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MULTIDICIPLINE TEAMS FOR INTELLIGENT INNOVATION: EDUCATING AND TRAINING ENGINEERING AND DESIGN STUDENTS TO CO-CREATION.

Unpublished work

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ABSTRACT:

Holistic approach for intelligent innovation is obtained in integrated design teams by mixing up backgrounds and skills into multidiscipline teams. However, is mixing enough? To go further than a simple addition of skills and create a synergy, the key ingredient is to favour communication and understanding between individuals in the team. Our aim is to impulse the establishment of commons languages and favour constructive interactions between future engineers and future designers. It aims at preparing future engineers for team-working with people with various backgrounds, different methodologies and skills. A specific educational program has been tailored for engineering students to favour mind opening through variety of lectures and hand-on activities. The focus point is a multidiscipline international workshop in design and engineering, gathering students from both areas. The workshop process has been studied and it was demonstrated that significant knowledge transfer and efficient complementarities of skills and methods were occurring and led to a global and user-centred response to the Design brief.

KEYWORDS: co-creation, multidiscipline design workshop, industrial design, design development strategies

INTRODUCTION

In the 19th century, the Industrial Revolution led to major changes in agriculture, manufacturing, mining, transportation, and technology. Direct consequences of those industrial changes are visible also on socio-economics and culture [Le Boeuf 2006]. While technology somehow led innovation and product success during that era, a new industrial strategy is occurring these last few decades. Pushed by the competition with products from Southern Asia and China, innovation is not restricted to technological innovation and intrinsic qualities anymore and new product specifications such as ergonomics, sensory characteristics, aesthetics, and personality..., have become fully associated to the product or service design process. In France, the history of Engineering Schools highly anchors the educational contents to industrial needs, first in Civil Engineering and then in variety of industrial domains. On the other hand, Design Schools more often derive from Art Schools. Thus, due to their educational environment, students from those two disciplines accumulate two different knowledge and communication skills. Meanwhile, the evolution of industrial strategy has pushed Design and Engineering closer together. Both disciplines are forced to work in close connection due to the increasing importance of the “time-to-market” element in modern innovation and industrial challenges. With this evolution of industrial innovation, more and more designers are now integrated in innovation teams in large companies and SMEs. Nevertheless, industrial development remains the essence of engineers’ work. Thus industrial and intelligent products must come from a synergistic effort from both designers

and engineers trained to work as a team. Our contribution as a graduate school of engineering is to train our engineering students to work efficiently in multicultural, multidiscipline environments.

Tom Kelley [Kelley 2005], in his book “the ten faces of innovation”, highlights ten personas that can play a positive role in an innovation team (table 1). These personas could spontaneously fit to our own personality but can also work as guideline to enrich innovation teams. Thus to assemble a competitive innovation team, mixing up backgrounds and cultures is one part of the recipe, and is commonly done in industry. However is mixing backgrounds and skills enough? To go further than a simple addition of skills and create a synergy, the key ingredient is to favour understanding between individuals of the team so that a synergistic communication and complementariness can occur. Our aim is to impulse the establishment of a common language and favour constructive interactions between future engineers and future designers.

Table 1: ten faces of innovation proposed by Tom Kelley

Personas	Personality
The Anthropologist	Brings new learning by observing human behaviour
The Experimenter	Prototypes new ideas, learning by a process of enlightened trial and error
The Cross-pollinator	Translates findings from other industries and cultures to fit the needs
The Hurdler	Develops knacks to overcome obstacles
The Collaborator	Helps bring eclectic groups together
The Director	Gathers together a talented team and helps to spark their creative talents
The Experience Architect	Designs compelling experiences that go beyond mere functionality
The Set Designer	Creates a stage on which innovation team members can do their best work
The Caregiver	Anticipates customer needs and deliver customer care beyond mere service
The Storyteller	Communicates fundamental human value or reinforce cultural traits

To successfully instigate a design-led approach in the project methodology of our engineering students, tools, methods and design thinking exercises are gradually implemented during one year in their educational program following three sequences with different aims.

The first sequence (120h) occurs during the first semester and focuses on tools used in product design. These courses provide basic knowledge and skills in value engineering, drawing and sketching, 3d modelling, materials and process selection. Once these common tools are mastered by both engineers and designers, they can either become communication supports to exchange ideas and point of views, or can be used as innovation stimuli, as detailed hereafter. The second sequence (80h) occurs during the second semester and moves toward human factors by introducing the importance of user experience and other methods used in innovation to grow from an idea to a concept. The final sequence is a multidiscipline workshop that gathers engineering and design students. This 5-day workshop demonstrates the efficiency of multidiscipline teams working on a Design brief. The relevance of these

three sequences, in terms of implementation of interactions between Design and Engineering, will be explored hereafter. In particular, a detailed analysis of the workshop process will be presented, based on observations made during the last three workshops that were organised at Ecole des Mines in Saint-Etienne since 2009.

