國立成功大學 106 學年度碩士班招生考試試題

系　　所：科技藝術碩士學位學程

考試科目：科技與藝術　　　　考試日期：0214，節次：1

※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. 何謂「科技藝術」？ 請說明之。(15%)

2. 請提出 2 件作品，為您未來在「科技藝術」領域的創作規劃? 如何完成您的作品，請以文字圖表詳述說明: 主題、創作理念、技術、形式、展演。(60%)

3. 請閱讀下列文章(註 1)，並撰寫該文章的英文摘要(至少 600 字)?(25%)

   註 1: 該文章主題為: Art-technology Collaboration and Motivation Sources in Technologically Supported Artwork Buildup Project, 文章出處: http://www.sciencedirect.com/science/article/pii/S187538921501545X

Keywords: collaboration; motivation; art & technology; co-operation; laser cutting

1. Introduction

In this research case, living lab as a term means a type of research approach that includes end user into the research context. The research is user centric and it happens in real open-innovation ecosystem (Von Hippel 1986, Chesbrough 2003). Also the process integrates research to currently ongoing practical development effort (Bilgram et al. 2008). In this practical research case, a user was co-creating with researchers. This co-creation happened in innovation and process development context. Co-operation included artwork and new art build process co-creation, ideas and production concepts exploration, experimentation (build of the artwork and ideas for art design) and evaluation of innovative ideas (actual process of generation physical artwork from ideas). The research process included early stages of laser cutting application up until the art creation process, where the actual "product" life cycle started (creation of the actual artwork) (Kusiak and Tang 2006).

Instead of just defining strict limits and reducing artist freedom to the known ways to work for the engineers, in this study different approaches of using the technical laser equipment were studied and tested. This research study was based on art needs suggested by the artist. The whole research process was engaging, which fits in the living lab concept. Especially when new methods were developed for artist-oriented engineering context, with a goal to foster innovations for sustainable artworks and products (Jackson 2005). The sustainability was important factor in this study of technology and artwork generation collaboration, as it was already known that only new solutions and processes will reveal new ways to work and generate innovative new tools (Spaargaren 2004, Thøgersen et al. 2002, Welfens et al. 2010). From knowledge generation point of view, the purpose of this study was to establish efficient knowledge and idea transfer from artist to engineers and vice versa. The challenge of the artwork, for the engineers, was the fact that correct layer dimensions and precise forms do not guarantee the desired artist effect as by the artist vision. Understanding of the basic idea for the artwork, behind the artist impression and vision is crucial for possibility to succeed in this undertaking. Also new novel ways to work with the laser equipment have to be innovated and invented to reach the given goal. Thus, constant knowledge and idea transfer is needed between an engineer and an artist. Transfer of ideas and reflecting of learned experiences are also needed as technological and social innovations can only be developed interactively by mirroring and reflecting each other's personal work. This is essential for development and technology growth because unique, individual oriented or process oriented solutions are going to play a significant role in a continuously differentiating global life (for this, 3D printing and Uber work as nice practical examples).

The artist had some previous experience working with corrugated cardboard. He had cut thin 4mm thick boards by hands and with other cutting methods. To illustrate the buildup process time and current manual work process laboriousness, artist did show an example about the time it took to make "handmade" artwork. This previously made artwork, 2.2 meters high with 550 individual layers in total, took a total of 2.5 months to complete. In this practical example, thickness of one individual cardboard used to build the large artwork was 10 mm for one layer.

2. Methodology

This study approaches living lab style research with development style action research work in the science and R&D, as it is defined by (Tan et al. 2011): *"The Living Lab Research Approach (LLRA) takes a developmental view of innovation and studies novel technologies in complex real world settings"*. In this setting the environment was as defined in (Tan et al. 2011): *"Real world setting, involving multiple stakeholders from multiple organizations and their interaction" and so was the* goal too *"Joint collaboration to create a desired outcome"*. Artist was the lead user in the process, following the lead user definition by von Hippel (1986, 1988).

In this research, technical tools usability to transfer as a service offering in art context was part of the research setting. The art context was the artwork process and the artist-engineer collaborative in co-development process. Goal was to promote conditions of sustainability, such as high resource efficiency, art process orientation and intuitive comprehensibility of the concept. The action research method of the study allowed participants to collect research data and participate in ways that gave artist the needed freedom of creation. The people worked together as a team, improving the work flow models applied for artworks.

