Design as an integrating factor in an International Cross-Disciplinary Innovation Course

Prof. Anders V Warell, Lund University, Industrial Design

Bio Anders Warell Professor Anders Warell is Director of Research at the Division of Industrial Design, Lund University, Sweden. He received his PhD on Product Identity and Design Aesthetics from Chalmers University of Technology in 2002. After being part of the development of the Industrial Design Engineering masters programme at Chalmers, he joined the School of Design at Massey University in Wellington, New Zealand in 2005, where he led the Industrial Design programme and founded Affect – the Centre for Affective Design Research. Research interests include user centered design and innovation, user experiences, design methods, product brand identity, visual design aesthetics, and strategic design.

Dr. Charlotta Johnsson, Lund University

Charlotta Johnsson holds a position as Associate Professor at Lund University, Sweden where she also serves as the Program Director for the master program Technology Management. Charlotta Johnsson has PhD in Automatic Control from Lund University, Sweden. Her research interests include; technology management and innovations, entrepreneurship, automation, operations management, and pedagogy. She is teaching and advising students in undergraduate, graduate and industrial programs.

Dr. Carl-Henric Lennart Nilsson, Technology management

Associate Professor Carl-Henric Nilsson is a business development specialist focused on industrialization processes with a PhD in Industrial Management. He has founded several startups and is currently CEO of Kunskapspartner AB and researcher at Lund University specializing in pedagogics, entrepreneurship, business development and industrialization.

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1. Introduction

Today, innovation is a key word for many universities, as it constitutes an important part of most universities' public and scientific interaction with society. Many universities are striving to increase the number of innovations spun out. At many universities, innovations are thought of as being sprung from research projects and generated by researchers. However, Sandström (2014) claims that while 20 of 100 significant Swedish innovations come from the academic environment, 80% arise in businesses. Therefore, we see the need for innovation-oriented courses at both undergraduate and graduate levels, which foster students into becoming innovators. Creating innovations requires deep disciplinary knowledge, diversity, knowledge of innovation processes, and knowledge of how to take an idea to the market. It also requires the application of this knowledge in novel areas and contexts, to reveal the potential of truly innovative ideas.

Despite this need, however, undergraduate or graduate courses that mix students with different academic backgrounds allowing them to freely synthesize their domain specific knowledge in new contexts are rare. By combining design, business and engineering students in an innovation course, and by letting the students apply their knowledge to current market needs, innovators can be fostered, innovations generated and entrepreneurs born. Furthermore, mixing cultures and mindsets may stimulate creativity, leading to novel and unexpected ideas.

In this paper, we present a novel graduate course on innovation, which was developed in spring 2012, and which has since been executed three times on an annual basis. The course is international and multi-disciplinary in terms of students, teachers and subjects. The course is six (6) weeks long and held in China, with Swedish and Chinese students collaborating in multidisciplinary teams.

The novelty of the course lies in the mixture of students and in the fact that design is seen as an integrative factor in the course. The mix of design, business and engineering students is powerful since knowledge in these three disciplines mirrors the three central characteristics of a successful innovation – feasibility, viability and desirability. While engineering students know if and how a technical innovation can be brought into reality (feasibility), management students can determine the market and financial aspects of bringing an innovation to the market (viability), and design students can make sure the innovation is experienced and presented in an attractive way (desirability). If the innovation is not desirable, it does not matter if it is feasible and viable – it will not likely be successful in a competitive marketplace. Consequently, the role of the design students in the course is fundamental. The course offers the opportunity to integrate design thinking in a truly multidisciplinary and multicultural setting – a place where the activities and mindset of design thrives. The yearly outcome of the course consists of eight innovations, one per team, manifested in terms of eight prototypes, eight short movies and eight business plans.

Following the introduction, the first two sections of this paper discuss innovations and design in general. The following section presents general information about the iMDE course; the background, the aim, and the outcome. Next follows a discussion about how and why design is incorporated into the iMDE course. Thereafter the assessment is presented and there is a general discussion about the impact of design in courses. The last section contains the conclusion.

2. Innovations

The term innovation can be defined as "the application of better solutions that meet requirements or needs" (Wikipedia (2013)). Innovations could of course be sprung out of research, but could equally well be based on new insights or market-discoveries. The latter type of innovations could be generated by undergraduate or graduate students as well as by senior researchers. A key factor for successfully generating these types of innovations is diversity; a course that strives to encourage innovations must allow for students with different backgrounds and different curricula to meet and work together. "People who have the same background, skills, or location have little use of exchange with each other. For this reason, diversity of the network is a critical ingredient for successful entrepreneurship" (Sidhu (2013)). Three important steps in the innovation process are; inspiration, ideation, and implementation (Brown and Katz, 2009).