1 - THE MATERIALS USED AS TOOLS AND STIMULI IN INNOVATION

The main reason motivating an introduction based on toolsets is to counteract the exceedingly theoretical and conceptual approach in the education of French engineering students. Additional benefits are observed. Providing them with working tools and asking students to use these immediately helps demystifying Design as a discipline. It also helps building-up confidence in the idea that engineers may have a creative input in multidiscipline projects and should not limit themselves to providing solutions to other's ideas. We illustrate the process by detailing the example of materials selection.

Materials selection is a mandatory step in product design. While mechanical specifications are most often the primary constraints that drive the selection, product differentiation focuses on other material specifications such as colour, touch, smell, i.e. the sensory properties of the materials. Indeed, products are designed to be in interaction with human users so the perception of the product is necessarily influenced by the selected materials. Research work on how to implement sensory properties based on sensory evaluation and metrology [Depledt 2009] has been published elsewhere [Faucheu 2010, Eterradosi 2010]. A global approach of design favouring the perception of a product is known in the design industry as Kansei Design or Emotional Design [Lévy 2007]. The term Kansei appears in the design community thanks to the works of Mitsuo Nagamachi on "Emotional Engineering", and of Kenichi Yamamoto (President of Mazda Automotive Corporation), who used the term "Kansei Engineering" for the first time in 1986. Since then, Kansei Engineering was developed in both academic and industrial fields. Keywords associated to Kansei are for instance sensitivity, impression, feeling, and emotion. According to Harada [Harada 1998], Kansei is an internal process of the brain, involved in the construction of intuitive reaction to external stimuli. Nagamachi [Nagamachi 1997, 2001] is recognized as the main actor in the creation of Kansei Engineering, the first and so far most advanced engineering design method based on Kansei considerations. He has described Kansei as an "individual's subjective impression from a certain artefact, environment, or situation using all the senses of sight, hearing, feeling, smell, taste as well as recognition" To this description Schütte has added the sense of balance [Schütte 2002, 2005]. In addition to this growing interest for human perception in the product design process, design and materials have always been related. Books aimed at industrial designers and architects are constantly being published to familiarize them with the abundance of new materials and the even higher abundance of "old materials" [Lefteri 2006]. Materials libraries [materio 2011, Kings College 2011] are also flourishing because, evidently, materials perception is limited in book representations and feeling the materials by touching, smelling, making it play with light are more likely triggering imagination. Based on this assessment, a specific setup for the courses on materials properties has been designed for our engineering students. Materials are considered both as a tool for product designers and as model stimuli used to explore the spontaneous interactions between users and products. These courses are divided into two sequences.

The first sequence provides basic technical knowledge on the different classes of materials and their main properties based on Ashby's materials' properties maps [Ashby 2005, 2010] and using the CES Selector software [CES 2011]. This part is comparable to what is being taught in many engineering courses.

The second sequence explores the perception of materials and focuses on the interactions between human sensors and specific material textures and shapes. This course aims at

creating a link between matter and sensations, i.e. how the choice of material can induce a specific feeling. A new facet of materials is introduced to the students by feeling and evaluating the materials through their human sensors, using samples of various materials (wood, ceramics, metals, plastics...) in various shapes (solid, textile, sheet, rod...). This complementary approach of materials properties illustrates the importance of the choice of materials while creating a product that will be in interaction with a user. During these experimentations, the students make a parallel between materials properties (thermal, mechanical,...), usually given in numbers and units, and material sensations, described by words (translucent, soft, warm, sticky...). The students enrich their knowledge of materials behaviour through the experience of materials with tools (their senses) that they own and can use anytime. Through this process, students experience the need for formal descriptors of sensory properties and the way these can be measured. At the same time, they confront the impossibility to completely relate an emotional experience to quantified descriptors only. They are ready for the introduction of “human factors” in the product’s DNA.

2 - USER EXPERIENCE AND INNOVATION METHODS

Lectures are addressing the importance of integrating user experience at every step of the design process. The success of an innovation does not come from the sole intrinsic qualities [Mallein 1994] and the future of an innovation cannot be determined by the only consideration of functions. Talented designers are known to be nimble at using and hijacking archetypes and social conventions. Successful and desirable products are those in which this equilibrium between “matching the user’s needs” and “creating a rewarding experience” is anchored in the daily experience and social context of specific groups of users. Addressing this last aspect is of prior importance in the early training of engineers. We consistently observe that the “good for everyone” syndrome is the most common pitfall for engineering students when developing ideas they believe in. In addition to various instances of “persona research” types of exercises being introduced in different courses, tutors constantly press their students to clearly specify the Who ? Where ? and When ? in their proposals. Once the idea that innovations have to be targeted at specific groups in specific contexts is beginning to be enforced, the next step is to set the stage to initiate the collective creative process itself.

