STRUCTURED ABSTRACT

A Conceptual Framework to Analyse Diversity of Perceptions in Engineering Students on Learning Management Concepts

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CONFERENCE SUB-THEME

3.   Beyond the classroom – tailoring engineering and STEM education to meet the needs of all stakeholders. (External Industry requirement)

CONTEXT

Several research studies showed that a move from technical specialty to a technical management role often begins at early stage of an engineer's career. Engineers often find themselves in a management role as soon as they are assigned to a project. This transition from technical specialty to technical management by engineers in a very early stage of their career, means engineering graduates need relevant training to help them to be successful in new positions, either as a team supervisor, or manager of a division, or a department. In technically orientated organisations, evidence shows that the majority of managers have engineering or science degrees. The above notes also show that engineers or scientists are expected to have *a very diverse* knowledge and skills to perform duties outside the technically related engineering works, *tailoring engineering education to meet the needs of all stakeholders.*

PURPOSE

The phenomenon we explain above had a major impact on engineering education; therefore, it is worthy to investigate how *a wide range of* engineering students would see the importance of learning *different* management concepts.

APPROACH

This paper outlines a development of a conceptual framework to conduct this educational research (quantitative research) regarding a particular core subject in our institute's engineering curriculum. In our work we design two surveys and distribute them among students and then analyse students' opinions in relation to *different* management concepts. After obtaining initial results, we will modify our teaching and learning processes and we will conduct this research again to see whether *diversity of* students' perceptions being changed or not.

RESULTS

In this stage, we have initially collected the first survey and we anticipate that by mid-year, we have a better understanding of engineering students' opinions about learning management concepts. We have a wide range of students from different disciplines and we expect different opinions due to a variety of approaches by students to target potential careers. It is clear that students look for technical jobs first, and therefore, they may not pay attention to learning management concepts.

CONCLUSIONS

Due to teaching a variety of management concepts, the likely conclusions could be that students prefer to learn those management concepts that have some technological components, such as: Quality Control Management, Product Design Development and Managing Innovation. Concepts that have pure business themes such as: Marketing, Economics or general Laws may be less attractive for engineering students.

KEYWORDS

Engineering management, Technological strategy, Technology-based entrepreneurship, Management and Engineering education

Introduction

By reviewing the evidence from research studies, it is noticeable to say that the majority of engineers spend at least half of their careers in supervisory or managerial positions (Babcock, 1974; Kocaoglu, 1984; Storto, 2008). One reason is that engineers often find themselves in a management role as soon as they are assigned to a project. They have to make a decision in regards to human, organisational and financial subsystems of a project (Kocaoglu, 1984). This transition from technical specialty to technical management by engineers in a very early stage of their career, means engineering graduates need relevant training to help them to be successful in new positions either as a team supervisor or manager of division or department (Babcock, 1974). Engineering graduates from different programs/courses in different universities, recognise that they have had opportunities to be promoted in more senior management positions after several years work experience. Babcock (1974) revealed that engineers would be expected to have knowledge and skills to perform duties outside the technically related engineering work.

Especially in technically orientated organisations, Storto (2008), claimed that the majority of managers have engineering or science degrees. This is because many serious factors in high technology companies are often technical, and therefore, engineers and scientists are best able to identify and manage their resolution. Also, engineering managers can best evaluate the capability of technical personnel. In addition to the above points, within high tech firms, engineer managers can more easily gain respect and loyalty from their subordinators.

These research studies also show that engineers or scientists are expected to have knowledge and skills to perform duties outside the technically related engineering work. This situation has had a major impact on engineering education. Research studies such as, the work done by Alvear and her colleagues (2006) or the article written by Becker (2009) and the research paper produced by Storto (2008) showed that engineering graduates who would like to work in technologically-based environment and promote themselves to managerial positions; have a profound need to obtain management skills while they are gaining their technical skills.

On the other hand, a group of professionals led by Sara Jansen Perry (2017) focused on different matters and addressed the requirements for efficient methods to incorporate leadership development into technical curriculum and skill-building programs (Perry et. al 2017). They believed as engineers continue to be crucial contributors in current innovation races for international economic competiveness; engineering educational providers should be capable to transfer engineers into leaders.

