HARNESSING EXPERIENTIAL LEARNING ON REMOTE CO-DESIGN EXPERIENCES: 24H OF INNOVATION

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ABSTRACT

The Ecole de Technologie Superieure (ETS) organizes an annual international design competition, “24 Hours of Innovation”, with almost 850 university student participants from more of 20 universities in all continents. Students are given 24 hours to create an innovative solution to an industrial problem of their choosing, which provides an experiential learning opportunity in creativity and innovation issues. “24 Hours of Innovation” follows a charrette method. This method organises thoughts from experts and users into a structured medium in a way that promotes creativity and the generation of multiple scenarios in a quick period of time. This method is often used in co-design sessions in which a group of designers draft a conceptual solution to a design problem. This study analyzed how support collaboration between participants in different countries and promoting experiential learning. Particular emphasis was placed on ICT tools used by students to find and capture knowledge (e.g. from the web, from experts). Students made use of the Internet, groupware, computers graphic applications and cloud-computing systems during product design and development. Results show that the process of developing new ideas was not sufficiently supported by ICT tools. The data also revealed the important role played by social dynamics in teamwork during the process of peer-to-peer mentoring and learning from experts.

KEYWORDS

Co-design, distributed collaboration, peer-to-peer learning, design education, interactive design process, experiential learning.

INTRODUCTION

In this document, we discuss the Charrette method and some strengths and limitations of Information and Communications Technologies (ICT) environments during experiential learning of a design process. In our study, ICTs refer to a mean of support the process of generating,

collecting, storing, and sharing digital content needed to solve a design problem. In the following sections, we discuss on how the use ICT applications influenced participants to acquire and to share information. Our research team organized and analysed the educational framework of the 24 Hours of Innovation (24H). 24H is an international design competition created by the Ecole Superieure des Technologies Industrielles Avancées (ESTIA) in France and sponsored by École de technologie supérieure (ETS) in Montreal. The objective is to develop innovative solutions within a time frame of 24 consecutive hours.

CHARRETTE AS AN EXPERIENTIAL LEARNING METHOD IN DESIGN EDUCATION

Experiential learning theory defines learning as the process whereby knowledge is created through the transformation of experience. Experiential learning is the process of making meaning from direct experience [1]. The best known and most widely used model for experiential is proposed by David Kolb with Roger Fry [2]. The model consists of four elements in a learning circle that involves (1) concrete experience followed by (2) observation and experience followed by (3) forming abstract concepts followed by (4) testing in new situations. All this may happen in a flash, or over days, weeks or months, depending on the topic, and there may be a "wheels within wheels" process at the same time. In this model, students therefore learn "from the combination of grasping and transforming experience" [3]

Experiential learning requires no teacher and stems directly from an individual making sense or deriving a meaning from their direct experience. However, certain conditions need to be present. Student participants need to be highly autonomous and motivated – which is provided with the competition environment. In addition, for experiential learning to be truly effective, it should employ the whole learning circle described by Kolb: from goal setting, to experimenting and observing, to reviewing, and finally putting their plans into action. In this case, this involved students finding and implementing an innovative solution to the design problem they were presented with. This complete process allows participants to learn new skills, new attitudes or even entirely new ways of thinking [4-6]. In design education the workshop is usually the main teaching methodology. In the design workshop as educational space, students and teachers "recreate" a knowledge space of learning enriched by a reflective discourse. Our research team introduced the Charrette method. "Charette is an intensive, concentrated and deadline-oriented group confrontation and discussion technique applied to identify, analyze, evaluate and solve educational, organizational and community problems and needs" [7]. Charrette as an educational activity [8] encourages teamwork within R&D, timing or decision-making constraints. In this way, the Charrette method can be considered to be an effective interactive learning strategy. This sort of learning is typically sponsored by an institution – in this case, ÉTS. Student participation thus becomes a component in their professional education. Finally, experiential learning can occur individually and/or within social groups. In all cases, learners are able to construct firsthand a sense of understanding of the events going on around them. In this case study, experiential learning occurred in individual participants as well as within each team. This knowledge-based model was analyzed using two main approaches: task analysis of knowledge exchanged during the Charrette method and ICT applications used, this is explained in more detail in the Study Description section.