This sequence aims at providing students with tools and methods to overcome obstacles and efficiently evaluate and mature their ideas into concepts by adequately analysing their positive and negative aspects. To do so, fake trials of emerging concepts are organised in which some of the students are defending the concept, facing others that are attacking it. The ten faces of innovation presented by Tom Kelley are explored as theatre characters that can inspire the students while they are on either side, defending or attacking. In this setup, the students are forced to evaluate the concept with different point of views, sometime not their personal one. This exercise is akin to Edward de Bono’s six hats [de Bono 1985], but it was felt that, by focusing on the argument instead of the outcome, de Bono’s personnas could induce too much distance with the creative process itself, with the danger that reluctant students could use this as a pretext to keep their distances with the concept and not get fully involved. Additionally, this exercise makes them consider a larger number of aspects of a concept and forces them to evaluate all these aspects into more details.

Other instances of multi-sided approaches to product analysis and design are proposed. In the “product deconstruction” activity, they have to analyse an iconic product considering a large number of aspects that highlights the reasons of its success. Finally, they can develop their own product concept during the “re-design project” in which they have to re-design a product with a given constraint (for example targeted at a specific user group, location, context...). In this “re-design project”, the product is already industrially produced, thus technology is not

an issue. They are forced to focus on user experience and human aspects in order to propose a valuable solution.

3 - MULTIDISCIPLINE WORKSHOP

Since 2009, The Ecole des Mines in Saint-Etienne is organising yearly an international workshop in design and engineering that gathers students from both disciplines. While workshops are a common activity in Design Schools [Johnson 2007], such events are rarely held in schools of engineering. In 2011, 30 students participated: 12 students in engineering from Ecole des Mines de Saint-Etienne (EMSE), 12 MA students in Design Branding and Design Strategy from Brunel University (BRUNEL) and 6 undergraduate students from Saint-Etienne School of Art and Design (ESADSE). In former workshops, MSc students in Design and Engineering from Politecnico di Milano (PoliMi) also participated. The set up of our multidiscipline workshop has been developed based on various existing methodologies and workshop setups. The most important sources of inspiration came from the Syntectics innovation method [Gordon 1961] and a workshop in service design held in 2005 in UIAH Helsinki [UIAH 2006]. The workshop comprises two distinct sequences: a creative sequence and project development sequence. The creative part is semi-collective, with project teams not yet formed. It was felt that it favoured the early mixing of skills and contributions from both students groups. Opening on Monday noon and final concept presentation were on Friday afternoon. Thus the workshop duration is 4 full days spread over 5 days.

3a - HOW THE SETUP IS BUILT

First, the 4 days are divided into 2 separate sequences. A first sequence (creative part) relies on a collective effort. It is a divergent-convergent sequence during which large amounts of raw material (“ideas”) are generated rather quickly, then clustered and organised into concepts. In the second sequence, students are gathered into teams of three or four students (selected by the facilitators). Each team comprises at least one student from each discipline. Each team selects two concepts that they prefer and evaluate the positive and negative aspects of those two concepts. They finally keep one concept per team that they have to elaborate further during the second sequence called project development.

In Kelley’s classification of innovation personas, the workshop facilitators could be identified as Collaborator and Director, as they gather a talented team, help bring this eclectic group together and help to spark their creative talents. They also work as Set Designer in that they help create a stage on which innovation team members can do their best work. Favours exchanges and mixture of cultures by managing a creative environment mood is a key ingredient in multidiscipline workshops. Managing the process between participants that do not know each others before Day One is a challenge. Organising people, rooms, equipment and other resources has to be carried out in detail. Lunches are organised in the same building to favour informal exchanges across teams and foreign students are accommodated in the local students residence. Short collective highlights are organised every day in the main room, even after the team formation. These activities (lectures, votes, concept presentation...) helps students to remain connected to the whole group and prevent the isolation of a team during the project development process, w can be very intense. A chronological description of the 2011 workshop is detailed hereafter and an analysis of the innovation process is proposed based on observations made over the last three workshops.

DAY ONE: CREATIVE SEQUENCE

The workshop subject is sent to the tentative participants one month before the workshop. It is usually based on a new technology that has not yet found its application area (personal fabrication systems in 2011), or on existing ones that raise issues with user experience or

social behaviour (energy for mobile devices in 2009, numerical identities in 2010). These difficulties are briefly reviewed in the workshop description and the challenge of overcoming these with non-conventional solutions is set. On day one, all students are gathered in a main room for an opening lecture, which is the first collective highlight of the week. A lecture is given as a state-of-the-art or illustration lecture for the upcoming design brief. The content of the lecture has to be carefully selected in order to prevent unwanted self-censorship, obtained for instance when the content is so detailed that no room for innovation seems available at first sight. From our experience, design and engineering students have a different attitude towards introductory speeches. While the former, used to change subject often, are keen on gathering as much information as possible before starting to generate ideas, the later do not see much interest at that stage and usually have a more positive attitude towards focus lectures later in the week, when they are well into the subject and need fresh material to feed their projects. We opted for the quick-and-broad option. While the one-page subject highlighted difficulties, the opening lecture is aimed at opening new horizons by pointing at various unexpected directions, sometimes loosely related to the initial subject.