This paper outlines a development of a conceptual framework to conduct an educational research regarding a particular subject in our institute's engineering curriculum. This particular subject focuses on teaching a wide range of managerial topics such as: Strategic management, Marketing, Entrepreneurship, Finance/Accounting, and Quality and Maintenance management to engineering students. For developing this conceptual frame, while we are reviewing previous studies in relation to different engineering educational programs in different institutes and universities; we are also looking at the content of particular subject that our institute offers. This conceptual framework will help us later to ask questions about students' opinions via two surveys in regards to the importance of main content of this subject. Future results of these surveys will help teaching team to support their learning objects by providing more evidence from real world and current case studies available for students.

Literature review

In introduction of this paper we provided small proportions of evidence that nowadays, engineering students have to gain knowledge in a wide ranges of fields to be able to develop their personal professionalism. In regards to expand our understanding of recent attentions by researchers and educators to teach management to engineering students, in following paragraphs, we present the summary of reviewing recent studies.

Educational providers and institutes, particularly engineering universities, adapted their programs in relation to needs and requirements for engineer graduates in regards to their career developments. For many years universities have offered formal educational programs to assist engineers and scientists

move into managerial positions while maintaining their original identity (Kocaoglu, 1984). Universities offer programs such as: Engineering & Technology Management (ETM), Management of Technology (MOT), Project Management (PM), and Knowledge Management (KM) within either undergraduate or postgraduate curriculum. Santo (as cited in Kim, 2015) provided statistical information and said that number of schools that offer MOT program increased from 30 in 1976 to approximately 200 worldwide in 2001. Yanes, Khalil and Walsh (2010) evaluated different programs and mentioned that almost all of the above programs provide a broad spectrum of courses in technology strategy, creative enterprise management, technology-based entrepreneurship, technology innovation, technology forecasting. They also offer similar courses of traditional areas of management study such as: finance, organizational behaviour and information management. Variety of Schools at universities from Engineering Schools or Schools of Science to Schools of Management or Business offer these programs. Referring to a research study conducted by Portland State University's Department of Engineering and Technology Management in 2003 and 2004, Alvear and her colleagues (2006) found out that among 142 academic institutes in this particular study, 98 programs were in Engineering Schools and 44 programs were in Business Schools (Alvear et al. 2006). This is not, however, a case in the past. For example, long time ago Babcock (1974, p. 102) stated that: "Admittedly, most graduate-level training in management received by engineers has been through MBA programs offered by Schools of Business Administration or Management."

A question is raised now that why we need those above programs such as "Technology or Engineering Management" and so on. Some scholars such as Byrne (cited in Yanes et.al 2010) tried to find answer by looking at the "technology race" between the USA and the Soviet Union after WWII. Another possible answer is the speed of technological changes around the world which affected the socio-economic situations of many countries in Europe and some parts of Asia, such as: Japan, South Korea, and Singapore. The USA was possibly the first country to understand the importance of managing technology. Therefore, to respond to these massive technological changes, educational experts changed their practices and new processes evolved to meet the new needs. As educational experts developed new programs, various improvements in every aspects of managerial practices have been seen through lenses of technology focus. These included efforts to incorporate technology into strategy process as Friar and Horwitch cited in (Yanes et. al 2010) or greater emphasis on changes of operations and total quality management (Kim, 2013). Another case is the impact of science and technology on society (Yanes et. al 2010).

If we look at the situation from industry and manufacturing points of view, we can recognise that about a decade ago, manufacturing and innovation-based industries experienced significant changes and entered a new phase in their development. These changes have contributed to the rapid growth of the global economy. In response to these changes, education and related academic research programs in technology management have been evolving worldwide (Kim. 2015). As a consequence, some governments such as South Korean government has commenced to invest seriously in engineering education and specially focused on Management of Technology (MOT) to facilitate the transformation of Korean industries from being capital intensive to knowledge intensive (Lee cited in Kim, 2015). At the same time, transformation from manufacturing to service-oriented industries has been undertaken. The recent transformation worldwide caused MOT education to also focus on integrative multidisciplinary approaches and international perspectives. Kim (2015) believed that Management of Technology education also moved from its origins in traditional engineering management toward educational curricula that more suited to a knowledge-based and entrepreneurial economy. Adding subjects such as: technology-based entrepreneurship and technology innovation into educational curricula in different universities in the USA and Europe confirms this recent movement toward knowledge-based and entrepreneurial economy. One study in South Korea (Cheong, 2016) suggested that in MOT programs, it is better to focus on technology commercialization or technology-based entrepreneurship and also on globalisation of technology. The latter is very important especially to enhance firms' competitiveness in the global market. In regards to educational curricula, researchers such as: Cetindamar, Phaal and Probert (2016) stated that graduates from MOT programs also need to plan, direct and control the development and implementation of technological capabilities of an organisation. These roles, planning, directing and controlling, are parts of traditional management study.