ICT IN EXPERIENTIAL DESIGN LEARNING: UNDERSTANDING STRENGTHS AND LIMITITATIONS OF ICTS TOOLS IN THE CHARRETTE METHOD

In recent years, particular attention has been directed at the convenience of ICTs in design collaboration [9, 10]. The set of technologies and tools involved are enabling great strides in expanding the coverage and flexibility of the design process. However, the exploration of and

questions concerning relevant and appropriate strategies for the effective integration of ICTs, as well as responding to the challenge of exchanging ideas and information in the early stages of the design process have yet to be dealt with. For that reason, we are now highlighting some strengths and limitations of ICTs tools. The strengths we consider in our study include the following (for more information about the strengths and limitations of ICT, please refer to Jiménez-Narváez, et al. [11]):

a) Interconnectivity between users and systems, *b) Immersion experience, c) Social interactivity through ICT, d) Real-time enhancement, e) Sketching and graphical interaction, f) Integrating distributed collaboration among peer-to-peer and with external experts.*

One of the pedagogical objectives of Charrette was to place students in a real design context. Students had to face the specific needs or demands of entrepreneurs and sponsors, and they had to learn to properly manage the design activities and handle the design process. Similarly, the design conditions of this interactive experience allowed educators to evaluate the level of responsiveness of their students faced with the intercultural situation of the participants. Figure 1 provides an initial framework to better understand how the structure elements were interrelated in the Charrette, as well as the strength of ICT applications during this early stage of the design process, see Figure 1.

On the other hand, taking into account the limitations of ICT tools for interactive design experiences, we can highlight:

a) Isolation, b) Scarce design application connectivity, interfaces not support teamwork, This study also addressed the question of: *Which ICT tools support knowledge acquisition and collaboration between participants in Charrette method? How do the strengths and limitations of ICT tools influence experiential learning in design?* To answer these questions, we began by analyzing the knowledge acquisition process. One of more useful approaches of knowledge acquisition analysis purported by Dalkir [12] consists of analyzing three knowledge acquisition phases: “identification, conceptualization and codification” (p. 117).

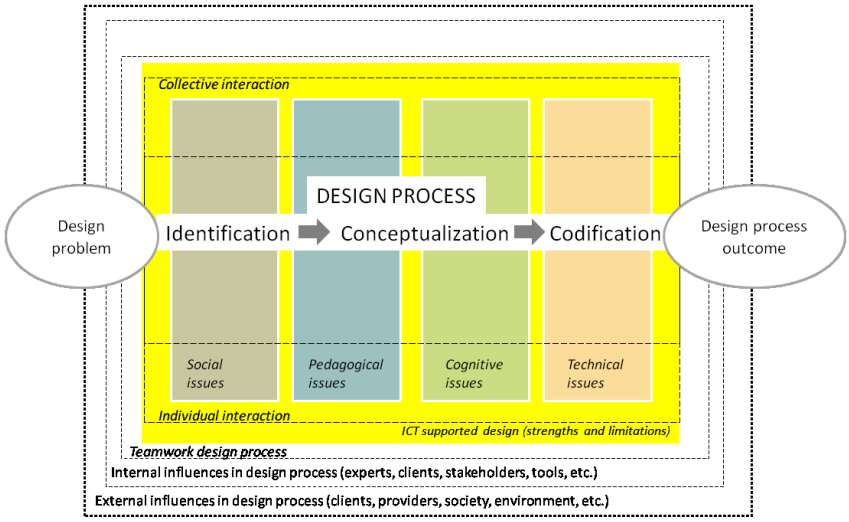

Figure 1. Systemic approach of knowledge using ICT tools in design process

Table 1 provides an explanation of each knowledge acquisition phase. The first phase, identification, refers to the process of characterizing key problem aspects such as participants, resources, goals, and existing reference materials (idem). In a design team, this phase allows teammates to analyze the project context and to also recognize constraints and limitations

identified by participants such as industrial stakeholders, market or consumer expectations and team members.

