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Case study-based learning in customer-centric operations management: Unleashing the potential of experiential learning and accreditation

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ABSTRACT

The increasingly evolving context in manufacturing and service industries calls for more active learning approaches to easily grasp new business strategies, such as customer-centric operations management. The authors report on case-based courses about a specific customer-centric strategy namely mass customization. The courses echo the Kolb model for experiential learning and refer to guidelines about accreditation requirements. An analysis of the achievement of learning outcomes is realized based on student surveys. The authors witness the relevance of case-based learning in particular for customer-centric operations management. Furthermore, they put forth the accreditation as a relevant tool for fostering the implementation of experiential learning practices.

KEYWORDS

Accreditation; case study; experiential learning; mass customization; operations management

Introduction

Manufacturing and service industries challenges are increasingly evolving, which calls for a proactivity of the company so as to keep up with these evolutions. Recent technological advances, increasing market segmentation and individualized demands, competition on both prices and quality, are among the factors motivating companies to pursue more customer-centric business strategies, such as mass customization (MC). In a simple way, MC aims to fulfill customer individual demands with near mass production efficiency (Medini, 2015; Medini, Da Cunha, & Bernard, 2012; Salvador, Holan, & Piller, 2009). A full understanding of MC and customer orientation in operations management requires an adaptation of the practices and content of engineering education curricula, toward more active learning approaches (Bassetto, Fiegenwald, Cholez, & Mangione, 2011; Kolb & Kolb, 2005; Medini, 2018; Peillon, Medini, & Dubruc, 2016; Visich, Gu, & Khumawala, 2012). These approaches are expected to increase the motivation, self-efficacy, and subsequent retention rate of the learners and train them for complex business environments (Finney & Pyke, 2008; Hakeem, 2001; McCarthy & McCarthy, 2006).

However, for these objectives to be achieved, the learning process should be considered within a holistic framework considering the various stakeholders and their interactions toward achieving learning outcomes (Cornell, Johnson, & Schwartz, 2013). Accreditation programs are a major driver toward such a holistic framework as they consider a variety of factors within engineering education programs (Patil & Codner, 2007).

Here, we report on case-based courses about MC, which have been given to students pursuing a master of science in industrial engineering. The courses echo the Kolb model for experiential learning and refer to guidelines about accreditation requirements. An analysis of the achievement of learning outcomes is performed based on a students' survey conducted upon two different classes.

The next sections of the paper report respectively on a brief overview of the related background literature, a method for designing a course integrating an active learning approach and accreditation requirements, a designed course following the proposed method, the achievement of the learning outcomes based on students' perceptions considering courses with different integration levels of experiential learning, and finally concluding remarks.

Background literature

Among the focal points for engineering education systems is the ability to let students acquire the necessary skills, abilities, and knowledge to become university trained engineers (Owens & Fortenberry, 2007). Several examples reported in literature show that practical industrial experience has always been part of the engineering education (Taylor & King, 2007). For example, Finnish students have on average 23 months of working experience when they finish their master's degree. Yet, the exchange between the industry and the university is not as frequent as would be desirable (Korhonen-Yrjänheikki, Tukiainen, & Takala, 2007). Industrial partnerships, students, and academic staff commitment are among the prerequisites to generate more employable graduates meeting industries' requirements (Arlett, Lamb, Dales, Willis, & Hurdle, 2010; De Graaff & Kolmos, 2007). Subsequently, teaching practices needs to keep up with the pace of the industrial requirements giving more space for active and experiential learning.

Learning process: Experiential learning rationale and practices

Experiential learning theory sees the learning as “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience.” (Kolb, 1984, p. 41). According the experiential learning theory, learning is a recursive process assimilated to a four-stage cycle spanning over: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Figure 1). Students can start learning through concrete experience that they observe and reflect on, to derive abstract concepts. Then, they draw new implications from these abstract concepts and test them through active experimentation (Kolb, 1984; Kolb & Kolb, 2005).

Kolb and Kolb (2005) identified a number of educational principles that ensure the consistency of the experiential learning experience of the students and avoid miss-education experiences: respect for learners

and their experience, begin learning with the learner's experience of the subject matter, creating and holding a hospital space for learning, and making space for conversational learning, development of expertise, acting and reflecting, feeling and thinking, inside-out learning, and motivate learners to take charges of their own learning. These practices within engineering courses support an improvement of the students' retention rate (Kolb & Kolb, 2005). Experiential learning has been widely used in a variety of engineering education contexts and within many universities all over the world; examples of these are reported in the following research works (Bassetto et al., 2011; Medini, 2018; Visich et al., 2012).