In relation to entrepreneurship and technology innovation, it is also worthy to notice that creativity plays an important role in facilitating entrepreneurship and technology innovation. Therefore, some

researchers such as Chen, Jiang and Hsu (2005) tried to foster students' creativity in their reformed curriculum for their engineering students in Taiwan (Chen et al. 2005). While they offered content of production management and quality management in their subjects, they also offered creative problem solving techniques and tools.

According to findings of a survey among 142 academic institutes conducted in 2003 and 2004 by Alvear and her colleagues (2006); some courses that offered by different schools were as: Strategic Planning, Competitive Strategies, Creativity Management, Change Management, Technology Management, R & D Management, Technology Marketing, Accounting, Finance Management, Law, Intellectual Property. Those academic institutes also offered courses such as: Decision Analysis, Statistical Analysis, Operations Research and Team Building. In regards to projects that students needed to complete, according to this study, most engineering schools asked students to focus on industry and product oriented projects. On the other hand, business schools showed that students could focus on a wide range of topics and there were more variations in project's topics within business schools.

In the following section, the present authors focus on the subject content that our teaching team offers in the third year of our institute's engineering curricula, which is the second subject in the management field for engineering students. It is worthy to note that engineering students must study another core and complementary subject in the field of management, when our teaching team offers managerial concepts such as: four major managerial roles including planning, organising, leading and controlling, concepts of sustainability, ethical and social responsibilities, project management, team building, and group behaviours.

The subject has three hours lecture for 12 weeks and totally 18 hours tutorial classes during 12 weeks of semester. Members of teaching team offer a wide range of concepts during 12 weeks and they are including: Strategic Management, Entrepreneurship and Innovation, Marketing, Quality Control Management, Product Design & Development, Supply Change Management, Inventory Management, Lean Manufacturing, Maintenance and Reliability Management, Economics, Accounting and Laws (general aspects of Law).

Students also need to complete their group projects during a semester, which should be either developing a business plan for stablishing a new venture based on a new idea or improving operational activities and processes of an existing firm, whether the business is considered as SME or a family business.

It is clear that our teaching team are required to teach so many concepts during only 12 weeks, that we use every minute of teaching time and have a variety of tools and sources that we use during semesters. One of the general tools that we use is monitoring students' projects by encouraging them to apply knowledge they gain during lectures in their projects and highlighting main criteria that they have to address in their projects. For instance, we monitor their marketing strategies, operational planning, their business structures and legal or government's requirements, financial analysis and so on. In addition to that and to follow up each concepts, we distribute handouts that students need to answers several related questions for each concept. We also offer students a number of case studies to analyse and we analyse them during tutorials. We evaluate students not only by assessing their final exams, but also by assessing their projects, and marking three short (45 minutes) tests.

We also welcome students' feedback. This is one reason that recently the teaching team has decided to investigate and revise the managerial subject content. To develop our conceptual framework, we reviewed literature, we recognise the areas within the subject that should be improved or changed. We also recognise our limited time for teaching. Therefore, by considering all factors and also recognising our obligation to prepare engineering graduates for their future carriers, we developed two surveys to gather students' feedback during each semester. We present more details in following section.

Research method and our conceptual framework

We conducted a quantitative research by distributing two independent surveys during first semester of 2018. We will continue distributing two surveys in semester 2 2018 and semester 1 2019. This is a reason that this paper will only illustrate the initial findings and it is in its first stage of research. In the first survey, we asked students about their choice of group projects and only three concepts that we teach in early stage of semester which includes, Entrepreneurship, Innovation & Creativity and

Marketing. In the second survey, we asked students about other concepts we teach for the rest of semester such as Strategic Management, Quality Control Management, Product Design & Development, Supply Change Management, Inventory Management, Lean Manufacturing, Maintenance and Reliability Management, Economics, Accounting and Laws (general aspects of Law). Also, we monitor how students effectively and efficiently use all above concepts (whether they are applicable) in their group projects. After gathering data for two semesters in 2018, we will be able to identify managerial topics that engineering students like more.