The students group is then divided into 4 groups of 7-8 students comprising all and universities. Each group goes in a separate room with one facilitator from the staff. This first sequence is devoted to idea generation. Most of the tools implemented in this sequence are derived or adapted from the Synectics methodology, which is a creative problem-solving method for corporate contexts. The students are facing the facilitator and are asked to interact with him/her and not with each other. This setup is aimed at preventing sterile and time-consuming discussion or arguing between students during the idea generation sequence. Discussions are deferred to a second sequence, clearly distinct from the idea generation phase. The animator does not interact as a creative input: his role should be limited to note-taker and “atmosphere-minder”. The aim of this sequence is to produce thought material that will serve as textual stimuli for the concept development in the next sequence. After breaking the ice by an introducing everyone, the animator begins with a series of warm-up exercises. These exercises are mind challenges of increasing difficulty, aimed at levelling the ground across design students, who may have had different experiences with creativity exercises in their backgrounds. They also help overcoming a possible apprehension towards working in English, which is not the native language of a majority of students.

The idea generation sequence starts by delivering the design brief for the first time. The brief is a one-sentence incentive summarizing the subject, expressed in a way as to challenge students to be open-minded and creative (e.g., for 2011, “Imagine what personal fabrication will make possible”). The facilitator asks the students to provide one-sentence ideas that come to their mind. Students are asked to provide ideas without considering their feasibility. They may begin their sentences with “I wish ...” or “It would be cool if ...” as if writing a “letter to Santa Claus”. The animator writes each idea on a paperboard without censorship. The “no censorship” is the only enforced rule during this sequence, neither from the facilitator, nor from the other students. The facilitator has to shorten arguments or discussions to keep the pace of idea generation high enough. The students do not justify or elaborate on their ideas. They are encouraged to rebound on other’s. When they seem to run dry, the animator can propose alternative exercises (brainstorming, image associations, drawing...) as a way to generate fresh material before a new round of idea generation. The result is about 60 to 100+ ideas in each group generated in 90 minutes and posted on the walls. This material remains on display during the whole week and can be used as the first step toward a concept or as rebound material later on. At the end of first day the walls of each room are covered with the ideas provided by each group (Figure 1). Students are encouraged to wander in other groups rooms and steal ideas if necessary, in order to defuse a possible

early sense of property and an excessive investment in ideas that may turn out to be weak later on.



Figure 1: textual stimuli: ideas generated collectively after the creative sequence.

Before calling the day off, each student randomly picks the picture of a persona (the exactitudes website [exactitudes 2011] is a rich source of material) and is asked to gather four other pictures related to the persona they were given. This simple assignment clearly states the end of the idea generation sequence. Secondly, the hundreds of gathered images that will be used as visual stimuli (Figure 2) in addition to the text stimuli (Figure 1) produced earlier. This assignment is in line with the afore mentioned effort to have students anchoring their proposals in a given user group and social context.



Figure 2: Visual stimuli brought by each student (Day Two morning).

DAY TWO: IDEA GROWS INTO STARTING CONCEPT (STARTER)

Based on text and visual stimuli generated the first day, the students are asked to gather ideas that can be linked together through a social context, a user experience, a geographical location or any explicit common point. Elaborating on and challenging ideas is now encouraged, as the main objective is that such clusters of ideas go through a “natural selection” process, in which only the strongest will survive. By mid-day two, smaller groups of four are formed, which prefigure the project teams for the remainder of the week. Each team chooses two clusters of ideas and turns them into starting concepts or Starters. They are asked to prepare a poster with visuals and one unique sentence (as long as they want) that defines the Starter (figure 3). The sentence has to address the “What”, “Who”, “Where” and

“When”, but leave aside the “How”, which will be dealt with during the project development phase. This stage is a more involved and linear one than the idea generation. A presentation session is then organised in the main room: each team has five minutes to present each Starter with the posters. All the posters are displayed in the main room so that every participant (students and staff) can vote for the most promising Starter (figure 3). Each team has the choice to follow the result of the vote or to choose the Starter they personally prefer, but at the end of the day, only one starter per team remains and they will work on that one for the rest of the week. This vote session creates a very emulative atmosphere in that the teams defend and rephrase their Starters to the others and also re-interpret others’ Starters based on their own interests and views. It can be noticed that this sequence is very exciting for the students because all of them got highly involved in the idea generation, Starters definition and defense processes. The challenge now is to go from these Starters to viable and mature concepts in the remaining two days of project development.



