%) (2 institutions)

Table 2: Sample Excerpts from Selected Unit Outlines which articulate Intellectual Property Education

Sample Excerpt	Course Code	Course Name	Institution
“Syllabus: ... Intellectual property law copyright, patents and designs”	BLAW2000	Law for Engineers	Curtin University
“Unit Content … Intellectual property in Australia: confidentiality, copyright, designs, patents, protection of computer technology”	ENS2159	Engineering Innovation and Ethics	Edith Cowan University
“Overview of Intellectual property, copyright, patents and digital rights”	ENGR9742	Standards, Ethics and Compliance	Flinders University
“Course content … Lectures by engineering practitioners and managers on specialist topics selected from … IP and commercialisation”	EEET 3033	Professional Engineering Practice E	University of South Australia
“Content (topics) … Intellectual Property Protection”	48270	Entrepreneurship and Commercialisation	University of Technology Sydney

Upon conclusion of the second stage of analysis it was found that 14 units (2.2% of total) at 11 institutions articulated unit content related to intellectual property, 9 units (1.4%) at 7 institutions articulated unit content related to patents, 2 units (0.3%) at 2 institutions articulated unit content related to registered designs, and 4 (0.6%) units at 2 institutions articulated unit content related to copyright. No unit outlines referred to trademarks, plant breeder rights, or geographic indicators. Five selected sample excerpts from unit outlines which articulated education on IP (as well as specific types of IP) are shown in Table 2.

Discussion and Implications

The findings of this study highlighted that overall, there is generally a low inclusion of IP-related instruction in undergraduate electrical engineering syllabi throughout Australia. Reflecting upon the research question, of the six hundred and thirty-nine unit outline which were analysed, only fourteen unit outlines directly articulated that students were expected to receive instruction on IP-related topics during the course. Moreover, only eleven of the twenty-five tertiary institutions which offered electrical engineering programs were found to include at least one unit which articulated IP-related instruction (Table 1). This highlights that fewer than half the tertiary institutions in Australia require students to specifically and intentionally learn about IP during completion of an undergraduate electrical engineering degree. This reflects the arguments put forward by the Higher Education Academy (2008) and Kaplan and Kaplan (2003) that instruction on IP-related topics is somewhat marginal within the engineering curriculum. The limited inclusion of IP education in engineering syllabi suggests that although engineering graduates in Australia may be equipped to create, they may not be adequately prepared to fully understand their IP rights, avoid infringement of others rights, and how to protect their creations.

Limited inclusion of IP-related instruction on engineering syllabi may be linked to the fact that there is no requirement by Engineers Australia (2017) that material is taught. Adding credence to this argument, engineering academics have previously reported that IP awareness was not assessed at their institutions because it was not an explicit requirement for accreditation (R. Soetendorp, 2002). Therefore, this suggests that if IP-related knowledge and skills are indeed considered to be important for engineering students to possess, it may be necessary for Engineers Australia to consider adding this to accreditation requirements to ensure widespread adoption into curricula. It is necessary for engineers to be able to understand the fundamentals of IP to be able to protect their creations (Kaplan & Kaplan, 2003).

It is important to teach students about IP earlier in their tertiary education as they demonstrate greater motivation to learn about the topic at this time (Intellectual Property Office, 2012). It is also highly important that students are able to understand the relationship between IP and their future career, and students want this to be clearly articulated (Intellectual Property Office, 2012).

Engineering educators have described various ways of successfully introducing IP education to engineering students, providing outlines for how this may be achieved by other educators. Nestor (2009) described creation of a unit focused on educating students about concepts related to IP, namely ethics and professionalism, copyright, patents, trademarks, and trade secrets. The unit introduced students to working with each of the four types of IP, and focused on the use of case studies. Silva, Henriques, and Carvalho (2009) investigated the potential for increasing creativity in a product development course in Portugal in part through providing students with an understanding of intellectual property. Over ninety percent of forty-two participants reported that after completing the course they had improved "understanding of problems and opportunities related to intellectual property rights". McLaughlan et al. (2005) found that students reported having a better understanding of IP, patents, trademarks and copyright after completing an IP instruction module. On the other hand, others have demonstrated that it can be effective to build engineering students' understanding of IP though projects which involve collaboration with students studying law (Humphries-Smith, 2009). One suggestion is that engineering students should be provided with an understanding of IP through understanding (i) the right to own IP, (ii) infringements, (iii) copyrights, (iv) trademarks, and (v) patents (Kaplan & Kaplan, 2003). IP may also be discussed in terms of fairness in ethics and respecting others' creations (Colby & Sullivan, 2008).

Overall, there are a range of potential methods that educators may use to engage students in learning about IP. Courses dedicated to teaching IP concepts are likely to be infeasible due to lack of space in the curricula (Ruth Soetendorp, 2004), and it is likely to be more successful if IP education is integrated into existing units. Educators may seek to use external resources created specifically for this purpose (thus helping to remove the problem of academics being unsure what to teach as reported by McLaughlan et al. (2005)), such as online modules which are readily accessible and may be integrated into existing units. A relevant example are those recently developed as part of the Edge on Innovation project (Austraian Technology Network, n.d.). This may aid educators to provide students with the opportunity to learn about IP education in a manner which is adaptable for educators.

Limitations

It is important to note that instruction about IP may in fact be occurring in certain units, but this may not have been clearly described in the unit respective outlines, which may influence reliably of the findings. Unit outlines may be aspirational in nature and the content which is delivered may vary slightly from what is described. Unit outlines may also be out of date, and the outline may not accurately reflect the current status of the unit content. Students also tend to learn content most effectively when they are assessed on it, so learning activities which discuss IP that are not directly assessed (such as guest lectures) may have limited influence on students' long-term understanding of IP.

Unit outlines are not standardised meaning that the level of detail provided varied depending on the institution being considered. Although a clear majority of institutions provided unit outlines with comprehensive descriptions and explanations of unit topics, content and learning outcomes (sometimes over 1500 words in length), some institutions provided unit outlines which were only about 200 words in length. Shorter unit outlines obviously limits the reference information which is available, which is a limitation of the study.

The findings may vary if the study was conducted on a different discipline of engineering, using postgraduate degree programs, or on engineering programs from a different country.

Future Work

Future work may build upon this study by surveying engineering students, academics, and industry to understand perceptions about inclusion of IP education in Australian engineering curricula. This may focus on perceptions of whether IP education is important, how it should be taught, and whether it may be integrated into the existing curricula. This will provide educators with more guidance about to what extent IP education should be a focus in Australian engineering curricula.

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