Despite the large use of experiential learning and the increasing awareness of its benefits to the students, guidelines for designing effective experiential learning courses or activities are scarce. Most experiential learning applications are inspired by the basic learning cycle and design methods of the activities or courses are either implicit or briefly presented. In this sense, no less importantly than teaching practices and approaches, proper attention should be given to the quality and accreditation standards in designing and maintaining engineering education materials (Patil & Codner, 2007). Accreditation standards and stepwise methods at large are likely to ensure a consistency with industry requirements and to provide means for quality assurance.

Learning system: Accreditation requirements and initiatives

The purpose of accreditation is to evaluate the engineering programs based on well-known standards that are accepted by the academic community and other stakeholders (Aqlan, Al-Araidah, & Al-Hawari, 2010). Among the well-known standards is the Accreditation Board for Engineering and Technology (ABET). The ABET accreditation of engineering programs goes through a rigorous evaluation process taking into account several criteria including students, program educational objectives, faculty, and program criteria, to name a few. One of the focuses of ABET is on the graduate attributes criterion, which defines the knowledge, behaviors, and skills needed for the students to obtain through their studies (Aqlan et al., 2010). The European Network for Engineering Accreditation (ENAE), with support from the EU Tempus program, was founded in 2006 by 14 European associations concerned with engineering education. ENAE aims to enhance and promote the quality of the

Figure 1. Kolb learning cycle.

education of engineering graduates. The European Accredited Engineer (EUR-ACE) label, implemented by ENAEE, can be awarded by engineering education institutions complying with certain European quality criteria (Aqlan et al., 2010). Among the most common accreditation criteria one can list the explicit educational content that is consistent with the mission of the institution; needed requirements for the admission of the students; the quality and the performance, faculty teaching experience, area of specialization, and qualification; and subject areas that are appropriate to engineering.

As a summary, Figure 2 shows a framework of the interactions among engineering education stakeholders, with the process of teaching business students being at the heart of the model. The research in experiential learning methods contributes basically to investigating educational processes and allows for testing their effectiveness for multiple criteria. Besides this, the industry exerts pressure toward governance, and this pressure is transformed organizationally (through education regulator) in some of the accreditation requirements (e.g., labor requirements), especially those related to graduate immediate effectiveness (e.g., decision making, self-confidence, and awareness to real-life situations). Education regulator implements the accreditation requirements and uses student input for continuous improvement

Figure 2. Learning framework.

(e.g., requirements fulfillment). No less important than labor requirements, the industrial transition context helps in deriving relevant business cases to support an active learning process with more effectiveness toward well trained engineers. However, it is worth noting that the interactions between experiential learning on one side and accreditation requirements and education regulators on the other side are less investigated (McDavid, Huse, & Ingleson, 2018). Exploring the crossings and complementarities between these areas is likely to unleash the potential of their interactions.

In the present article, we are interested in coupling accreditation guidelines with experiential learning to increase the efficacy of the learning process in the business domain. A method is proposed for this purpose and will be described in the next section.

Course design following EUR-ACE guidelines and experiential learning principle

This section reports on a stepwise method for course design following an experiential learning principle. The method builds on EUR-ACE guidelines for educational programs design, and on learning cycle and educational principles from the experiential learning theory. More specifically, the general steps of the method are inspired by previous works on how to develop a program based on accreditation criteria (EUR-ACE; Chuchalin & Kriushova, 2011). The identification and articulation of learning modules and modes are inspired by the experiential learning cycle and educational principles.

Figure 3 shows the steps of the method, reported on in the boxes. Vertical arrows refer to the main used concepts from literature. Full line horizontal arrows illustrate the sequence of the steps, while the dashed arrows show some of the main iterations which occur during the design process. The general design steps are needs analysis, general objectives identification, learning outcomes definition, learning

Figure 3. Course design method.

modules identification, building syllabus, and course assessment plan.

Needs analysis is recognized as an important step in course design which contributes toward more contextualized content (Lekatompessy, 2010). This step is expected to enlighten the course designers on the learners' current skills, knowledge gaps, objective and subjective needs, and the expected use of the know-how and knowledge transmitted through the course. Needs analysis is not a one-shot action; on the contrary, it should support a continuous improvement process of the course.

Needs analysis contributes to the subsequent steps namely the formalization of the course general objectives and learning outcomes. Similar to the program design context (ENAAE, 2005), in course design, the general objectives should reflect how the needs of the students (or any other targeted public) are met through the course.