Other definitions of the term innovation also exist. For example, Gertler and Vinodrai (2006) claim that, ”the essence of innovation is the process of bringing to market new products or processes which, if successful, generate new economic value”. Gertler and Vinodrai further challenge the prevailing view of innovation as ”a process in which the primary inputs are scientific, technological, or commercial”, stating that ”the traditional approach fails to capture an important dimension of the innovation process that leads to the creation of economic value: design”. In response to this need, the iMDE course integrates as one of its core components the processes and knowledge of design to reach the full potential of innovation.

3. Design and its value

Increasingly, design has been discussed as an integral component of innovation (see e.g., Brown and Katz (2009)). Hobday et al. (2011) emphasize this standpoint further, claiming that design is “a central part of industrial innovation”, and should therefore be considered an essential and integrated component in each of the steps in the innovation process. Design can be defined as ”a work process which has a user perspective and drives development based on your specific customers’ needs” (Swedish Industrial Design Foundation (2014)). In Herbert Simon’s seminal work ‘The Sciences of the Artificial’, design is recognized as “the transformation of existing conditions into preferred ones” (Simon (1996)). As such, design engages anyone and any practice where improvement and problem solving is at the core of their business. In terms of generating meaning, use worthiness and aesthetic appeal, industrial design plays a pivotal role. Furthermore, the approaches and processes of design, often referred to as ‘design thinking’ (Brown and Katz (2009)), is an integral component of innovation. Thus, the contribution of design is not restricted to user experience or perception of the product, but is a key contributor to competitiveness and market success.

Studies have shown that in competitive segments, product design is a key factor for the manufacturing industry. For example, Audi states that up to 60% of a consumer’s decision to purchase a vehicle is based on styling rather than technical performance (Kreuzbauer and Malter (2005)). Multiple studies have shown that companies that embrace design increase commercial success (Black and Baker (1987), Bruce and Whitehead (1988), Gemser and Leenders (2001)) and financial performance (Hertenstein et al. (2005), Lorenz (1986)). Design is now recognised as a key business asset that can add significant value (Lockwood (2010)). This is achieved not only due to design acting as a ’differentiator’ (creating competitive advantage), an ’integrator’ (improving product development processes), and a ’transformer’ (creating new business opportunities or coping with change), but also at the strategic resource level, as ’good business’ (increasing sales, brand value or as a resource for society at large – sustainable and inclusive design) (Borja de Mozota (2010)). According to Clark and Smith (2010), ”design thinking is a remarkably under-used tool for achieving strategic business initiatives that are increasingly driven by the need for innovation”. For businesses and institutions, incremental innovation is not longer adequate to solve today’s complex and ‘wicked’ problems (Rittel and Webber (1973)); instead, business transformations are needed, which integrate design thinking (Nussbaum in Lockwood (2010)).

By proposing a hierarchy of design implementation leading to increasing strategic value of the application of design in businesses (see Figure 1), the ‘Design Ladder’ model (DDC (2003)) highlights the value of design for competitiveness. Typically, companies’ design maturity, exhibited by their attitude towards design, is reflected in how they integrate design thinking as part of their innovation process. In the first step of the ladder, design is a negligible part of their business. When design is applied as ‘style’, it is typically seen as an appearance attribute, relating to the final physical form of the product, which may be the responsibility of a designer or someone else within the company. In the third step, design is not the result, but a method, which is integrated into the product development process, thus influencing the final result. In companies where design is seen as ‘innovation’, design is used to influence the total business concept, and is a key competitive factor for the company, including owners and management (Fleetwood (2005)). It is important to remember, however, that ‘design’ has different roles in each of these steps, and that in order to reach one step further, the lower levels need to be implemented in the mindset of the organisation. For example, for design to become integrated as a natural part of all innovation processes, the tools and methods of design need to be understood and used (the ‘process’ step), and, furthermore, the value contribution of design for aesthetics and user experience need to be recognised and valued (the ‘style’ step). Therefore, building a design mindset within a company requires a bottom-up approach, where the expressive as well as operative and strategic benefits of design are implemented. This implementation requires people in various disciplines with knowledge and skills of design. This is the starting point for the iMDE course.

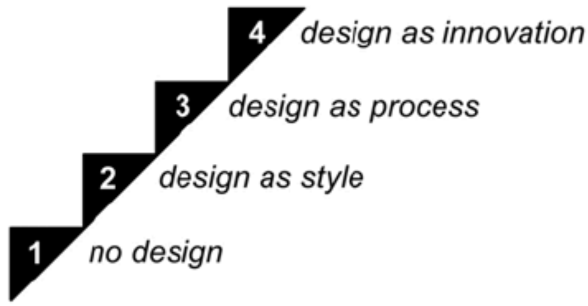

Figure 1. The Design Ladder (adapted from Fleetwood (2005)).