In the research process, action research had three stages (named as Stage 1, Stage 2 and Stage 3), which were also partially repeated. The stages are illustrated in Figure 1. In stage 1, a series of planning actions were initiated with the artist and researchers. In stage 2, actions were taken and research data from the actions was collected. Any new idea and learned "facts" from stage 2 were transferred back to stage 1 as feedback. Stage 1 was then repeated. After a chain of verifications and repetitions the results and new methods for artwork process, suggestions and findings of this study were collected in the third stage.

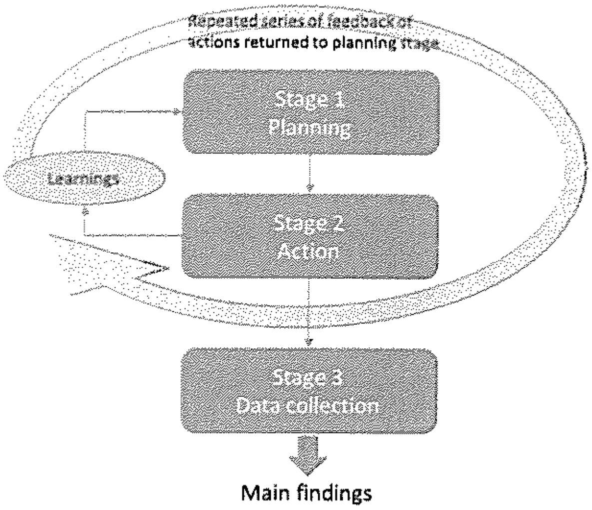

Fig. 1. Illustration of different stages in the research process

This process followed the way (Lewin 1946) defined the cycle of action research *"a comparative research on the conditions and effects of various forms of social action and research leading to social action"* that uses *"a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action"*. Two main elements were living lab style case and artist in charge of the design. These factors allow this research to contribute to innovation research area. Also because the collaboration motivation sources and demand for resource efficiency was part of the study, action research data was collected from behaviour processes with combination of personal and organizational learnings when co-operation between different parties in concrete context (Sanne 2002, Wenger 2007). This collection of understanding from collaboration motivation sources of participants was important element of the study. In fact the results of this study provide the knowledge in form of in-context and artist-centered research, where the motivation sources and collaboration success factors are revealed.

2.1. Structure

Artist defined that the sculptures had to combine several visual effects defined by the artists vision and impression needs. Some conceptualizations of these needs of the artist sculptures are shown in Fig.2b and Fig.2c. Fig.2a shows both the 3D model of the sculpture and 2D geometry of a single layer to be cut with laser equipment.

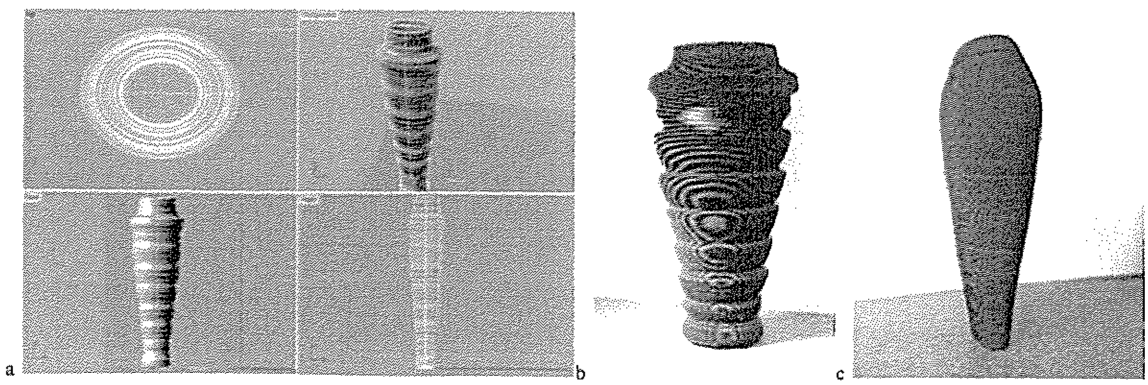

Fig. 2. (a) Models of the sculpture in 2D and 3D; (b) and (c) artworks cut from cardboard by laser (source: William Dennisuk)

To achieve the set goals in given time, participants had to find their inner motivation towards the process, as working outside of the office hours and also working outside of comfort zone would be required. Goal was to develop a simple and smooth process for producing artwork made from corrugated board by using laser cutting and by stacking the pieces on top of each other to form the final artwork. Designs were made by artist William Dennisuk† and laser cutting was executed at Lappeenranta University of Technology. This type of artwork allows the combination of deeply subjective expression and working with exact 3D design, so that the final result reduces the difference between the internal vision of the artist and the actual concrete artwork. Manual process would not allow as exact dimensions as what the laser cutting will do. This added precision, in the art build process, was one thing that ignited the artist's inner motivation towards working with laser technology.