Learning outcomes refer to the graduate attributes in terms of technical and soft skills that can be achieved through the course (Chuchalin & Kriushova, 2011). The definition of learning outcomes uses the revised Bloom taxonomy (Krathwohl, 2002). The dimensions of the revised taxonomy are as follows:

- **Remember:** Retrieving relevant knowledge from long-term memory
- **Understand:** Determining the meaning of instructional messages, including oral, written, and graphic
- **Apply:** Carrying out or using a procedure in a given situation
- **Analyze:** Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose
- **Evaluate:** Making judgments based on criteria and standards
- **Create:** Putting elements together to form a novel, coherent whole or make an original product

In the next step of course design, the learning modules are identified and mapped to learning outcomes. The share of the grades among learning modules is partly based on learning modules importance to learning outcomes achievement. The identification of learning modules is inspired by experiential learning theory to define the learning cycle. The four learning stages of experiential learning theory are used as guidelines to identify the focus of each learning module. Altogether, learning modules should support a specific learning cycle.

The subsequent step, build syllabus, consists in defining how learning modules will be actually conducted (e.g., sequence, organization, teaching technologies) and how the grades are assigned. This step is referred to in Figure 3.

In the final step in course design, course assessment, the methods and ways of assessing the course will be designed. Usually, students' surveys are an easy-to-implement method and provide valuable insights into student perceptions.

Designed MC courses

This section reports on the design of new courses through adapting a similar course (given in 2016) following the proposed method. The use of the method supported substantial modifications in both objectives and content of the course resulting in three slightly different courses which have been given in fall semesters of 2017, 2018 and 2019, respectively. While the courses share the same objectives and learning outcomes, the learning modules and syllabus were slightly different. The design of the 2018 and 2019 courses is reported on in the following paragraphs.

The course is developed within an MSc program in Industrial Engineering. The students have backgrounds in industrial or mechanical engineering. They hold either a bachelor or an engineer or equivalent MSc degree in these domains. Most of the students are international and come from Europe, North Africa, Asia, and Latin America. This also means that the course language should be no other than English, as it is the most likely common language for all students. Within the context of industrial transition, the students lack a deep understanding of how business strategies such as MC could foster the industrial renewal and how they can actually be implemented.

The objective of the course is threefold; (a) introduce MC as a customer-centric strategy, (b) enlighten the students on how MC can actually be implemented in the manufacturing and service industries, and (c) enhance students' research abilities and critical thinking.

Learning outcomes have been identified following Bloom's taxonomy (Table 1). These outcomes are common to 2017 and 2018 courses, which also share the introductory learning module (LM1), as shown in Table 2. However, unlike the 2017 course, in 2018 it was chosen to focus on a single case study with more detailed data so as to allow a deeper analysis by the students. In addition, not only was a seminal article provided within learning module 2 (LM2) but

Table 1. Learning outcomes.

Reference	LO definition
LO1	Understand MC philosophy and main capabilities (choice navigation, solution space development, robust process design (Salvador et al., 2009)
LO2	Analyze how these capabilities can be put in practice
LO3	Evaluate the experience of a given company with MC implementation
LO4	Plan the required actions for a service company to benefit from MC
LO5	Criticize the soundness of case studies analysis performed by other peers

Note. LO = learning outcome; MC = mass customization.

Table 2. Learning modules.

LMS	2017 course	2018 course	2019 course
LM1	An introduction into the topic;	An introduction into the topic.	Experience with a product configurator and a performance simulator
LM2	A seminal paper reading about MC capabilities	A seminal paper reading about MC capabilities	Introduction into the topic A seminal paper reading about MC capabilities
LM3	Analysis of several short MC case studies;	Mini MOOC from MC experts Analysis of a single but detailed MC case study	Analysis of several short MC case studies
LM4	Review of peers' work about case studies analysis Restitution and discussion	Presentation of the detailed case study and discussion	Restitution and discussion

Note. LM = learning module; MC = mass customization; MOOC = massive open online course.

Figure 4. Learning module (LM) mapping to learning cycle.

also several videos from an MC expert were made available. Finally, there has been a session in 2018 for discussing the detailed case study and providing a general MC overview (LM4). A conference from an MC expert was given within this framework. In 2017, a peer-review process was conducted with a restitution session at the end. The idea with the 2019 course was to start with a concrete experience before an introduction into the concepts. The students used an online configurator to experience a customer perspective. Then they moved to a case-based performance simulator (agent-based simulation) to experience the company perspective in dealing with variety management. Remaining modules (LM2 to LM4) are similar to the ones from the 2017 course, except the fact that no peer review process was planned in 2019 course.