Table 1 Phases of knowledge acquisition, research questions and most used ICT tools on experiential learning

Phases	Process of knowledge acquisition	Most used ICT tools
Identification	What knowledge was needed to "capture" the context during the project?	Internet search engine Innovation reference sites Video conferencing Mind mapping applications Drawing software Photo**s**, images, and video tools
Conceptualization	How were the key design concepts defined by the team?	Internet search engine CAD software Office automation software
Codification	How was the new design represented by the team? (to be understand the new features inside and outside the team)	CAD software Photo**s**, images, and video tools Video conferencing Presentation software

In summary, we propose a knowledge-based model which consists of the identification of knowledge exchanges during the process of project development, while assessing the knowledge acquisition phases, as shown in Table 1. We present more explanations in the next section.

DESCRIPTION OF THE STUDY, METHOD AND PARTICIPANTS

Six institutions participated in the 4th International 24H Innovation Competition: ISA - École de l'agriculture, l'agroalimentaire, l'environnement et du paysage Lille – France, ISEN - École d'ingénieur généraliste en haute technologie ingénieurs Lille – France, UNIV-MLV Université Paris-Est Marne-la-Vallée - Ecole d'ingénieurs par apprentissage des sciences et technologies Paris-France, UTBM -Université de Technologie de Belfort-Montbéliard-France, UTC -Université technologique du Compiègne in France and Lycée Lislet Geoffroy from Reunion-Island – France, ETS – École de technologie supérieure Montreal - Canada. 24H. This competition took place in Quebec City, during November 22 and 23 in 2011 during the AMETVS conference: "Quebec Ground Transportation Cluster – Innovation Partnership, 2011". The research study consisted of an empirical study within the scope of analyzing the teamwork carried out by the 40 teams during the 24H competition.

Method of task analysis

Task analysis is the analysis of the specific steps involved in achieving a task. It is a detailed description that includes cognitive and psychomotor actions performed by a person as they carry out the task. Some of the details include: sequence of steps, duration, frequency, task allocation, complexity, environmental conditions, necessary prerequisites (e.g. tools). Task analysis is a form of applied behavior analysis and it is used to derive a job description, to recruit and select employees, to develop training for that task, to design support tools and

environments, to document procedures (e.g. produce a manual or checklist) and to automate tasks [13]. The results of as task analysis are often presented in the form of a model, typically a hierarchy, with the overall goal of the task on top and the lower-level steps on the bottom as proposed by Kirwan and Ainsworth [14].
The analysis of knowledge acquisition was compared with the use of ICTs during the competition. The initial project request was presented using the ETS license from the Cisco WebEx Meeting Center by Mickael Gardoni. He then received the industrial and academic proposals as well as the 20 minutes presentation summaries. During the competition, all participants were encouraged to question, discuss, and work remotely with academics, professional experts and companies in Canada, Belgium, Senegal and France. Skype was then used for meetings between industrial personnel and participants, also at the last period of the competition, international teams presented their projects remotely to the jury.
During the competition, we sent out online forms to all registered students who had agreed to participate in the research. This was an introductory questionnaire about some biographical information and teamwork experience, open-ended questions every two hours about which design process stage they were at, and what knowledge and tools they had needed and used. There were a total of ten forms, participants had to submit if they worked in that two-hour period. They then completed and submitted a final user satisfaction questionnaire at the end of the Charrette.
We studied three variables linked to the experiential process during computer-mediated interactions:
1) Visualization of the representation of ideas during the three stages of acquisition knowledge: identification, conceptualization and codification, proposed by Dalkir [12];
2) Information sources (cognitive and knowledge exchanged) used effectively by the teams for idea exchange demand (project proposals) or teamwork among team members and external experts, partners or sponsors;
3) Communication tools used during knowledge sharing stage.