4. iMDE-background, aim and outcome

4.1 Background

The idea of setting up a joint course between Lund University and Zhejiang University was born in the fall of 2011 and the work of outlining the course and its content was intensified in the spring of 2012. The subject for the course decided upon was “Innovations and Product Development”, being key words for both LU and ZJU. The pedagogical intention was to support the students learning in “relating parts of the subject matter to each other and to the real world” and “comprehending the world by reinterpreting knowledge”. The course was titled “international Market-Driven Engineering (iMDE)”.

The two universities already had cooperative agreements that the course could leverage upon. One such example is the Joint Centre for Innovation and Entrepreneurship (LU-ZJU JCIE), a platform aiming to help realize joint activities of innovation and entrepreneurship. iMDE is a joint course, developed within the framework of LU-ZJU JCIE. Diversity was one key factor, and the idea of having students with varying disciplinary background was therefore agreed. As a consequence, various disciplines at both LU and ZJU were also involved in the development of the course:

- LUSEM: School of Economics and Management, Lund University, Sweden
- LTH: Faculty of Engineering, Lund University, Sweden
- SoM: School of Management, Zhejiang University, China
- ID and CSE: Engineering, Industrial Design (ID) and Department of Control Science and Engineering (CSE), Zhejiang University, China

Freedom-of-choice was another key factor, and the idea of letting students work with each other in international teams and freely synthesize on their current knowledge was also included as a cornerstone of the course curriculum.

The Swedish students, coming from LUSEM and LTH are already cooperating though the 2-year master program, Technology Management (Nilsson, 1997, Johnsson and Nilsson (2008), and TM (2013)). The Chinese students have not previously worked together.

4.2 Aim

The iMDE-course intertwines the disciplines of technology, management, and design, in Sweden and in China, in four dimensions; Students, Teachers, Subjects and Cultures.

- Subject: The focus in the joint course is on Innovation and Product Development, a subject that is of great relevance from technical aspects as well as economical and management aspects and design. The course contains lectures, field trips, and a project. The final examination is an oral presentation, a written report and a 3-minute film.
- Students: The student base is the 40 Swedish students from the Technology Management program (20 from LUSEM and 20 from LTH) together with approximately 40 Chinese students (20 from SoM and 20 from the technical departments (ID and CSE).

- Teachers: Teachers from both Sweden and China and from Engineering, Design (LTH, ID and CSE) and Management (LUSEM and SoM) are involved in the lectures. A minimum of two teachers with different aspects of the subject are present at each lecture to ensure cross-fertilization across competence areas
- Cultures: The cultural aspects of innovations, product development as well as project management and business behavior are covered in the course and practised in real life throughout the project.

The aim of the course is defined as follows:

"The world is becoming more international and cutting edge knowledge in marketing as well as engineering in a global world is becoming a valuable asset on the job-market. There is a lack of people with skills in both fields with the ability to connect market needs and innovations with product development, especially in an international context. International Market Driving Engineering (iMDE) is aimed at providing this knowledge and skills."

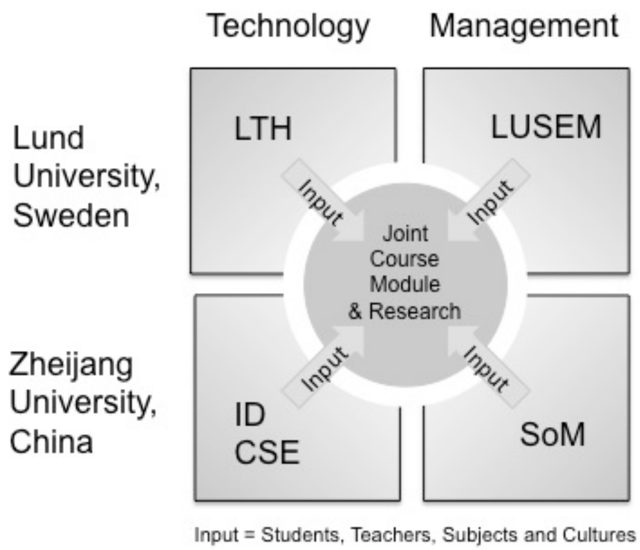

Figure 2: The collaboration model of iMDE.

