Management Consulting Techniques in Engineering Education – The Case of Operations Engineering

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ABSTRACT

There is an increasing need for engineering students to learn how to market themselves as professionals in globalised and competitive environments. When it comes to postgraduate education, students seek to build on their existing work experience and develop their management and leadership skills to complement their engineering knowledge. The collaborative nature of engineering work suggests that increased engagement in university engineering education will only come from the introduction of activities connected to professional practice.

A solution to the challenge of learning in interdisciplinary, socio-technical subjects within engineering can be found by looking at the collaborative professional practice of interdisciplinary professions such as management consulting. In this article, we explore how an activity that has proven successful in engaging corporate stakeholders in a management consulting context, can be adapted in a management subject aimed at engineering students.

Based on requirements identified from literature and student feedback, we tailor and implement a shift-and-share activity in the postgraduate subject Operations Engineering, highlighting the potential for consulting activities to contribute to the students' learning experience. We also measure its success by evaluating the students' work output and asking the students about the extent to which the activity contributed to achieving those requirements in a short survey.

Our study confirms that management consulting techniques can be a source for inspiration when it comes to new activities and lays the foundation for the transfer of other activities in line with case-specific requirements.

Our paper highlights a practical case example of how consulting techniques can be appropriately adapted from a corporate to an academic learning environment in a way that aligns with both institutional and individual learning goals. In this context, the paper provides guidance on how to successfully adapt further consulting or other practice-based techniques to the teaching and learning context

KEYWORDS

Operations Management, Engineering Education, Management Consulting Techniques

1 Introduction

Engineering academics have for many years been experimenting with new teaching strategies that shift towards the acquisition and application of knowledge through project and problem-based learning activities (Mills & Treagust, 2003). These experiments include improving engineering education by focusing on integrative course design (Bordogna, et al., 1993), the promotion of active and collaborative learning (Felder, et al., 2000), the use of online learning (Bourne, et al., 2005), and more recently, the focus on flipped learning (Karabulut-Ilgu, et al., 2017), utilising new digital technologies (Potkonjak, et al., 2016) and the inclusion of entrepreneurial activities (Maresch, et al., 2016).

In the search for active, engaging, entrepreneurial learning activities suited to engineering education, it is important for engineering programs to teach students to understand, structure, process and transmit knowledge in collaborative networks (Camarinha-Matos & Afsarmanesh, 2006; Hargreaves, 2002). The practical nature of engineering work suggests that an increase in engagement and interaction in modern university engineering education can come from the successful introduction of activities connected to professional practice. A solution to the challenge of learning in interdisciplinary, socio-technical subjects within engineering can be found by looking at the collaborative professional practice of interdisciplinary professions such as management consulting. Management consultants must draw on the highest levels of subject-matter expertise as well as problem-solving and professional communication skills (Turner, 1982; Kubr, 2002). Nikolova and Andersen (2017) explore management consulting techniques in a business school environment.

The current study builds on their work. We argue for using the techniques of management consulting to help students develop the skills of management consulting in an engineering context. Firstly, the study focuses on management consulting methods and tools as an important stepping-stone for developing students' management and leadership skills. Secondly, the context is extended to engineering in order to evaluate the suitability for management consulting techniques beyond the realm of business studies. To this end, we explore how an activity that has proven successful in engaging corporate stakeholders in a management consulting context, can be successfully adapted and implemented in a subject aimed at engineering students.

In section 2, we introduce the context of management consulting skills and education in engineering at a metropolitan university in Australia. Then, we describe the methodological framework used in this article in section 3. In section 4, the design of the activity is presented, followed by implementation, and discussion in section 5. The paper closes with a summary of the findings, their limitations as well as implications on future research in section 6.