The planned contribution of learning modules to the learning cycle is reported on in Figure 4.

Table 3 reports on the mapping between learning modules and learning outcomes: a plus sign in the crossing between a given row i and a given column j means that LM_i contributes to the achievement of

Table 3. LO and LM mapping.

	LO1	LO2	LO3	LO4	LO5
LM1	+				
LM2	+	+			
LM3	+	+	+	+	
LM5		+	+		+

Note. LM = learning module; LO = learning outcome.

LO $_j$. Clearly, case studies (LM3) have the most significant contribution to learning outcomes. However, these cannot be achieved without the other learning modules altogether. This is quite expected because of the involvement of LM3 in various learning stages of the experiential learning cycle.

The syllabus as a result of compiling the above information will not be detailed. Only key points about learning modules sequence, course requisites, and assessment will be reported on. Figure 5 shows the sequences of the learning modules within the 2017, 2018, and 2019 courses from left to right respectively.

LM1 is planned in the beginning so as to provide an introduction and work instructions to the students. With the 2019 course, students started with some experience and followed up with the introduction. Afterward, students are left with the paper reading (LM2) (2017 or 2019 course) or paper reading and video watching (2018 course). A summary of the paper (and videos) is required, which enhances also the reflective observation activity in reference to experiential learning cycle. In LM3, students are instructed to analyze the case studies following a set

of guiding questions. The input material for the multiple case studies analysis consists basically of written interviews of MC experts speaking about case companies' experiences with MC, and case companies' websites. The single case study is analyzed based on a report with the history of the company and the path toward MC as well as several key numbers.

Requisite skills of the course can be met with an industrial engineering or engineering management background. The evaluation is based on the

Figure 5. Learning module (LM) sequence. MOOC = massive open online course.

deliverable quality, the presentation and discussion, and a final exam about MC case.

Course assessment relies on a questionnaire that is given to students few days after the last session. A hard copy is used to increase the response rate and avoid nonexploitable answers. The questionnaire includes the following sections: students' background, MC implications to firm strategy and competitiveness, MC implications to variety management, MC implications to production and supply chain management, Experiential learning approach, and MC topic relevance. A full version of the questionnaire can be found in Medini (2018).

Students perception and insights into learning outcomes achievement

Surveys were conducted after achievement of each of the three courses using the assessment questionnaire. Figure 6 depicts the aggregate results of the surveys according to the questionnaire sections.

Sample sizes are in the following ranges, 12–14 for the results of the 2016 survey, 14–17 for the results of the 2017 survey, 19–20 for the results of the 2018 survey, and 10 for the 2019 survey. Generally, we assume that these sizes are acceptable for this first level analysis. The difference in sample sizes is due to the number of enrolled students and on the few nonanswered questions among the 12 ones in the questionnaire.

The questions are answered using a 5-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Overall, it can be seen that there is an

Figure 6. Summary of the survey results. MC = mass customizaton; SCM = supply chain management.

improvement in the achievement of the objectives whilst the significance of the improvement is higher in the 2018 and 2019 courses. MC implications to variety management were equally addressed by the 2017 and 2018 courses. However, there is an overall improvement of students' perceptions of these implications after the course adaptation. Furthermore, the 2018 course contributed to enhancing students' understanding of MC implications to firm strategy and competitiveness. This can be explained by the focus on a detailed case study with key numbers about the MC market and firm history with MC. Seemingly, the case study in the 2018 course helped also clarify the implications of MC to production and supply chain management, in a more accurate way. Conversely, the experiential learning approach was more obvious in the 2017 course. Removing the peer review process could be one reason explaining this fact. Also, unlike in 2017, the students did not give presentations of their work in 2018. Rather, they attended an interactive session reporting on the detailed case study. Finally, the MC concept relevance is more witnessed with the adaptation of the course. Generally, the 2019 course contributed to an overall improvement of students' satisfaction and understanding of the taught concepts. Although the sizes of the samples are relatively small, these results support the idea of mixing several learning modes and of using cases studies to get higher retention rate.

Complementarily, [Figure 7](#) shows a word cloud derived from students' answers to the open-ended questions of the three surveys. The size of the words is proportional to their frequency of occurrence. The word cloud is generated by the R software (Ihaka & Gentleman, 1996) with the following rules: number of the words in the cloud should not exceed 50 (for the

Figure 7. Word cloud of students' comments.

sake of readability) and minimum occurrence frequency of the words in students' comments is 2 (to cover as many topics as possible).