From artistic perspective, the goal was to combine several different visual effects into an artwork. Each layer would have individual dimensions, to allow artist to achieve a continuous visual line along the outer shape. This would generate important "natural flow" like design into the artwork. By using corrugated cardboard as material, it would be possible also to add additional visual effects into the art work. Structure of the cardboard could result a visual effect of transparency when the sculpture was observed from a certain direction but from another perspective the sculpture would seem to be solid. Another desired effect was "shape within a shape", which would be technically achieved through cutting layers with both inner and outer shapes. Sculptures were designed as 3D models using Rhino software. The software was also used to slice the 3D models into 2D geometries of separate layers. As the layers had individual dimensions, layers had to be cut separately. Boards were cut with great attention to corrugated layer directions in order to obtain desired effect of transparency. Thus, natural wave structure of the cardboard was used as part of the process to achieve the design features and artistic impression of the art work. With laser cutting, a smooth cut edge was achieved. This was an essential advantage of laser cutting as mechanical cutting could have destroyed corrugated boards outer layer edge line and the transparency effect would not be achieved. In addition to the cut quality, the cutting speed of laser machine fulfilled the needs of the artist. Laser cutting allowed relatively fast changing of cutting geometries. In addition to mechanical aspects, as a small additional bonus for the artist, laser cutting allowed small fine tuning of the edge color for the cut line. Technically this was achieved by slightly adjusted the cutting power. Higher laser cutting energy resulted in stronger coloration of cut edge in card board edge.

2.2. Cutting procedure

In this research case, the laser cutting tests were carried out at Lappeenranta University of Technology (LUT) in Finland. Laser source of laser workstation was Trumpf TLF 2700 HQ CO_2 laser (wavelength 10.6 μm) which produces laser power in range of 160 - 2500 W. The cutting tests used a XY cutting table (see Fig. 3a.).

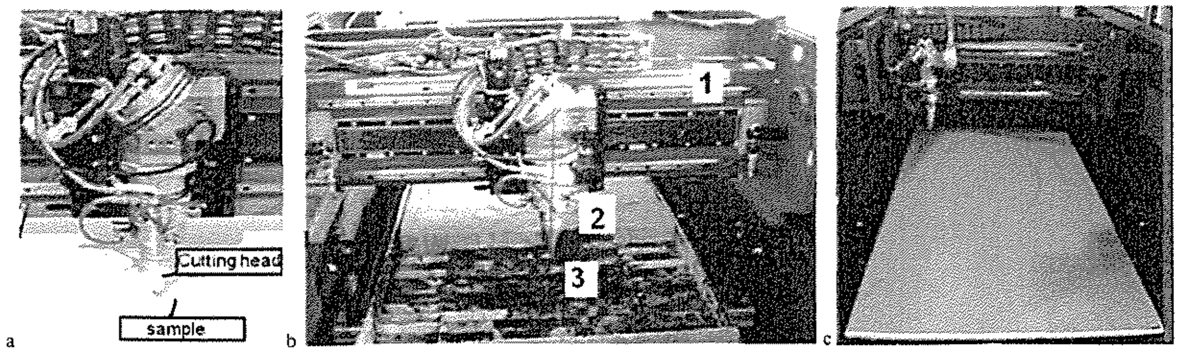

Fig. 3. (a) cutting head (b) Trumpf TLF 2700 cut station (1=laser beam, 2=cutting head, 3=cut table) (c) cut process of the cardboard sheet.

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† Artist explaining his visions about earlier artwork process. URL = http://playgallery.org/video/william_dennisuk_sculpture_on_the_huron/

Focal length of 127 mm (5'') was used for the cardboard cutting test. The cutting gas in these tests was compressed air (gas pressure 3 bar). Laser power of 250 W and cutting speed of 6 m/min was used. Cutting a layer could be accomplished under a minute. The set-up of the cutting process is illustrated in Fig. 3b. The 2D cutting geometry was converted into G-code for the cut station (with EngView software). G-code defined cutting geometry and main laser parameters such as cut speed and laser power. Cardboard sheet was placed on the table and the actual laser cutting was done for the given layer. After this, process is repeated layer by layer.