Figure 3: Starter’s poster in progress (left), Starter’s vote (right)

DAY THREE TO DAY FIVE: PROJECT DEVELOPMENT

During the development and implementation sequence the teaching staff is in charge of challenging the concepts in order to make them mature and viable. The students are asked to implement a global approach by developing five aspects of their concepts: scenario, user, context, technology, and business model. They are asked to develop all of these aspects equally. The mental image of pizza slices is used to emphasise the importance of balancing their efforts: no matter how thick they are, pizza toppings (which represent the material produced during the development phase) have to be evenly distributed across all slices.

Figure 4 is a schematic representation of the workshop layout gathering 18 engineering students (triangles) and 18 design students (circles). They are divided into four balanced groups (b) with four engineering students and four design students each. These groups generate ideas collectively (c) as raw thought materials for the later process. Each group is allowed to collect ideas from other rooms (d) back to their room (e) so that the idea generation sequence is completely collective over all the participants. Then each group is divided into two balanced teams. Each team evaluates the positive and negative aspects of two preferred concepts before selecting the most promising one (f), with advices from other participants (teaching staff and other students). Finally, the concept is implemented and developed into a viable project (g). In 4 days, the workshop results in eight different project emanating from the same Design brief.

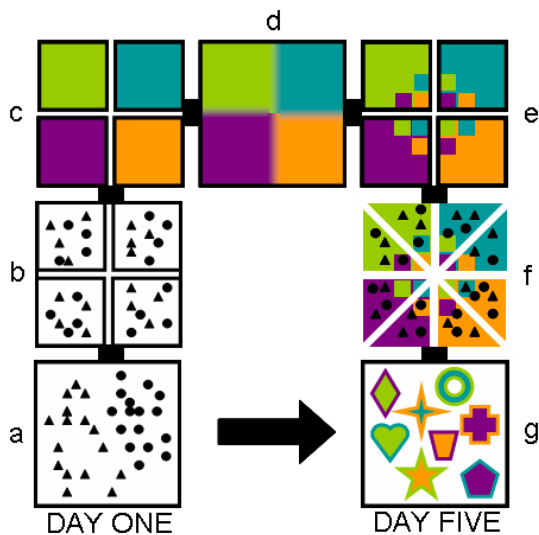


Figure 4: Schematic of the workshop process.

3b - HOW THE SETUP WAS PERCEIVED

On Day Four, during the project development sequence, the students are gathered into the main room and are asked to represent the process they have been through on an A4 piece of paper. They have a few minutes so that their response has to be very spontaneous. Some chose text-based representations in flowchart form, while others chose visual representation with schemes and figurative drawings such as light bulbs or smiling faces to represent ideas. Independently of their text or image-based form, these representations could be classified into two categories. In the first category, the focus is on the idea generation followed by the selection of a good idea that would then grow into a valid concept (Figure 5). In the second category, focus is on a process based on clustering and gathering pieces together to create a valid concept (Figure 5).

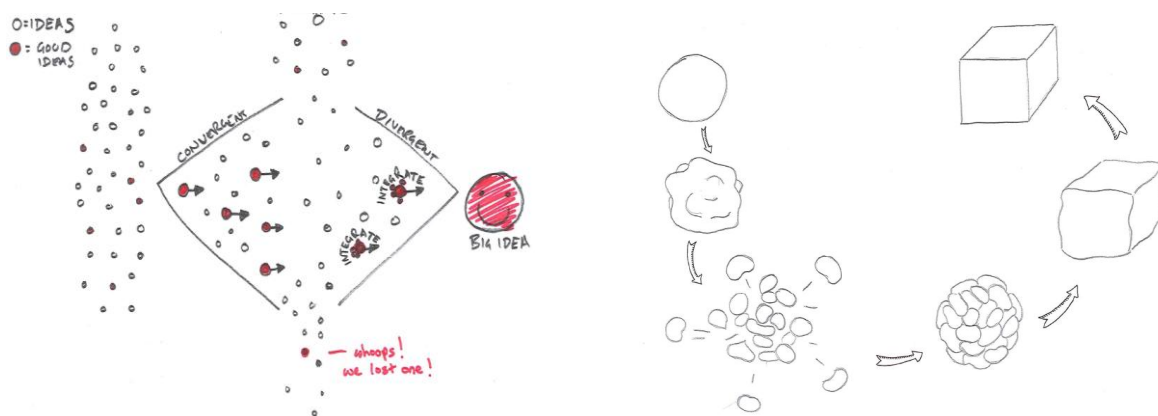


Figure 5: Student representation of the workshop process (left) focused on idea selection, (right) focused on idea clustering.

Actually, the whole workshop process contains both types of ingredients at different stages. Day One is devoted to idea generation, leading to a very large amount of thoughts than can be either valuable or not as pictured in figure 5 (left). A selection does occur during Day Two while the teams have to build up Starters and at the end of Day Two during Starters selection. As highlighted on the left picture (figure 5), some good ideas might be lost in the process. To

limit those risks, all thoughts are displayed permanently during the workshop and opportunities to re-phrase, re-formulate and re-interpret ideas are provided during Day Two. When project teams encounter difficulties or “sticking points” during the development phase, a member of the teaching staff may help them re-run a miniature session of idea generation and clustering on a sub-problem (being too involved in their project, students do not usually have the capacity during the week to step back and formalize such a process). Finally, the building up of the starters is performed through a clustering of ideas as pictured in figure 5 (right). While the process was not perceived identically across students, their interpretation of the process showed that for all of them, the process should point towards a viable and valuable concept.