2 Context

2.1 Management consulting skills in university education

Management consulting is "the industry and practice of helping organizations improve their performance by analysing existing problems and development plans for improvement" (Statista, 2019). Success factors of management consulting projects have been the subject of academic research for many years. In professional service firms, the main assets are their people (Maister, 1982). Management consultants are "change agents for innovation and transformation (Cerruti, Tavoletti, & Grieco, 2019). The competence of the consultant (along with the consultation mode and the organisational characteristics of the client) has been identified as one core success factor of successful consulting projects (Jang & Lee, 1998).

In the context of university education, students, too, need to draw on those core consulting skills like problem solving and communication. Complex problem solving is often described as a defining feature of engineering and is an important skill outlined in the Engineers Australia Competency Standard (2017). However, there are many different types of problems faced by engineers and problem-solving in the operations context largely focusses on organisational decision making. Jonassen, et al. (2006) highlight the need for engineering education to understand the nature of workplace decision-making. The high stakes nature of decisions in the workplace makes learning on the job a high-risk activity and therefore operations management the ideal candidate for a skill better learned within the university context.

2.2 The place of management education in engineering

Engineering education aims to satisfy the students' demand for a constant connection between theoretical concepts and application in professional practice. The functions and activities in operations management are central to any organisation as they produce the goods and services that form the organisation's reason for existing (Slack, Chambers, & Johnston, 2004). Students learn how to design, manage and optimise operations in manufacturing and non-manufacturing environments.

Operations management is taught in block mode with two full days of on-campus activities scheduled 3-4 weeks apart. A typical class for OE would be around 25 students who have completed a technical undergraduate degree and are trying to improve their employability by developing an additional set of management skills. In-class learning activities during the block days consist mainly of two elements: teacher-led presentations and work sessions in groups.

The collaborative learning environment provides opportunities to discuss practical examples of organisation processes in which groups work through a series of different methods for reviewing organisations and their operations related to technology, market, competition and customers that are common in the current business environment. The collaborative learning activities provide some experience in solving practical problems with students developing a case study by applying a range of concepts and methodologies discussed in class.

3 Methodology and data collection

In order to identify and implement an activity from the realm of management consulting into the subject, we follow a three step method. First, we identify requirements in the field of management consulting from literature combined with student feedback in relation to their learning needs. Second, we use those factors to select, adapt and implement an activity from the realm of stakeholder engagement in consulting into the subject. Third, we measure the success by evaluating the students' work output. We also ask the students the extent to which the activity contributed to achieving those requirements in a short survey. Empirical data were collected at several stages throughout the above described methodology.

4 Design of consulting activity

4.1 Identification of requirements

The required skills for a successful consultant identified above will be used in conjunction with student feedback to create a set of requirements for the purpose of selecting and evaluating a learning activity. While it has to be acknowledged that there are varying opinions on the reliability of student feedback and evaluations, they can be used to gain some insights into the effectiveness of teaching methods (Wright & Jenkins-Guarnieri, 2012). We asked students to identify the in-class activities that were effective tools to support their learning experiences. Students remarked that they enjoyed the class activities and interactive elements of the sessions the most and they believed that in-class exercises would help them the most to gain and retain knowledge. Apart from group work sessions, these interactive elements were not yet an integral part of the subject design. In addition to more in-class activities, students suggested one large-scale scenario could be created that incorporated the different subject components and ensured a link to actual problems arising in professional practice.

This feedback was in line with the common conception that active learning experiences enhance student learning (Fink, Ambrose, & Wheeler, 2005, p. 192) and with the professional practice focus in the UTS model of learning (UTS, 2018). It also supports the aim of this research to find new sources of engagement activities to improve the learning experience and create stronger links between academic learning and professional practice. In the follow-up interviews students confirmed that an interactive learning environment helped them take or maintain a deep approach to learning. Conversely, an overly competitive environment forced the students to use a surface learning approach. We therefore concluded that in order to help students use a deep learning approach, any activity should require collaborative learning, be interactive and contribute to a safe learning environment in the classroom – a perception, that has been well researched in the past (Marton & Saljo, 2005), has been shown in different contexts such as college teaching (Grauerholz, 2001) or sustainability in higher education (Warburton, 2003), and aligns with the UTS philosophy to encourage deep learning approaches (UTS, 2018a).

