# Engineering Enterprise through IP Education: What is needed?

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## Abstract

There is a widespread movement within tertiary education to build the capacity of engineering students to engage with enterprise. This is reflected within the accreditation requirements of professional bodies, stated industry needs, initiatives by government agencies and the emergence of related curricula content in some engineering courses. Entrepreneurship education for engineers relies on developing student capabilities in the business and the legal intellectual property domains as well as their traditional engineering capabilities.

Intellectually Property (IP) education has a particularly important role to play by supporting engineers in the creation of product or process development opportunities which have a unique and defensible IP. This is the fundamental basis upon which further entrepreneurial activity can be based. However there is no well established pedagogy for educating engineers and scientists about Intellectual Property.

The goal of this paper is to explore student and educator beliefs about what engineers need to know about IP. This work is in part based around the experience of introducing IP education into engineering subjects. It was found that engineering educators were initially unclear about exactly which types of IP knowledge and skills were the most important for students to know. To what extent should the various elements of IP Law, IP valuation and exploitation, IP Policy, IP Management and IP ethics be emphasized? To what extent is a general grounding or scaffolding of law needed for engineers to place IP Law and practice in the context of their engineering activities? Student responses indicated many already had an appreciation of the engineering process and were seeking an IP perspective on issues. The findings outlined here show that to meet the needs of engineering faculties and students there will need to be strong contextualisation of IP education and that engineering educators will also need to engage with identifying what IP education can offer .

## Introduction

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The need for increased entrepreneurship within the higher education curricula has been well recognised[3] and intellectual property competence has now been explicitly recognised within the UK-SPEC 2004[15] engineering accreditation criteria. In Australia, limited progress is being made towards development of entrepreneurial skills training, or integration of entrepreneurial skills development into higher education Science and Technology courses (especially opportunity recognition)[4]. The report also recognised there was also 'lack of a deeply rooted entrepreneurial culture within Australia which would see entrepreneurship becoming a more socially legitimate activity'. This suggests the need for a more broadly based education in enterprise engineering.

Entrepreneurship education for engineers relies on developing student capabilities in the business and the legal intellectual property domains as well as their traditional engineering capabilities. This requires engineers to develop skills and knowledge about working with intellectual capital. Klien and Prusak (as cited[6]) define intellectual capital as "intellectual material that has been formalised, captured and leveraged to produce a higher value asset". This can be achieved through Intellectual property education. Intellectual Property (IP) can be defined as "Creative ideas and expressions of the human mind that have commercial value and receive the legal protection of a property right. The major legal mechanisms for protecting intellectual property rights are copyrights, patents, and trademarks. Intellectual property rights enable owners to select who may access and use their property and to protect it from unauthorized use."[9]. Intellectual Property education is the teaching of explanations of and arguments concerning intellectual property laws. It covers diverse domains including IP Law, IP valuation and exploitation, IP Policy, IP Management and IP ethics.

The goal of this paper is to explore student and educator beliefs about what information engineers need to know about IP. It does this through exploring what is currently known about teaching Intellectual Property into the Engineering discipline and through surveys of students and educator needs in regards to IP education. It is expected that this paper will be of use to Engineering and Law educators within engineering courses when determining how to develop the capacity of their students to engage with entrepreneurship as well as their broader engineering practice.

**Teaching Intellectual Property into Engineering**

Even though it is widely recognised that IP concepts underpin the successful move towards a knowledge-based economy, IP education is not uniformly valued and therefore is not taught across a range of high technology courses. Within Management Information Systems education there is a proposed Model curriculum. However IP is not mentioned[10]. Within the Computing Science Model Curricula[2], IP is recognised as a Core element of the curricula under Social and Professional Issues and it is recommended that it be allocated at least 3 hours. It is also explicitly recognised in Software Engineering Model curricula[14]. Within the Engineering based entrepreneurship curricula[7] Intellectual Property is seen as a foundational skill. The UK Engineering Accreditation body recognises that engineers need the ability to secure the necessary intellectual property rights of engineering technology and require IP understanding for registration as a Chartered Engineer[15]. The Australian Engineering Competency Standards for graduate engineers (Stage 1) recognise the need for engineers to "appreciate the commercial, financial and marketing aspects of engineering projects and programs and the requirements for successful innovation" but does not explicitly recognise Intellectual Property in the Stage 1 or Stage 2 competencies.