Although students may have different opinions, based on our understanding of future requirements for future engineering graduates, we will be able to plan for improvement of our subject by making the lectures more attractive, enjoyable, productive and efficient. Therefore in future, students may recognise that even those concepts that are not important for them at the moment (or they do not like them now), in future will help them in their career development.

In our research we also wish to identify if there is any correlation between students who have had experience in workplace and the need to learn management (they would recognise that it is important to study managerial topics). We expect that after entering to workplaces, via programs such as Industry Based Learning (IBL) or Work Integrated Learning (WIL); students understand the importance of learning management, and therefore, they would probably acknowledge that it is important to learn managerial topics.

Initial findings and results

The following Tables (1-3) present our findings at this stage; however, we hope that by completion of the research in 2019, we are able to analyse our findings in depth. As it is shown in Table 1, in the first survey, we had 65 participants from diverse programs such as: Mechanical engineering (30%), Civil (33%), Robotics and Mechatronics (13%), and 24% from other disciplines.

Table 1: Demographic patters of respondents

	Program enrolled				Year of study			Completed IBL or WIL		Studied Management 1		
Survey 1 (65 participants)	Mech.	Civil	R&M	Other	2nd	3rd	4th	Yes	No	Yes	No	Same time
	19 (30%)	21 (33%)	8 (13%)	17 (24%)	11 (17%)	20 (31%)	34 (52%)	15 (23%)	50 (77%)	57	7	1
Survey 2 (54 participants)	13 (24%)	20 (37%)	8 (15%)	13 (24%)	6 (11%)	21 (39%)	27 (50%)	19 (35%)	35 (65%)	49	5	0

Although in the next survey we had a small group of participants, we also had a diverse range of engineering students. Around 23% of participants in survey 1 and 35% of them in survey 2 have completed the Work Integrated Learning (WIL) or Industry Based Learning (IBL) programs before studying this subject. This will help us to see whether these programs affected students' perception in regards to learn management concepts.

Referring to Table 2 and in regards to how important is for students to learn different concepts, it shows that the high level of importance from students' point of views are *Innovation & Creativity* (69%) followed by *New Product Development* (41%). In relation to moderately important, we can see learning *Lean Manufacturing* is considered by 56% of participants in this study as moderately important followed by *Strategic Management* by 55% respondents.

Table 2: The level of importance for various managerial topics among respondents

Concept of teaching	The level of importance				
	Very	Moderately	Neutral	Low	Very low
Entrepreneurship	31%	38%	18%	8%	5%
Innovation & Creativity	69%	15%	14%	0.0%	2%
Marketing	32%	31%	22%	12%	3%
Strategic Management	26%	55%	17%	2%	0.0%
Quality Control M	29%	50%	19%	2%	0.0%
Supply Chain M	28%	50%	18%	4%	0.0%
Inventory M	30%	44%	24%	2%	0.0%
New Product Development	41%	35%	17%	7%	0.0%
Economics	33%	33%	19%	9%	6%
Accounting & Finance	30%	36%	21%	8%	5%
Law (in general)	23%	36%	25%	13%	3%
Lean Manufacturing	17%	56%	23%	4%	0.0%

Also, by looking at another question in regards to how students would like to learn, the data from Table 3 indicates that for both learning concepts *New Product Development* and *Innovation & Creativity*; students preferred to have more case studies during tutorials and lectures with 49% and 40% respectively.

Table 3: The responses of participants in regards to how they would like to learn topics

Concept of teaching	Like to learn more via more time spent in lecture	Like to learn more via presenting case studies	Information presented is enough	Prefer to have less time spent in lecture	Prefer to not addressing this subject at all
Entrepreneurship	25%	29%	31%	11%	4%
Innovation & Creativity	23%	40%	26%	6%	5%
Marketing	23%	32%	32%	8%	5%
Strategic Management	11%	38%	45%	4%	2%
Quality Control M	5%	38%	53%	2%	2%
Supply Chain M	11%	36%	43%	6%	4%
Inventory M	8%	35%	48%	7%	2%
New Product Development	19%	49%	24%	6%	2%
Economics	7%	34%	40%	13%	6%
Accounting & Finance	23%	29%	29%	15%	4%
Law (in general)	19%	26%	28%	23%	4%
Lean Manufacturing	13%	30%	47%	6%	4%