3c - ANALYSIS OF THE WORKSHOP PROCESS

This workshop has been held in the Ecole des Mines in Saint-Etienne since 2009. Besides the educational interest in terms of student experience, we have been interested in analyzing the knowledge exchanges and process characteristics occurring during the workshop. To do so, the students' insights needed to be collected at different times during the workshop. Three specific times were selected: first at the beginning of the workshop (Day 1), before any interactions between student groups, second, after the creative part, i.e. right after the concept selection (Day 3) and finally at the end of the workshop (Day 5).

The first year, a questionnaire with six questions was given to be filled-in by the participants. The questions were:

1- What do you see as the main or most important reasons for using multidisciplinary teams in the innovation or product development process? List three only, starting with the most important.

2- What barriers, obstacles or difficulties do you think will occur in the St Etienne workshop? List three only, starting with the most important.

3- What do you think the ‘groups’ will contribute to the workshop, in terms of tools, skills, attributes – positives and negatives?

4- What personality traits do you think the other groups will exhibit...which are directly associated to their ‘discipline’ or training?

5- Circle or Underline the words that best describe the process you imagine being pursued for the project.

linear, structured, unstructured, directed, iterative, activity based, cerebral, creative, consensus driven, authoritarian, practical, abstract, chaotic, other...

6- Circle or Underline the words that best describe the tools that you imagine will be used within the workshop / project

brain storming, synectics, personas, QFD (Quality Functional Deployment), scenario building, Six Hats (DeBono), SCAMPER, body storming, Soft Systems Methodology, mapping, customer journey, blue sky, intuitive thinking, critical thinking, other...

Some obvious conclusions pop out from the analysis of the questionnaires. For instance, the reason for using multidisciplinary teams in the innovation or product development process is the access to complementary views and skills. "Brain Storming" is often cited as a tool, but is probably used as a generic reference to describe "unstructured creative thinking" type of activities. Finally, English language is consistently cited as difficulty by student, although it has not been seen as an issue by the tutors (note that English is not the native language for most participants). Indeed, in another multidiscipline workshop held in French and gathering engineering, design, architecture and social science students (mostly native French speakers), language and communication were even more strongly pointed out as a difficulties by the

students. Our analysis is that communication issues more probably stem from differences in cultural backgrounds and approaches/priorities than language. On the contrary, it seems that the constraint of working in one's non-native language helps the students accepting the obligation to constantly rephrase their ideas, which is a cornerstone of such multidiscipline team working, and which may appear as a burden when working in one's native language. Other answers illustrate the knowledge transfer that is occurring during the workshop. We noticed the appearance on Day 3 of a positive vision of the multicultural aspect, which was seen as a possible obstacle on Day 1. The increase of the number of cited tools, some of them having been used, but not formally named and identified is an illustration of learning by practice. Personality traits of design students seen by engineering students significantly shift from imaginative and creative towards methodological. Engineering students discovered that design students had strong methodology and market analysis skills. Some engineering students realised that designers focused on a user-centred approach, as opposed to solution-driven approach. Concerning the viewpoint of design students on their engineering counterparts, the most impressive evolution between Day 1 and Day 3-5 is that all preconceptions - which portrait engineering students as robots - vanish in the course of the week (apart from the focus on technology, which remains strong along the week).

While these questionnaire produced interesting data on the workshop process, filling them in seemed to impair the momentum of the workshop, by forcing the students to adopt a critical view on their own contribution. During the 2011 workshop, we opted for a more spontaneous and visual way of collecting students insights. Large charts (2meter tall and 1.5meter wide) headed with a question and with 2-perpendicular axes hosting one proposition at each end (four in total) were displayed in the main room. The students were given stickers with their the different institutions' names and were asked to position these on the charts. Like with the questionnaire, charts were displayed days 1, 3 and 5. Some of the resulting charts are plotted in Figures 6, 7 and 8. The first question was related to the personality and the educational discipline (figure6). On Day 1, engineering students (EMSE on the charts) were mostly perceived as rational and not specifically narrow nor open-minded. At the other end, undergraduate students from the School of Art and Design (ESADSE) were clearly seen as non-rational and open-minded, while graduate Design Branding students (BRUNEL) were perceived as open-minded but not specifically rational or irrational. On Day 3, the collective work that they have all been through during the creative sequence has levelled the differences in personality that was previously imagined. All three groups of students are described as open-minded and not specifically rational nor irrational.