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There is relatively little published literature on teaching IP into the Engineering curricula. The published studies which describe teaching activities where IP concepts have been introduced into the curricula[5,6,11,12,16] can be categorised as treating IP within the Engineering curricula in three different ways. Firstly, IP can be introduced by focusing on IP Law and the vehicles used to implement it (e.g. patents, copyright, trademarks). This approach is often favored when IP is introduced as part of idea-generation and venture-creation process in entrepreneurship or enterprise subjects. Secondly, IP can be introduced into the engineering curricula within a surrounding context of legal fundamental and principles. The extent of the surrounding context may range from part of a lecture to a whole subject on Law related education. A third way that IP can be brought into the Engineering curricula is as a source for raising issues about social and professional responsibilities of engineers.

It should be stressed that these three approaches are not mutually exclusive and are categorised just to represent the extent to which IP Law is embedded within a bigger content of Law and Society. This raises the question of to what extent is a general grounding or scaffolding of law needed for engineers to place IP Law and practice in the context of their engineering activities?

Intellectual capital can be considered to be at the heart of the creative engineering design process. The way that intellectual property knowledge can best be used to stimulate the development of the idea or opportunity within the engineering design process may well be context specific. Kington[7] notes that the value creation process appears to differ between enterprise education in business-run and engineering-run courses. Within the business school environment, the idea or opportunity is thought to arise from a market need and a technology is then developed, while in the engineering school environment the product idea will flow from a technology on to an entrepreneurial opportunity. This perceived difference in the innovation process may therefore impact how intellectual property education is taught. It may present a challenge for staff who have a business or law background to find the right emphasis and approaches which develop business and legal skills in engineers that specifically focus on the engineer's role in product development and innovation. There is a clear need for further studies into disciplinary differences in the teaching of IP.

The types of knowledges and understandings that IP Education is seeking to develop within engineers and how that should be assessed is an area that needs more discussion within the literature on engineering education. For example, it is relatively straight forward to assess knowledge about the various types of intellectual property types (e.g. patents). However there are few studies about how to assess an activity where IP knowledge and skills are deeply embedded and fundamental to the outcomes produced from an engineering design activity. Soetendorp[12] discusses several innovative activities designed to give students IP capabilities rather than just IP knowledge. These have involved engineers assessing the innovation in their product against a patent database and engineering and law students working together in a client-advisor relationship. Being able to evaluate how effectively engineering students have used IP knowledge and skills will be particularly important within engineering enterprise subjects.

Several key barriers to the integration of IP into the engineering curricula have been identified. Many engineering academics felt that IP content was not as important as other engineering content and that the engineering curricula was already overcrowded and could not support any new subjects[13]. One approach to addressing these barriers is to be able to integrate IP education more tightly into existing subject domains taught within the curricula.


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However there is little specific guidance within the literature about this approach. While there is some material on law related teaching for other programmes[1,8] there is little work on how to contextualise generic IP education to suit the style of delivery and areas of study within the undergraduate engineering curricula.

What is needed is an established pedagogy for creating well planned, integrated, sequenced and cumulative learning experiences for IP education when the learning activities reside in different subjects within a course. This challenge of integrating relevant material from other disciplines into the core engineering curricula is also a challenge faced by other initiatives (Sustainability, Safe Design) that seek to do likewise across the curriculum. The development of pedagogical approaches to Engineering Education that are not limited to the incorporation of technical skills and understandings will be critical if Engineering Education is to meet the aspirations of broadening the engineering professional and meet the requirements of the Engineering Accreditation bodies and Professional Associations.

**UKCLE study**

In recognition of the need to further develop pedagogies associated with Intellectual Property education in the engineering curricula a grant was sought from the UK Centre for Legal Education (UKCLE). It is a subject centre of the Higher Education Academy in the UK which was set up to support lecturers in enhancing student learning and the student experience. The project involves a staff member from both the Engineering and Law Faculties at both Bournemouth University in UK and University of Technology, Sydney as well as other key collaborators. The project commenced in March 2005 and is expected to run for two years.