4.3 Outcome

The set of lectures provided the students with new integrated knowledge and hands on experience of e.g. innovation, product development, business, engineering and design. The innovation process was introduced using the three stages suggested by Brown and Katz (2009); inspiration (e.g. looking for market needs), ideation (i.e. coming up with ideas solving the market need) and implementation (i.e. ways to implement and make prototypes of the idea). The innovation process was also covered from the aspects of desirability (market need etc.), feasibility (product development), and viability (business plan etc.). In addition to the new knowledge obtained through the lectures, the students were expected to combine and build on their own prior knowledge in their respective domains e.g. financial, management, technical, design etc.

The groups were divided into eight (8) teams, each one having members from both countries and all disciplines. In total there were about 8-10 members in each group (Nilsson, et. al., (2012)). Some lectures were used to discuss cultural differences in innovation climates, project leadership and management. At the end of the course each group had six (6) deliverables, see Table 1 below.

	Deliverables. At the end of the course, each group:
1	had developed a prototype manifesting their innovation.
2	could describe their potential customers and market need and argue why the innovation was

	desired (desirability).
3	could present how the prototype should be built technically (feasibility).
4	should understand the potential financial and market situation of their prototype (viability).
5	had written a report presenting the innovation, including an executive summary in Swedish, Chinese and English.
6	had produced a short (3 minutes) film demonstrating the group's work process and their innovation.

Table 1: Deliverables at the end of the iMDE-course.

The eight innovations from iMDE in 2012 are also visualized in Figure 3:

- Group 1; Naptop – sleep comfortably in public places on top of your laptop
- Group 2; Beddy Teddy – a teddy bear for children connected to the parents' cell phone
- Group 3; iLock – maintain control of your computer while taking small breaks
- Group 4; SoLED Lights – a safety product for e-scooters
- Group 5; EAchair – elderly accessible (EA) chairs for public places
- Group 6; Onewake – waking the user up in a quiet way
- Group 7; EasySpace – everyday life recycling made easy
- Group 8; PoPo – a photo receiving phone making interaction with family members easy for elder people

Figure 3: The eight innovations from the course iMDE 2012.

5. iMDE and Design

Diversity is generally not found in traditional undergraduate/graduate courses, since only students with the same curricular background are taught together. In addition, in most undergraduate/graduate courses, the objective is to provide the students with, for them, new and more advanced knowledge, rather than to apply and leverage/synthesize on the knowledge they already have. In the iMDE course, students from different disciplines are brought together, including students with a background in design to leverage and synthesize their knowledge on real issues in the everyday life of people.

In the iMDE course, we have embraced the idea of 'design' as the integrative discipline in innovation processes. In the course, industrial design students, who are specifically trained in the art of representing the user, visualising the emerging product idea, and the ability to integrate a number of often disparate factors into a coherent whole, act as a key competence in the projects by making ideas and concepts visible and tangible.

In the context of the iMDE course, we emphasis the value of innovation as fulfilling a need, in contrast to only fulfilling an economical value. Further, we introduce design as a key asset for strategic performance. By integrating industrial designers in the course projects, and by introducing the mindset and tools of design thinking (Brown and Katz (2009)), the ambition is to raise the level of awareness of the power of design from level one to level four of the 'Design Ladder' (see Figure 1). As the engineering and business students gain insight into the processes and thinking of design, they will adopt an attitude that will enable them to integrate their own disciplinary competencies and knowledge to utilise design as 'innovation', rather than merely as 'style'. Likewise, the opportunity for industrial design students to work with design as a tool and strategy to innovate together with other competencies in the product development process will enable them to experience and contribute to an environment where all parties are seen as innovators and contributors of value. Thus, design, as a competency alongside engineering and business, contributes to innovation by offering an approach, which integrates disciplines and knowledge domains and builds user-centred value.

6. Assessment

The effects of the course have been analysed in 2 ways. Firstly using Pertex analysis (Helmersson, (2010)) and secondly a frequency-analysis of (the Swedish) students' career choice: employment or entrepreneurship.

Pertex

The Pertex Analysis[1] (Helmersson, 2010) is best described as intuitive text-analysis. As opposed to traditional analysis methods, Pertex uses the text writer's frame of reference as found embedded in the text, rather than translating to categories defined by the reader/analyser. Pertex uses three axiomatic human functions as the basis for analysis: objective, action and orientation. A writer writes based on his/her objectives, actions and orientations to the phenomena at hand thus producing a "fingerprint" of the text. Pertex deciphers this fingerprint thereby revealing the writer's frame of reference.

For the Pertex analysis the students were asked after the course to produce a text about the course in accordance with the Pertex methodology. The analysis setup consists of 3 dimensions each with 2 groups: Swedish-Chinese, engineering-business, male-female. The texts of the respondents have been run through a Pertex analysis for each of the 8 analysis groups[2] of (2^3 groups).