Participants

Using ICT applications, every design team worked remotely from their host institution. As seen in Table 2, participants formed 40 teams of 3 to 9 members from a variety of design, engineering or business disciplines and universities. The 40 teams were challenged to come up with an innovative solution to a problem (creative challenge) presented at the beginning of the event[1]. They were then assessed by the manufacturers present, during the AMETVS event. Each team was presented with 25 innovative challenges and they could freely select one to work on, given members' experience, knowledge and/or interests.

DATA ANALYSIS

Biographical data

Approximately 250 students attended the competition and 142 agreed to participate in the research study. On average, 50% completed and submitted the questionnaires. Each participant filled out the form every two hours only during periods in which they were working effectively. As shown in Figure 2, participants were in a variety of different disciplines: 57% were undergraduate students and 37% were studying for their Master's degree. Approximately 50% responded that they had experience working at a distance and 69% stated they knew or were

[1] For more details, please see: Montreal version: http://etsinnovation.wordpress.com/2011/11/28/les-24-heures-de-linnovation-a-lets-les-gagnants-de-la-4e-edition-de-novembre-2011/
Bidart version: http://www.24h.estia.fr/index.php?lang=en

familiar with 5 groupware applications for project development. In addition, 73% said they frequently used from 1 to 5 groupware systems and 19% used more than 5 groupware systems. Most respondents were project development team members (69%) and 44% reported that had experience as a team leader. Students who had previously worked together tended to be on the same 24H team. 32% had not worked together for more than a year and only 19% responded that they had worked together for two years. 94% of participants reported that were comfortable working in teams, and almost 50% had experience in remote work.

Figure 2. 24H participants' biographical information

Internet and ICT tools as critical sources of knowledge acquisition for innovation

In general, there was a wide range of variation in the use of ICT technologies during the 24H competition, as see in Figure 3. Participants made use of Internet as a main tool for knowledge search and acquisition. The Internet was a source of information for innovation activities, and a tool for knowledge sharing. Participants used the search engine and information from patent databases as references to determine the "state of art" of the technology of the product that they were currently developing. In an open question about critical tools used in product development, respondents agreed that the Internet was a critical tool to arrive at an innovative solution (Figure 3). In other words, the Internet was the main tool used to conduct a technology watch and to obtain critical information about creative or innovative methods, as explained by participants. Technology watch is a "systematic procedure of capturing, analysing and exploiting useful information for strategic decision making in a company or organisation" [15].

The Internet was also used as the space where information about methods and organizational resources. The teams were interested in supporting their knowledge acquisition process by searching for information in Web Portals about innovation strategies and methods. For example, INNOKIZ http://www.innokiz.com/ offered to share information and project results with the industrial sponsors and the innovation information and methods were also made available for the organizational team at http://24hinno.wordpress.com/. In effect, the Internet and ICT technologies were important vehicles of knowledge acquisition and knowledge sharing because

they mediated the interaction (groupware), contributed to knowledge externalization (coauthoring or document production): sharing and retrieving documents and a easy visualisation (Portals), contributed to knowledge internalization by connecting training and resources between novices and experts (Learning Modeling Systems LMS), and finally, ICT technologies supported workflows, decisions and visualization of knowledge.