3. Results and discussion

The research revealed a constant need for communication between participants. For example there was a need to personally check and double-check on the site of the mechanical process the meanings of information provided through conversations, either via phone or by emails etc. It was found out that artist and engineers work with a different set of assumptions about the meanings of terms and information. For example, interpretations are different due to different backgrounds of participants. The differences in interpretation comes from the assumptions made by people where the assumptions are based on previous experiences, educational backgrounds and different set of meanings for known terms and use environments for any given tool. Because of these differences, a lot of communication between stake holders is needed, particularly in the beginning of the collaboration. A specific example game up in the early stages of the work. The situation started from small misunderstanding of the meaning of size of the XY cutting table and limits of the laser cutting machine. For artist, size of a table would determine the size and possible parameter range for the final sculptural form. With this information in mind, the artist designed first model of the artwork. Artist was given information that the cutting table had a width of 60 cm. A 3D drawing was developed and corrugated boards were ordered. Finally all 3D design "safety marginal" dimension adjustments were fit in this cutting table size limit. However, when the time came to make the cut, it was found that the machine had a cutting limit of 52 cm in width. So the actual design was wider than what the laser equipment would be able to provide as cut dimensions for the piece to be cut. This misunderstanding in specification was a setback that literally sent the whole process back to the drawing board. Considering this sort of examples of misunderstanding in communication, it is obvious that at least the artist and the cutting engineer should have met first on the technical site, to find the actual limits (width and length of maximum area the laser can cut without human intervention). With the ability to make questions and with the ability to test by using the actual machine, concrete testing would have revealed the true meanings behind the question and also behind the answers. In this case, it would have been also good to try to program the machine to cut outside the specified area limits, to see the actual limits of the machine and how it reacts into programming outside of the limits. Depending on these equipment limits, changes to design or programming should be undertaken. Table 1 summarizes most important findings made in this collaboration research, defined by the artist and interpreted from the motivation and from the process perspective.

Table 1. Benefits and observations defined by the artist.

Type of observation	Source of observation	Learnings
Challenge / Misunderstanding		
• Information recipient does not interpret the information in the same way as the information provider intended it to be. • In different cultures, e.g. summer vacations and other "time off" from the work can vary quite a much. • Skills to change the 3D model and vision of the artist to a real plane cut form with the cardboard material.	• Artist assumed cutting unit capabilities based on table width information given by engineer. The size limit difference proved to be costly misinterpretation in terms of time and cost of materials. • The delays in cutting and engineering work seemed to be a surprise for the artist. There seemed to be an assumption that because of the tight time table, summer vacation times would be re-scheduled. • In the process of changing the form to G-code and also in the process of cutting.	• If not 100% sure about the information, please ask for clarification. When you provide information, try to add visual clues to simple text expressions. Visual information reveals much more little details, which could hint recipient that something might be off. E.g. picture of the table with dimensions might have raised a question, is it possible to cut in extreme limits of the table. • You should have week, month and project level goals, which are known for every participant. This should help people to predict any delays somewhat before, not just in the event time. • Challenge was due the fact that there was no straight flow of dimensions. Tuning was needed on the way to obtain sculpture as it is desired. Also dimensions for the shape changed in process, if the artist saw interesting effect on shapes in middle of process. Again constant communication and fast experiments are needed, to lessen the effect of changes inside the process.
Benefit		
• Access to equipment beyond artists' means of working and "wallet size". • Working with people with different perspectives and technical knowhow. • Extend art out of its usual context to learn its potential to reach non-typical audiences and seeing art to have influence on areas outside normal domain.	• Working both directly and via telephone and written forms with people in the fields of technology. • The best situations were working directly with the materials and machines, where real knowledge surfaced.	• Explore as much as possible into the hidden assumptions in questions and answers. • When possible check in real-life situations, such as the functioning of equipment or how the equipment and materials interact. • These situations might be challenging, but they are also motivating as you know you are working in the limits of the knowhow, and as such you are building new knowledge, in both directions.

4. Summary of the findings

The artist summarized the goal for art was to be able to wrap up of accidental discoveries that come unexpectedly from work in process, the so-called epiphenomena. The unknown potentials or limitations of the process revealed or generated new directions and innovations for artwork as a whole. An example of that kind of epiphenomena in this project was the rather small cutting width capabilities of the laser equipment. This e.g. forced the artist to change a round shape into an oval shape. This change opened up the possibility of the object to have different characteristics from different view direction. E.g. different view angles design concept allowed more steep curves to be used as part of the overall artwork design. The steep curve produced a staircase like effect, which then exposed part of the surface of the corrugated board for the artwork viewers. For the spectators, this added a new and exciting visual dimension, which supplemented the overall development of the visual vocabulary of the material. The engineers and researchers summarize that in artist-engineer co-operation, one should be really ready to face the challenge of getting the view of artist to be executed as closely as possible. This is challenging due to the fact that in artistic artwork process, precise dimensions which engineers are taught to obey, do not play exactly as an important role for the artist, as what the general final outlook of sculpture does. Artist might give the dimensions quite exactly, but in the end, the visual result is all that matters for the artist.