Using the statistical analysis software, IBM SPSS, we found that among those who had IBL or WIL programs, there was a significant correlation between the importance of studying *Strategic Management* and *Supply Chain Management* (Spearman's rho at 0.637 at the level 0.01 within 2- tailed) and was correlation but not significant between *Strategic Management* and *Lean Manufacturing* (Spearman's rho at 0.487 at the level 0.05 within 2- tailed). Also, there was a significant correlation between studying *Supply Chain Management* and *Inventory Management* (Spearman's rho at 0.692 at the level 0.01 within 2- tailed). On the other hand, there was a significant correlation among those who did not attend IBL or WIL to study *Economics* and *Finance* (Spearman's rho at 0.567 at the level 0.01 within 2- tailed).

The outcomes of the statistical analysis suggest that this group of students would not pay attention to these topics. While for those who had IBL or WIL, they would like to learn those topics.

We have to recognise that the outcomes of statistical analysis might be changed after conducting surveys in next two semesters, so, we will monitor the situation until semester 1 2019 and by collecting more data, we would be able to present better picture how students see the need for studying various managerial topics.

Discussion and conclusions

We will change our teaching process, if we find that students cannot recognise the importance of couple of managerial concepts at this stage, but we believe that there are important for future professional developments of engineering graduates such as understanding Finance and Economics. We will continue our surveys in 2019 to get better understanding students' perceptions. Then, we will try new teaching approaches. We may use current real world case studies to show students that these concepts are practical and useful. Perhaps, another approach that could be useful is to use the outcome of our industrial research projects to illustrate the benefits of learning these concepts in the real world. By conducting this first stage of our educational research, we are able to find out for which concept(s) we have to focus more because we always face challenges of limited time for teaching. In another words, we cannot improve all areas of our teaching approach in one go. Our particular teaching processes are unique and we could not find similar approach in literature. So, we believe that it is worthy to present our work in international conferences in the future as well.

We are teaching Management to engineering students and we found out that at this stage of this research; majority of students considered that *Innovation & Creativity*, and also, *New Product Development* have been very important for them. They would like to have more case studies during their studies in these areas as well. On the other hand, *Economics* and *Finance* are not popular among engineering students. Please bear in mind that we are in initial stage of this research and more data will be gathered in semester 2 2018 and semester 1 in 2019.

References

Alvear, A., Rueda, G. R., Hernandez, I. P., & Kocaoglu, D. F. (2006). *Analysis of the Engineering and Technology Management (ETM) Educational Programs.* Technology Management for the Global Future - PICMET 2006 Conference.

Babcock, D. L. (1974). Engineering management education 2014; Status and goals of University degree programs. *IEEE Transactions on Engineering Management*, EM-21(3), 101-104.

Becker, P. R. (2009). *Technology management degree programs: Meeting the needs of employers.* Portland International Conference on Management of Engineering & Technology.

Cetindamar, D., Phaal, R., & Probert, D. R. (2016). Technology management as a profession and the challenges ahead. *Journal of Engineering and Technology Management*, 41, 1-13.

Kim, S.K. (2013). General framework for management of technology evolution. *The Journal of High Technology Management Research*, 24(2), 130-137.

Kim, W. (2015). The current transition in management of technology education: The case of Korea. *Technological Forecasting and Social Change*, 100, 5-20.

Kocaoglu, D. F. (1984). Engineering management programs as aids in moving from technical specialty to technical management. *Engineering Management International*, 2(1), 33-47.

Perry, S. J., Hunter, E. M., Currall, S. C., & Frauenheim, E. (2017). Developing engineering leaders: an organized innovation approach to engineering education. *Engineering Management Journal*, 29(2), 99-107.

Storto, C. l. (2008). *Engineering management education: trends, concerns, and open questions*. IEEE International Engineering Management Conference.

Yanez, M., Khalil, T. M., & Walsh, S. T. (2010). IAMOT and Education: Defining a Technology and Innovation Management (TIM) Body-of-Knowledge (BoK) for graduate education. *Technovation,* 30(7), 389-400.