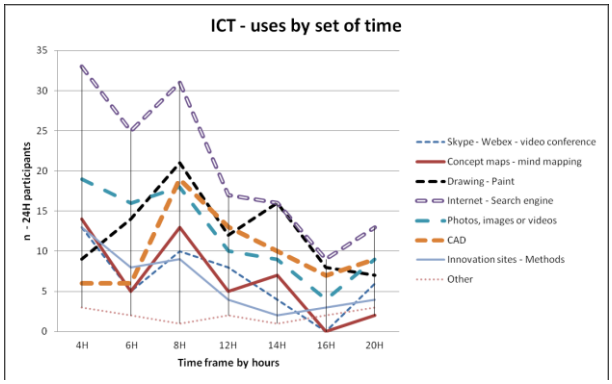

Figure 3 Tools and ICT technologies used by the 40 teams during a 24 hour period

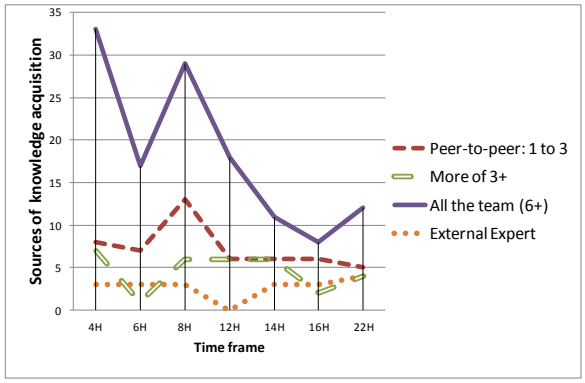

Figure 4 Social dynamics of information exchanges among team members and clients

As shown in Figure 3, 24H teams also used other platforms such as Skype, a Web conferencing service that includes a chat or SMS function allows rapid sharing of links and files. Cloud-computing services [16] and search engines, were used during the entire competition. They were used most intensively during the first 8 hours. The open-ended questions about the use of these technologies revealed that respondents admitted the need for synchronous tools to be aware of project progress and to be able to share digital information. Co-located participants showed other members their computer screen when they found interesting information or data. When team members were not located in the same place, they sent an email or instant message with the information obtained. However, this kind of information sharing had limits as it may be difficult to read and priority information could be lost. For this reason, teams preferred to coauthor documents in two ways: using GoogleDocs and sharing and working on a common document using DropBox.

The use of ICT technologies and the Internet in collocated and dispersed teams were also influenced by the social dynamics of acquiring and sharing knowledge which we analyze in the next section.

Sharing knowledge and information and knowledge interaction among teamwork members and other participants

In general terms, Knowledge sharing refers to the interaction and the social dynamic among teammates both as peer-to-peer relationships and interactions with external experts. We assumed that there are a strong correlation between knowledge sharing needs and the use of ICT technologies [17]. In the knowledge acquisition process, we hypothesized that this activity will be influenced by the social interactions, as observed in the exchange dynamic among team members shown in Figure 4. Inside the teamwork dynamic, we observed that each member is a source of knowledge (information and ideas) and decisions for the team. In Figure 4, we observed that the whole team works together during specific moments, at the beginning of the 24H Competition, at 8 hours and at the end of the 20-22 hour period. These data are useful to understand what the real dynamic of the teamwork is, because teams do not always work simultaneously, and the dynamic is supported by the work that occurs between peer-to-peer

subgroups of one to three members. Also, the information which comes from external experts (sponsors, clients and the organization board) was reported as not critical in achieving the innovation process, but it did contribute to maintaining the flow of the teamwork dynamic.

CONCLUSION

We observed that 24H teams were allowed to freely select their own information and communication tools, expect for the collaborative platform InnoKiz (Keys of Innovation), which was used mainly for the organizational board to manage and monitor design activities during the Charrete. As reported by the research results, 24H teams spent 67% of their time sharing document to describe the project concept. They preferred work in small teams of three or peer-to-peer, moving from individual work. The interaction with experts was limited and teams preferred consulting Internet.

The primary result of the study shows that participants preferred ICT applications to capture or share knowledge. According to participants, this was a success factor for evolving concept definitions and refining ideas during the design process. During the interactive learning experience, we observed continuous changes during the process. Teams produced simultaneous ideas, and then there were several modifications between peers (peer-to-peer relationships – see Figure 3 and 4). The capacity of storage of some ICT tools permitted team members to recall files and changes. At the same time, teams needed expert reviewing to validate concepts and refine the direction of the ideas. Teams reported a low interaction during all term with external experts. External experts were involved in the early and in the final processes (see Figure 4).

We can summarize some recommendations suggested by this study: a. Establish a clear object of study or a challenging design problem for the group of students, and close to the real world to maintain sense making, motivation, and collaboration towards knowledge acquisition. b. Identify the strategic direction of projects on each group of participants from the initial stage, and its evolution during the charrette. c. The need that all team members have appropriate computer skills in handling ICT tools selected for the charrette of design.