To achieve the desired effect, constant contact between participants is required in order to discuss and test different ways to proceed in any challenging implementation situations. The collaboration with artist gives everyone new ideas and new views on technology, even for the technical people, as they learn new ways to go around the challenging technical limitations. E.g. new and non-standard solutions and application ways of the technology are required to achieve the expression goal of the artist. Example of this sort of non-standard procedures was also found in this study. In general engineering tasks special manual work is not that much required, since technologies and procedures are usually well developed and known. But when technology was applied in artwork case, which is quite far from common engineering cutting cases, known procedures did not apply, and engineers had to build new processes from scratch.

These differences between artwork and engineering item cutting can cause exponentially growth in need for time resource, as the amount of manual work increases heavily and amount of needed face-to-face communication time increases too. E.g. the changing of shape of the artwork in different layers meant that all separate parts of the sculpture had to be cut and programmed individually. For example, cutting parameters of the current layer could not be used as a template to generate the cut parameters for the next layer. The amount of work needed for modifications and double checks for correctness would have taken considerably longer time that what it finally took to define cutting parameters directly layer by layer basis, from the models made by the artist.

4. Conclusions

It can be concluded, that working with different knowledge area specialist (e.g. artist and engineers), gives possibility to produce new concrete findings from actual living lab collaborative learning environment. For example, in this case the artist was able to help the engineers to find out more details about the cutting equipment and offered new ideas e.g. how to go around of the limitations. E.G. the cut could be done in multiple parts to achieve one larger end result element that could not be cut using one pass cut method.

This sort of collaboration is challenging, but it also offers highly motivating learning experience and new motivating skills for all participants. The major part of the challenges, in this research process, was related to communication and these challenged surfaced from the assumptions made by participants. These assumption based challenges can be applied to wide variety of collaboration projects between multiple diverse parties, which in turn suggests that the lessons learned are valuable for wide variety of audience. For example, many people make assumptions about used terms, in daily basis. When they work in their typical working environment, with mostly with same people in daily basis, even when some people use terms in a "wrong way" others do know what they actually mean. When collaboration with new people, you do not have this sort of luxury. As such you generally should not use terms in lax ways. This is something, that is easily forgotten and in general it results miss understandings between people. When new experts of same field start to co-operate, they tend to notice these abnormal ways of using de-facto terms, from the context information, but e.g. in this re-search case, the artist and engineers did not have this sort of similar know how base with them and as such people could not use the context related ques about the real meaning behind the used terms.

As a rule of thumb, a conclusion was made that any distributed information should come with visualization or with extra information source references, whenever possible. Also it is not enough just to ask questions. There is also a need to explain why these questions are asked for. Procedure like this should quite dramatically reduce the need for added communication and shorten the chain of message exchange. The gains are achieved as the receiver of question is usually the expert and with the explanation why the question is asked, the expert is able to provide more deeper and detailed answer. These clear answers directly fulfil the gaps that would have otherwise surfaced from original answer and would have generally need additional questions to be answered. This sort of procedure in communication should levitate the noticed type of challenges in communication and also in the process all together as when the information is good, in general so are the actions taken based on the given information.

From process flow perspective, especially with strict deadlines and time tables, it is important to find highly motivated people into the development processes. Motivation can be really high, if you can find people into the process who will gain new knowledge and skills from the participation or people who are interested to learn from new things from the knowledge areas they have not been working with earlier. This should guarantee a growth of knowledge and skills, which seem to be one of the key success factors in these sort of challenging research and development efforts. In addition, as the purpose of this research was to find out the key success points in artist–engineer collaboration process. Given the finding on challenges in collaboration between artists and engineers, especially in regard of the communication and assumption based misunderstanding, it is easy to see how this type of research is valuable in providing starting point for new research questions. For example, how to achieve given goals and at the same time be able to manage the collaboration and communication when trying to learn new trough element of surprise. In addition, it should be researched how this artist engineer collaboration, in practical context, differs from e.g. service designer – engineer collaboration.

Acknowledgement

This study is based on TEKES funded project Incumas which was carried out in 2011-2013 and project iHub which was carried out in 2012-2014. Authors would like to thank all participants of these projects. In addition authors would also like to thank William Dennisuk for his interest towards doing art by assist of laser beam.

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