The second noticeable finding from the student feedback was that the students associated learning with the acquisition of knowledge for later use in a work context. This is in line with the University's strategic priority to develop and implement learning activities that link the development of graduate attributes, critical thinking and reflection of complex problem to the students' employability. To inform the selection of an appropriate engagement activity, and to also measure its success, we consolidated the requirements identified from the literature and the student feedback to create the following selection criteria for the consulting activities: R1: effectively structure and communicate complex information; R2: be creative based on learning; R3: apply their learning to a professional context; R4: work effectively in a diverse team; and R5: feel an interactive and safe learning environment.

4.2 Context-based selection

Management consulting applies to a wide-ranging set of management methods and engagement activities to successfully deliver project outcomes to clients around the world. The 'Advanced Solution Center' (ASC) is a consultation methodology designed by Ernst & Young to facilitate stakeholder engagement with senior executives. ASCs were developed as a high-intensity workshop format 'to create and develop better solutions to complex problems in a short time period' (Mertin, Broetzmann, & Holzhauser, 2011). The workshops consist of a variety of group-based learning activities to jointly create solutions to complex problems and to increase buy-in and mutual understanding by utilising group-based learning activities (Mertin, Broetzmann, & Holzhauser, 2011). These group-based activities typically include:

Horizon scans – also see (Oliveras, Marquez, & Puig, 2011)

Study and discuss selected materials (such as videos, newspaper articles, documents etc.) and relate contents to a specific problem or challenge. Goal: Understand the scope of a problem and position it into a context or bigger picture.

Tradeshows – also see (Michalko, 2017)

Presentations by domain experts on different aspects/angles of a problem and participant feedback. Goal: Understand key elements of the problem and derive required tools and skills to solve it.

Gallery walks – also see (Francek, 2018)

Participants walk by a 'gallery' of relevant materials in an informal setting. Goal: Grasp the size of the problem and provide a platform for informal discussion to generate ideas.

Shift-and-share activities – also see (Priestley, 2016)

Groups work on different aspects of a problem at different stations. Later, group participants move to other stations to provide additional input and feedback. Goal: Combine specific work with opportunities to contribute to all aspects of a problem. Generate buy-in and commitment to collective solution.

Visualising future activities – also see (Lauttamäki, 2014)

Participants look at how solving a problem will affect their lives from a future perspective. They present their findings in a visually appealing way (such as a comic). Goal: Encourage participants to think beyond their usual ways. Prioritise the importance of how information can be presented.

The learning focus of the suite of group-based activities available in ASCs lend themselves to being adapted to higher education settings. Similar knowledge sharing methods have been used in different contexts for professional workshops such as, for example, the world café method (Elliot, Heesterbeek, Lukensmeyer, & Slocum, 2005, p. 185). The shift-and-share activity was chosen as the best match to the previously identified success factors because it encourages students to work in small, collaborative groups and report back their collective findings. It also offers 'relevance to professional practice' because it requires students to apply their learnings to real organisations as well as practice the professional skills of teamwork and public speaking. Using the input and feedback from a former Ernst & Young management consultant, who was heavily involved in designing and running ASCs as corporate stakeholder engagement events in different industries, the shift-and-share activity was tailored to the subject contents and implemented in the classroom.

5 Findings and discussion

5.1 Implementation of the shift-and-share consulting activity

The shift-and-share activity was introduced on the last day of a four-day block for the subject. The goal was to use this consultation process for students to recap on the previous day's learning and applying some of the methodologies learned in class to a new context. Students worked in groups on four stations. After an initial work session of 15 minutes, students moved to the next station for 10 minutes to review and add to the results from the previous group. This iteration was repeated until every group had worked on every station (three predetermined 'station chiefs' remained at the station to facilitate the discussions and brief the incoming groups and their predecessors' activities). The resulting posters were presented back to the whole group.