The interest of this article was not to model the entire design learning process, but rather to describe the type of knowledge acquisition during three specific stages: identification, conceptualization and codification. Also, we identify ICT applications that have to be put in place to support experiential learning for design education. The analysis of these conditions can lead to more effective knowledge acquisition and sharing during the Charrette method. We conclude that interactive learning requires ICT tools that allow designers to manage knowledge acquisition processes involving actors, communication platforms, and the Internet. The social interaction during the competition varied during different time periods: when the team worked all together at beginning of the event and at the end. The knowledge acquired during the interactive learning was fragmented by three conditions of peer-to-peer interaction: 1) a large number of information exchanges among participants during the initial stage of problem definition, 2) a social dynamic among peer-to-peer, team and external experts, and 3) a large quantity of media/tools used to acquire, produce, represent and share the knowledge of experiential design learning.

In further research, we will focus on defining the pedagogical relationships between actors and ICT tools in experiential learning conditions, and also define the knowledge management system that could support all the interactions in accordance with the nature of iterative teamwork.

REFERENCES

[1] C. Itin, "Reasserting the philosophy of experiential education as a vehicle for change in the 21st century," *Journal of Experiential Education,* vol. 22, pp. 91-98, 1999.

[2] D. A. Kolb and R. Fry, "Towards an applied theory of experiential learning," in *Theories of group processes*, C. Cooper, Ed., ed New York: Wiley, 1975.

[3] D. A. Kolb, *Experiential learning: Experience as the source of learning and development*. New Jersey: Prentice Hall, 1984.
[4] S. B. Merriam and R. G. Brockett, *The profession and practice of adult education : an introduction*. San Francisco: Jossey-Bass Publishers, 2007.
[5] J. A. Moon, *A handbook of reflective and experiential learning : theory and practice*. London; New York: RoutledgeFalmer, 2004.
[6] S. W. Weil and I. McGill, "Making sense of experiential learning : diversity in theory and practice," in *International Conference on Experiential Learning,*, Guildford, England, 1989.
[7] Bureau Translation Canada. (2011, 10 Jan 2011). *Termium plus*. Available: http://www.termiumplus.gc.ca/
[8] J. Kolko. (2005, New techniques in industrial design education. Available: http://ead.verhaag.net/fullpapers/ead06_id115_2.pdf
[9] Y. E. Kalay, "The impact of information technology on design methods, products and practices," *Design studies.,* vol. 27, pp. 357-380, 2006.
[10] W. Shen, Q. Hao, and W. Li, "Computer supported collaborative design: Retrospective and perspective," *Computers in Industry,* vol. 59, pp. 855-862, 2008.
[11] L.-M. Jiménez-Narváez, A. Segrera, and M. Gardoni, "Opportunities and Limitations of the Cloud Computing Environment: In the Early Stage of Design Process," *International Journal of Designed Objects,* vol. 6, 2013.
[12] K. Dalkir, *Knowledge management in theory and practice*. Cambridge, Mass. [u.a.]: MIT Press, 2012.
[13] B. Crandall, G. A. Klein, and R. R. Hoffman, *Working minds: A practitioner's guide to cognitive task analysis*. Boston: The MIT Press, 2006.
[14] B. E. Kirwan and L. K. Ainsworth, Eds., *A guide to task analysis*. Philadelphia: Taylor & Francis, 1992, p.^pp. Pages.
[15] J. Legardeur, J. Boujut, and H. Tiger, "Lessons learned from an empirical study of the early design phases of an unfulfilled innovation," *Research in Engineering Design,* vol. 21, pp. 249-262, 2010.
[16] A. Zika-Viktorsson and A. Ingelgård, "Reflecting activities in product developing teams: conditions for improved project management processes," *Research in Engineering Design,* vol. 17, pp. 103-111, 2006.
[17] P. Gottschalk, *Strategic knowledge management technology*. Norway: Idea Group Publishing IGP Global, 2005.

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