The project aims to;

- Develop resources to support the delivery of Intellectual Property education to engineering, and other science, technology and non-law discipline programmes
- Hold joint Law/Engineering workshops in both Australia and UK
- Develop pedagogy surrounding the integration of essential law knowledge into the non-law curricula. Of specific interest is Intellectual Property Education into the Engineering curricula.

The work undertaken within this paper is part of the UKCLE study.

**Engineering Educator needs for IP Education**

It was recognised within the UKCLE study team that a much clearer understanding about the relationship of IP to Engineering education and practice was needed. One approach of the team to this issue was to have informal discussions with Engineering educators about IP Education. The following questions for the UKCLE study team emerged;

- Where in the engineering curricula is IP education relevant?
- What is the essential IP material that needs to be taught?
- How much class time is needed for the delivery of that material?
- How can I support the delivery and assessment of that material?

**Survey into Postgraduate Engineering students needs**


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The subject Technology and Innovation Management is taken by students who have an undergraduate engineering degree. They are typically enrolled in an MBA or a Masters degree designed for engineers and technical specialists wishing to expand their managerial skills within a technology-based organisation. There are a large number of international students in this subject. The subject brings together knowledge from engineering and management disciplines. Emphasis is placed on the importance of managing the performance of the entire product and process development cycle. Topics include: technological change management, assessment and evaluation of technology, technology policy development, and new product and process development.

A survey was taken both before and after an Intellectual Property instruction module was taught. The lecture-based module was undertaken over a 75 minute period and covered the whys and whats of IP, patents, designs, trademarks, copyright and important issues such as IP identification, protection of the product development environment, exploitation of IP and the role of IP experts. The material was developed and delivered by Engineering Educators.

Students were surveyed both pre and post delivery of the IP instruction module. Responses were sought on their perceptions of understanding about Intellectual property in general as well as specific elements (Table 1).

**Table 1: Perceptions of understanding about IP**

| Item | How much do you know about? | Pre-IP Instruction | | Post IP Instruction | |
|---|---|---|---|---|---|
| | | Mean[&] | SD | Mean[&] | SD |
| 1 | Intellectual Property protection in general | 2.3 | 1.2 | 3.5 | 0.8 |
| 2 | Patents | 2.9 | 1.1 | 3.7 | 0.7 |
| 3 | Trademarks | 3.1 | 1.0 | 3.8 | 0.8 |
| 4 | Copyright | 3.3 | 1.3 | 3.8 | 0.7 |
| | Number of Responses (n) | 68 | | 77 | |

[&]Likert scale; 0 = nothing/ never heard of it; 1 = not much at all; 2 = have heard of it; 3 = can define it / know a bit; 4 = good understanding; 5 = know quite a lot
SD Standard Deviation

The data suggests there was a poorly developed understanding within the group about Intellectual property protection in a general sense compared with their knowledge about specific components such as Patents, Trademarks and Copyright. There is clearly a need to develop a strong contextual background about Intellectual Property Rights management in addition to specific elements. There was greater prior knowledge within this cohort about copyright followed by Trademarks and finally patents. It may be that the Engineers through their professional or personal life have a much greater exposure to copyright issues and awareness campaigns than patents. The lower standard deviation in the post IP module survey data showed that the IP instruction helped standardise the difference in the levels of understanding within the group.

This data in Table 2 is generally consistent with students' perceived knowledge needs prior to the IP instruction module. The group rated the usefulness of further knowledge about IP Protection slightly lower than specific elements such as Trademarks and Copyright. This rating of lower perceived usefulness may in part explain why the group had not developed an


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understanding of the broader management aspects of Intellectual property compared with knowledge about specific elements of IP Law. However after the IP Instruction module the group rated their desire for further knowledge about IP Protection higher suggesting they could now better see the value in it.