It can be seen that case studies are prevailing in the answers of the students, particularly highlighting a positive perception of the students. The case studies helped some students to understand “in a more concrete and independent way how mass customization is implemented.” Some other less frequent key words reflect the positive impact of the learning practices (e.g., *applied*, *real*). In fact, some of the students assume that the case study approach is “a relaxed way of learning” and that the classes are “dynamic.” Besides, terms such as *industry*, *company*, and *visits* appeared several times revealing the need for company visits. However, this does not conflict with the relevance of the available material for the students as also witnessed by the results, for example, according to the surveys, all material provided was useful and helpful to understand the concept. Interestingly, the students have shown an interest in the scientific articles they went through, as these are “very interesting to read and analyze.” This is particularly the situation within the 2019 course, in which several learning forms have been mixed. One can infer from this that for the students to get some benefit from scientific methodologies, there have to be some variety in the learning modes. In other words, paper reading and analysis should be coupled and preferably preceded with some concrete experience or case studies. Although these findings need more evidence, they provide valuable insights into the impact of the proposed approach and into some potential improvement avenues.

To identify potential relevant factors impacting students' perceptions, a clustering analysis was performed. There have been around four missing values distributed among five items. These have been dealt with using the average of the other values of the items throughout students' answers. The values were then rounded the closest integer value. Figure 8 shows the resulting cluster dendrogram of the 50 answers from the students, following the Ward criterion. To evaluate the quality of the clustering, cluster silhouette was used (Jun & Lee, 2010). Clusters silhouette in Figure 9 shows that for three clusters, there is quite good similarity among answers within same a cluster (positive values) and very low similarity with answers from other clusters (negative values). The cut level (horizontal dashed line in Figure 8) was shown with a view to get three clusters, namely CL1, CL2, and CL3 (from the left to right in Figure 8). Looking at

Figure 8. Clustering dendrogram.

Figure 9. Clusters silhouette with $k = 3$.

students' perceptions as per the clusters, it can be seen that generally items' scores are the highest within CL2, with an average of around 4.55 of 5. Almost 80% of the respondents falling under this cluster went through a single and detailed case study or a peer review process with an active restitution session. Also, around 27% were attending the 2019 course with quite mixed learning modes. Conversely, only 45% of the respondents belonging to CL1 used a single case study or went through a peer-review process and an active restitution session. The average score of the items belonging to CL1 amounts to approximately 3.40, which is much lower than in CL2. It can be inferred from this that the peer-review process, the active restitution session, and mixing learning modes have a positive impact on the MC learning process. Furthermore, focusing on a single and detailed case study is seemingly more profitable than are multiple short case studies. CL3 results are in between CL1 and CL2 results and they are consistent with the previous inference.

Interestingly, some positive correlation was identified between international students' percentage and the average items scores (55% in CL1, 89% in CL2, and 83% in CL3). This could be explained partly by the possible language barrier, as English is not the native language of local students.

Discussion and managerial implications

The survey results evidenced the gradual improvement of students' satisfaction and retention rate, resulting mainly from the continuous improvement of the learning process. This was enabled by a method inspired by programs' accreditation guidelines combined with experiential learning practices. In particular, a case-based learning approach was emphasized. Overall results from the present study show how to smoothly integrate experiential learning into course design consistently with accreditation requirements.

The survey tool has been used for several years in different courses and turned to be an efficient tool for

continuous improvement; however, it has some limitations. For example, the surveys are based on data collected from students only, and no alumni were surveyed. To gain more insights considering the employment market as well, it is important to extend the survey to alumni and other stakeholders (e.g., industrial clusters, partner companies).

The article leaves some additional open-ended issues to be addressed further. For instance, the method coupling accreditation guidelines and experiential learning practices is only one step along the way for exploring the mutual impacts among accreditation and experiential learning. Further research is still required to conceptualize the interactions among the components of the learning system and derive proper methods for designing and continuously improving the learning process.

Conclusions

The interdisciplinary topics brought by the industrial transition require proactivity on the side of academicians so as to design adapted course content and use appropriate teaching methods. Here, we call for integrating experiential learning theory and accreditation guidelines in the (re)design of courses in the engineering education domain to keep up with the industrial transition context. It was shown through the surveys that these approaches are likely to improve the achievement of the course objectives and student satisfaction.

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