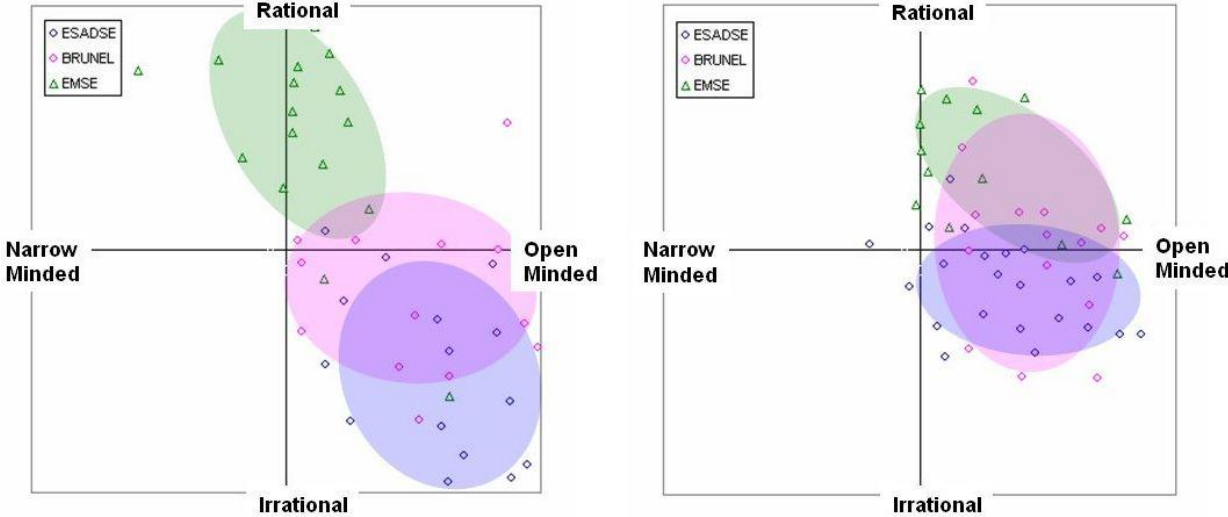


Figure 6: Resulting answer chart to the question: “What personality traits did the other groups exhibit which are directly related to their discipline?”. Day 1 (left), Day 3 (right). Colour areas are guides to the eye. The chart excludes self-evaluations from each group.

A second interesting chart (figure7) describes the evolution of the perceived inputs of each group. While both design students groups are similarly perceived on Day 1 and Day 3, i. e. they provide ideas and are creative. The engineering students’ group moves from providing solution and being methodical to a more balanced description in the middle of the chart meaning that they also provide ideas and are creative.

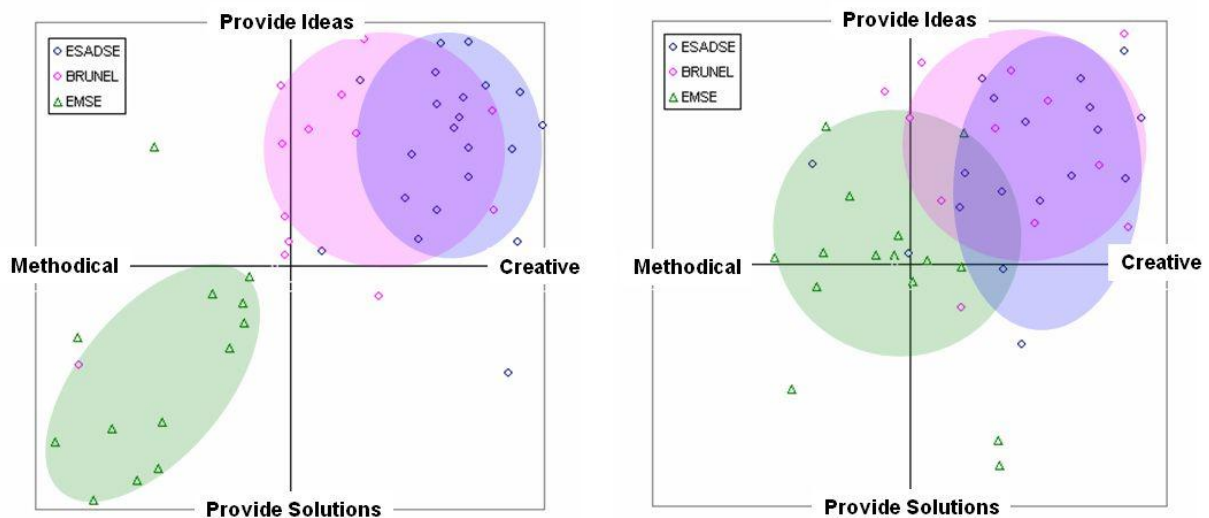


Figure 7: Resulting answer chart to the question: “How would you assess each group’s input in the workshop process?”. Day 1 (left), Day 3 (right). by others. Colour areas are guides to the eye. The chart excludes self-evaluations from each group.