Station 1: Learnings days 1 and 2

At this station, the group was asked to summarise the main concepts and ideas discussed during the first two days of block mode teaching. These include the history of operations management, the difference between products and services, product development and innovation, process and job design and eight forms of waste.

Station 2: Learnings days 3 and 4

At this station, the group was asked to summarise the main concepts and ideas discussed during the second two days of block mode teaching. These include inventory and supply chain management, production planning and control, reliability and maintenance, and the six sigma and lean methodologies.

Stations 3 & 4: Integration of lean, six sigma and theory of constraints

At these stations, the groups were asked to find a way to integrate key aspects of the three concepts of 'lean', 'six sigma' and 'theory of constraints' in order to define an approach to optimise operations for a company in the manufacturing industry (e. g. a car manufacturer) at station 3 and for a company in the service industry (e. g. a hotel) at station 4.

Whereas the first two stations required the students to consolidate their understanding of existing principles, stations three and four asked for the application of these principles to new contexts and went beyond the reflection on materials discussed in class. Stations 1 and 2 required remembering the most important learning aspects of the subject and, importantly, presenting this information in an appealing way. Stations 3 and 4 added an additional layer of complexity. At these stations, the participants had to apply discussed methodologies to a new practical context and present the information in an appealing way. The success of such interactive activities, like shift-and-share, relies on the provision of clear instructions to maximise the desired learning outcomes (Reeve & Jang, 2006). Transferring the shift-and-share activity from an audience consisting of management executives to postgraduate engineering students meant that some changes were required. The teacher's instructions clearly emphasised the expectation that students not only repeat information, but also think about ways in which this information could be presented to their colleagues in a structural, visually appealing, concise, and hence memorable way.

5.2 Evaluation and discussion

In this section, we discuss to what extent consulting techniques were able to provide an environment for students to reflect on their learning experience and identify applications in future employment. We do this by analysing the students' work output and by surveying the students' satisfaction with the activity's contribution towards their learning success. The shift-and-share activity was selected as a good approximation of real work activities likely to be undertaken by a management consultant in an engineering context. The evaluation was designed with industry input to follow a widely applied management consultancy evaluation process (Kay et al., 2019). In this context, success can be defined by the extent to which the activity improved the quality of students' work outputs with respect to the success factors identified in section 4. Having negotiated success criteria helped to minimise inconsistencies between ideal learning outcomes and actual achievements (Ramsden, 2003, p. 19).

First, the work output of the group activity was analysed based on the teacher's assessment with the above identified success factors in mind. While working on the activity, the participants produced posters that contained their solution to the tasks of the activity in the context of specific industry examples (R3). The posters created in the activity contained visualisations and complex consolidations of subject content (R1, R2). The students reflected on the subject contents and presented the key points back to the class in a way that was easy to remember using visual elements (R1, R4). This closely resembles real work environments in the engineering profession, where precise communication of key points to various stakeholders such as management, customers and project partners is an essential skill. The shift-and-share activity replaced traditional lecturing that had been used in previous semesters. The result was a more engaged class that provided opportunities for students to reflect on their learning experiences and make links to future employment.

Second, looking at the students' experience of learning success was necessary to assess the extent to which the learning goals were achieved (Ramsden, 2003, p. 26). This analysis was therefore not conducted based on the actual work output, but on the students' perception of the activity's contribution to meeting the initially identified requirements. The analysis can, therefore, be considered to be more indirect as it takes place on a higher aggregation level (one meta-level above the content produced as work output). Figure 1 below outlines the results of the student survey, which confirm a positive impact of the activity concerning the requirements R1-5. This positive impact is visible on several levels: Structuring communications and collaborating effectively (stations 1 and 2); creative utilisation of acquired knowledge in a professional context (stations 3 and 4), and; working in an interactive and safe learning environment (overall).