The Pertex analysis reveals a nuanced picture of the meaning and utility of the course. The means of the course for 7 of the groups is: cooperation, teamwork, mixing of cultural backgrounds and educational background (Nilsson et al (2013)). When asked what to add to the course the single most wanted addition is matters of social interaction between the working groups in the class.

The Pertex analysis further reveals that the students' take-away from the course differ most in the dimensions in the following order, arranged from most to least:

a) Attitude: (Positive – Negative). One group stood out with 2 distinct subgroups (Swedish Female Engineers). The subgroups differ in attitude toward the course: positive and negative hence affecting the whole analysis. Our view is that the explanation is found on an individual level and has nothing to do with Swedish Female Engineers as a category.
b) Home University: (Swedish –Chinese) Swedish students found more overlap with prior courses that did the Chinese students. Otherwise no major differenced were found on this country/cultural dimension.
c) Major: (Engineering – Business) Business students reasoned more around goal and problem solving that did the engineers.
d) Gender: (Male – Female) Little differences were found relating to gender.

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[1] For a description of Pertex and its theoretical foundation: https://sites.google.com/site/aaoaxiom/pta-pertex

[2] Note that 8 mixed groups worked together during the course, however the Pertex analysis is made in three other dimensions, each with two categories, hence the analysis dimensions cuts across the 8 working groups. This makes it possible to analyse similarities between eg Swedish-Chinese students even though they were mixed into all the 8 working groups.

Impact on Career choice
The frequency of entrepreneurship when comparing the 3 classes of students taking the iMDE course with the prior 14 Technology Management classes not taking the course reveals that before the introduction of the iMDE course ≤ 1 of 40 (ca 1 student every second year on average) students pursued an entrepreneurship career directly following the graduation, while in the three classes taking the course 1-4 out of 40 (on average 7/3) chose entrepreneurship, an increase of about 500%.

7. Discussion

In his book 'Riv Pyramiderna' (Carlzon (2009)), former SAS (Scandinavian Airlines Systems) CEO Jan Carlzon describes how the Nokia CEO had told him that they were working like dogs to fill their phones with values people were willing to pay for in order to keep the margins required (Åman and Andersson (2012)). At a shareholder's meeting some time later, a young girl had asked the Ericsson CEO "Why does Ericsson not make phones that people want?". The question had been ignored, with the CEO instead emphasizing the need for cutting costs.

In hindsight, despite the latter unfortunate events of both of these former telecom giants, it is easy to say which of these brands were most successful on the market, and which one was perceived as more desirable. Åman and Andersson (2012) continue by asking the question whether Ericsson could have been equally successful in integrating aspects of 'beauty', which they define as knowledge of aesthetic and symbolic aspects, as they had been with the integration of a number of more or less related, complementary technological knowledge bases. From their starting point in knowledge engineering, Åman and Andersson (2012) emphasize the importance of industrial design as "a field that incorporates an integrative aspect, stretching across the divide between the rational and problem solving and the 'irrational' of the aesthetic and symbolic". As such, "design as an activity and profession is inherently integrative across 'arts' and 'sciences', but it is the integrative element that is at the forefront" (ibid).

We believe that a narrow-minded view of objectives in product development and design can contribute to a situation, where economic targets get over-prioritised in relation to value for customers and other stakeholders, such as described by Åman and Andersson (2012). It has been claimed that the only mobile phone producer making a profit today is Apple, who (coincidentally?) has a long tradition of focussing on user value, such as desirability and usability. We therefore see it as most important that design students are brought into the innovation process, and that design is seen as an integrative factor.

8. Conclusions

In the iMDE course, presented in this paper, a guiding star has been 'diversity'. We have implemented this ambition by integrating disciplines, cultures, mindsets and viewpoints of teachers, students, countries and programmes, all in one course. With this in mind, the ambition has been to create end-user value, balanced by knowledge and insights from a range of domains. Integrating design thinking as a tool and process to support innovation in the multidisciplinary projects this course has proven successful and appreciated by students and teachers. The ability and skill of industrial design students to visualise, model, and bring abstract ideas into tangible reality, has been a key component in this process. The disciplinary competences and expertise from all parties, combined with the eagerness and openness to embrace a designerly attitude towards innovation, have been the foundational corner stones for this diversity to bear fruit.

The iMDE course integrates the disciplines of design, business and engineering. The mix of design, business and engineering students is a powerful combination since knowledge in these three disciplines mirrors the three central characteristics of a successful innovation – feasibility, viability and desirability.

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