These two series of charts (figure 6, 7) illustrate what was qualitatively observed during the Starters’ presentation. As mentioned above, the Starters presentation is a very exciting moment for the students because all of them, designers and engineers, highly involved themselves in the idea generation process and the Starters preparation. After the fuzzy impression left by the idea generation sequence with unstructured methods and an overwhelming amount of data generated, students feel efficiently creative in that they manage to propose two Starters they believe in. To our sense, this feeling of satisfaction can hinder the efficiency of the development sequence. Indeed it has been observed that some teams that had very promising Starters did not manage to develop them into a mature concept: Their concept just went round in circles during the two days of project development. To prevent this “Day 3 Bug”, the two sequences of the workshop could be separated in time. A few days or weeks could be left in-between both phases to reduce the premature feeling of achievement associated to these presentations that may turn counter-productive.

Finally, the chart on figure 8 displays the evolution of how engineering students perceive themselves in the process. A trend is observed going from the engineer archetype that provides solutions and is methodical to a more versatile engineer that can also provide ideas. This means that an evolution has successfully occurred in the self-consciousness of the engineering students.

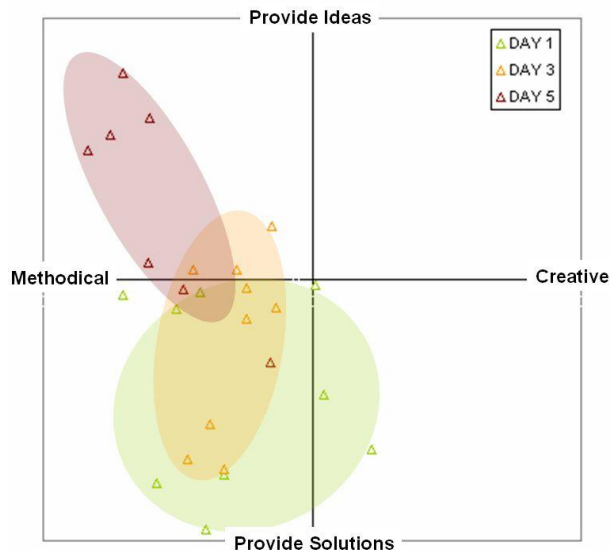


Figure 8: Resulting answer chart to the question : “How would you assess each group’s input in the workshop process?”. Day 1 (left), Day 3 (right). Colour areas are guides to the eye. Self-evaluation of the engineering students.

CONCLUSION

This specific teaching and training program was tailored for engineering students with interests for innovation and industrial design. The keywords of this program are co-creation, multidiscipline, synergistic communication. It aims at preparing future engineers for team-working with people with various backgrounds, methodologies and skills. The chosen strategy is to favour mind opening through varied of lectures (sociology, materials, perception, drawing, design cultures) and hand-on activities. The focus point is a multidiscipline international innovation and design workshop gathering engineering and design students from different European institutions. The analysis of the workshop process demonstrated that a transfer of knowledge is operating during the week. In this setup, design and engineering, are forced to work together since the very beginning during the first creative sequence of the workshop. An appropriation of the design brief is done simultaneously by both engineering and design students. A positive interaction between those two disciplines leads to co-creativity and enriches the innovation process. A holistic approach of the design brief is implemented during the project development sequence leading to balanced concepts.

Managing a balanced contribution from each group is probably easier when working with students during their initial training. In addition to a technical and cognitive task, design is a social process [Cross 1995] and prescribed social roles may play an important part when involving professionals [Austin 2001]. Our students groups are not immune to archetypes and social conventions, as exemplified by their replies to the surveys on Day 1, but it was seen that these perceived differences may vanish after two days of an intense collective creative effort.

A “Day 3 Bug” originating from a non-productive feeling of early self-satisfaction was observed between the creative part and the project development part. This “Bug” increases the risks of poorly challenged concepts and non-productive project development. A new setup with a time break between the creative and project development sequences could overcome this “Day 3 Bug”. This should improve the workshop efficiency on several aspects. The teams could have time to gather state-of-the-art material to enrich their concept. The

satisfaction feeling they have after the Starters' presentation should be given the time to partially vanish, so that a positive challenge feeling can reappear. Finally, it is worth noticing that the creative sequence imposes a heavy burden on the participants. To evaluate the effects of such a time break in the project development process, the 2011 engineering students took part in a prototyping workshop based on the concepts that were proposed at the end of the multidiscipline workshop. They were asked to choose one concept and to fabricate a functional prototype using cardboard. The target of that second workshop is to have students identifying the "critical function" and/or "critical experience" associated to a concept and to turn the concept into a physical prototype. They become Experimenters that "prototype new ideas, learning by a process of enlightened trial and error" and Hurdlers that "develop knacks to overcome obstacles". This second workshop occurred one month after the concept presentations and students had resumed activities unrelated to design in between, even though, the students' involvement, interest and memories of the concepts were acute and the prototyping workshop positively enriched the concepts in terms of ergonomics, user experience and product-user interface.

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