Combining the analysis of the work students produced and the students' perceptions of their abilities identified during the shift-and-share activity, it can be seen that – even when assuming that neutral indicates failure of the activity – introducing consulting techniques into the classroom is an effective way to connect theoretical learning to professional consulting practice. In addition, the activity was found to be engaging for the students and had the potential to benefit students in preparing for their assignments by ensuring the learning outcomes of the activity helped in solving some of the assessment tasks. The use of the shift-and-share consulting activity in an engineering education context met both the learning requirements of the students, as well as the expectations of the teacher.

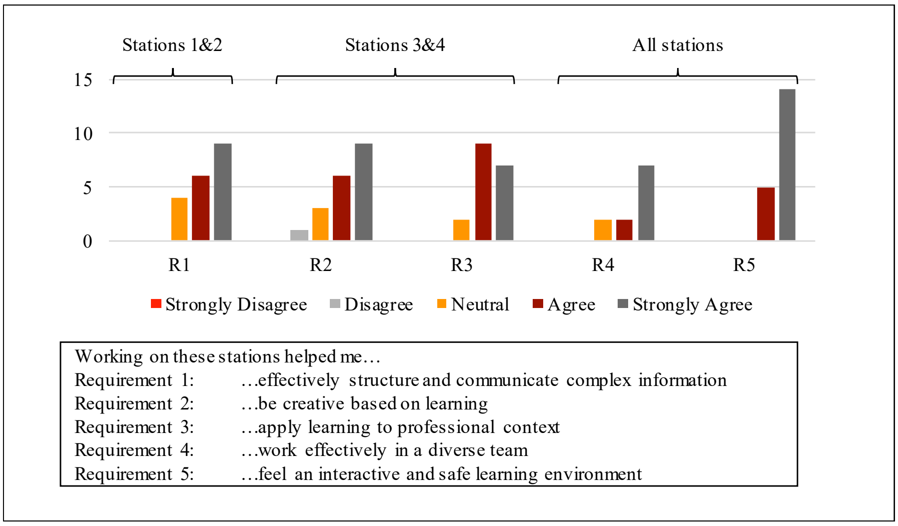

Figure 1: Student survey results

This result highlights the potential for such real work activities to make an overall positive contribution to the students' learning experience and success. It also assists the University's teaching and learning objective of offering more creative learning experiences to help prepare students for the future of work (Rampersad and Patel, 2014). While the application of an external consulting technique can be useful, the analysis also identifies opportunities to further increase its impact by appropriately adapting to the context. For example, a key outcome for the OE subject is the ability to associate the complexity of operations in a company with their effects on the overall value chain. This is a key concept in operations management and gains importance in times of global competition, increasing customer demands and mounting cost pressures. The analysis shows that this point was not demonstrated sufficiently through the activity in its original form. To better encourage students to identify value chain impacts of company operations based on a practical case scenario, the work from stations 3 and 4 on the integration of different approaches could be further embedded into effects and improvement concepts beyond the company borders.

6 Conclusion

This study introduced management consulting techniques to engineering students in a postgraduate university program as an opportunity designed to build student career readiness. While previous studies have generated valuable insights on students' engagement in external consulting projects (e.g. Nikolova and Andersen 2017), the present work adds systematic and context-based learning and application of consulting techniques. This significantly adds to students' career readiness in the sense that the consulting techniques they engaged in can be applied to any project-based work in their future careers. Since most engineering professions are organised around projects, the overarching knowledge and skills in consulting techniques appears particularly valuable.

In addition, this paper highlights a practical case example of how consulting techniques can be appropriately adapted from a corporate to an academic learning environment in a way that aligns with both institutional and individual learning goals. In this context, the paper provides guidance on how to successfully adapt further consulting or other practice-based techniques to the teaching and learning context.

Notwithstanding these insights, the study faces several limitations. While we have extended the context beyond management programs and tested the effectiveness of management consulting for the engineering domain, the particular context and case limit generalisability of the findings. Therefore, this case example could be extended by transferring other activities used in a management consulting context in line with case-specific requirements. It would also be advisable to follow up with students to see whether this encounter with consulting management activities has had a lasting impact on students' professional skills and employability once they enter the engineering workforce.

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