**Table 2: Percieved knowledge requirements**

| Item | Do you think it would be useful to know more about? | Pre-IP Instruction | | Post IP Instruction | |
|---|---|---|---|---|---|
| | | Mean# | SD | Mean# | SD |
| 5 | Intellectual Property protection in general | 3.5 | 1.3 | 3.9 | 1.0 |
| 6 | Patents in general | 3.5 | 1.2 | 4.0 | 0.9 |
| 7 | How and when to apply for a Patent | 3.7 | 1.4 | 3.9 | 1.1 |
| 8 | Trademarks | 3.8 | 1.1 | 3.9 | 0.9 |
| 9 | Copyright | 3.9 | 1.1 | 3.9 | 1.0 |
| | Number of Responses (n) | 68 | | 77 | |

#Likert scale; 0 = don't know; 1 = not very useful; 2=somewhat useful ; 3=neutral ; 4=useful ; 5 = very useful
SD Standard Deviation

Another aspect of the research was to understand what the students gained from their exposure to the IP module through the impact they believed it would have on their practice as engineers. This was examined in part through survey questions (Table 3)

**Table 3: Percieved impact of IP module on their practice**

| Item | How important do you think the following activities are in a product development environment? | Pre-IP Instruction | | Post-IP Instruction | |
|---|---|---|---|---|---|
| | | Mean* | SD | Mean* | SD |
| 10 | Keeping a journal with dates and activities. | 3.3 | 1.0 | 3.7 | 0.9 |
| 11 | Searching existing patents | 3.6 | 1.0 | 3.8 | 0.9 |
| 12 | Consulting with an IP Professional. | 3.3 | 1.0 | 3.7 | 0.9 |
| 13 | Implementing security measures and limiting access to areas and information. | 3.7 | 1.1 | 3.9 | 0.9 |
| 14 | Disclosure agreements | 3.5 | 1.0 | 3.7 | 0.9 |
| | Number of Responses (n) | 68 | | 77 | |

*Likert scale; 1 =Not Too Important; 2= Somewhat Important; 3= Quite Important; 4= Very Important; 5 = Critically Important
SD Standard Deviation

The exposure to the IP Instruction module, even though it was relatively short, did give the group a better understanding of the need to document their engineering activities and of the value of consulting with an IP expert.

**Undergraduate Engineering student needs**


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Undergraduate engineering student needs for IP Education was explored informally through responses received after a lecture on IP delivered in a subject 'Technology Assessment'. It is a compulsory senior undergraduate engineering subject, which involves students from all engineering sub-disciplines. The subject provides an overview of the different approaches to Technology Assessment used in the context of public policy formation, impact evaluation and innovation assessment. The 60 minute IP lecture was developed by an IP Law specialist from the Faculty of Law. The approach was to provide students with a brief general grounding/scaffolding upon which they could place IP law and practice in the context of their future practice as engineers - specifically addressing knowledge that a new graduate might require when starting engineering employment. The initial portion of the lecture covered areas of the law vital to engineer's future when securing their first professional job. The content covered statutes (notions of mens rea and strict liability); torts (negligence and professional indemnity issues); Occupational Health and Safety Law and contracts. A discussion of contracts of employment was then used to lead into IP related elements such as confidential information, trade secrets, patents, licensing, copyright and designs , employers' IP rights and employees' IP rights.

From the student responses it was clear that many students already had an appreciation of the engineering process and were seeking an IP perspective on engineering issues. They were typically asking the "what happens if I …." questions with a view to finding out the implications of IP in their engineering practices. The law faculty lecturer also found the style of students' questions, and the need for him to modify his question answering style, to be a salutary experience. He reported that, as someone who was extremely confident in fielding and answering questions from law students, it was a challenge to provide contextual answers to students lacking a background of legal studies and experience. This illustrates the need for academics (both legal and non-legal) to be conscious of this lacuna when structuring materials for use by non-law students.

## Conclusions

There is a clear need for engineers to be more broadly educated in the business and legal aspects of engineering. In particular Intellectual Property education needs to be more explicitly and deeply embedded within the engineering curricula. Only then will the full potential of engineering educational activities focussed around enterprise and engineering design be harnessed. However , IP education is also required to develop within undergraduate engineers the professional, social and managerial aspects of engineering. But to more fully engage engineering students with IP education will require both engineering and law educators to develop enough understanding of each others disciplines that they can better define the pedagogies that are required.

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