HCI Education: Innovation, Creativity and Design Thinking

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Abstract—**Human-Computer Interaction (HCI) education needs re-thinking. In this paper, we explore how and what creativity and design thinking could contribute with, if included as a part of the HCI curriculum. The findings from courses where design thinking was included, indicate that design thinking contributed to increased focus on innovation and creativity, as well as prevented too early fixation on a single solution in the initial phases of HCI design processes, fostering increased flexibility and adaptability in learning processes. The creativity and adaptability may be the best long-term foci that HCI education can add to its curriculums and offer to students when preparing them for future work practices.**

Keywords-HCI; innovation; creativity; design thinking; education.

I. INTRODUCTION

It has been argued in favor of purposefully managed innovation through design and creativity in many different ways [1]. Design thinking is one of those options. Understanding design thinking is not straightforward. In [2, p. 13], three different ways (of understanding design thinking) are offered: as a cognitive style, a general theory of design, or as an organizational resource. The latter understanding lends itself well as an approach to innovation and real-life problem solving through human-centered design, employing empathy with users, rapid prototyping and abductive thinking as its main components. This understanding of design thinking has strongly impacted the innovation in business, education, health and other crucial domains [3]–[7]. Many examples of how businesses and organizations could benefit from incorporating design thinking into business and organizational processes were given [8], making design thinking into an efficient innovation engine emphasizing observation, collaboration, fast learning, visualization of ideas, rapid concept prototyping, synthesis and concurrent business analysis.

However, no approach solves all problems. Thus, just some years after the design thinking made a breakthrough in the world of business strategy and management, its limitations were brought forth in works such as [9], [10]. The point made by Nussbaum in [11], though, hits home best: *"From the beginning, the process of Design Thinking was a scaffolding for the real deliverable: creativity. However, in order to appeal to the business culture of process, it was denuded of the mess, the conflict, failure, emotions, and looping circularity that are part and parcel of the creative process. In a few companies, CEOs and managers accepted that mess along with the process and real innovation took place."* In short, the core of innovation is creativity, a messy and unstructured process. By framing design thinking in a particular way, the creativity became limited, leading, in turn, towards failure to innovate.

Concerns are voiced around the failure of design processes currently applied within the field of HCI to support more radical innovation [12]. In particular, HCI design processes are held to lead mainly to incremental innovation and small changes. Innovation, of any kind, is a much more complex process than design and invention of new products, systems, or interaction modes. It also implies their acceptance and use by people [13]. Upon careful consideration of design practices within HCI, one could argue that the invention is common. However, a very small percentage of those inventions (prototypes) ever become finished products and even smaller percentage gets to be adopted and used, see [14].

Preparing today's students of Human-Computer Interaction (HCI) for tomorrow's work practices is challenging. The technologies, interaction modes and interfaces all change fast. In addition, there are rises and falls of techniques in use, design processes, work practices, software and platforms in use.

Students, on one hand, need to learn appropriate theories and research methods, understand the state-of-the-art research, importance of scientific rigor and relevance. However, being a profoundly inter-disciplinary field, HCI does not offer any unifying core theories, so this goal is hard to achieve once and for all (in other words, new application domains require acquisition of new theoretical knowledge, what the state-of-the-art research is, etc.).

On the other hand, students need to be able to design new technologies and interfaces, using design processes and methods. This is also hard to achieve without any formal training in design, which is, in part, why design processes in HCI often depend heavily on engaging users and other stakeholders, thus sharing the responsibility with them for success or failure of a designed prototype. The latter is not seen as problematic, as prototypes are often not intended to become artifacts, but are tied to the research objectives.

Combining insights from our previous work [12], [14]–[16], this paper argues that teaching about innovation, and engaging students in creative innovation processes such as the design thinking (with acceptance of the messy parcel of creative processes [11]), offers one possible answer to what kind of knowledge and skills the students could be taught in

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HCI. Adoption of this approach may be successful in a long run because, while on the road to becoming an innovator within a design team, one usually experiences creativity (one's own or that of others) and a need to be adaptable to series of new situations. Creativity and adaptability may offer a greater permanent value to human-computer interaction students than many other kinds of knowledge and skills commonly considered to be part of the HCI education. As reported in [15], all ten students in a graduate HCI course that made use of design thinking processes, perceived themselves as non-creative individuals at the beginning of the course. At the end of the course all, except for one student who felt neutral, stated that the design thinking affected them and that they see themselves as more creative and confident in their skills. A new survey was conducted at the end of a combined bachelor-master course in the fall of 2014. All design teams who participated in the class filled the survey (18 teams consisting of 3-4 students each). They all said that they thought that HCI design is a creative process, and provided qualitative statements related to their experience of individual and group creativity. Some of these are presented later, in the discussion section of this paper.

In summary, the question this paper tries to answer is: what kind of knowledge and skills should be passed onto new generations of HCI designers and researchers? While the whole solution remains elusive (many discussions around what HCI curriculum are already going on [17], [18]), our experience from the past two years of including design thinking and innovation in the curriculum shows that these benefit HCI students significantly.

The paper is structured as follows: the next section offers some thoughts as to why HCI education should include innovation and creative thinking. In Section III, the concrete case is presented of how these elements are introduced within a mixed bachelor-master HCI course. Discussion of the case is presented in Section IV, followed by the conclusion in Section V.

II. FOCUSING ON INNOVATION

The ACM SIGCHI Curricula for Human-Computer Interaction defines Human-computer interaction as "a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [19]. Teaching HCI typically includes teaching of user-centered requirement analysis, design and prototyping, implementation, design of experiments and evaluation. HCI's interdisciplinarity brings in tensions between the breadth and the depth of teaching, diverse theories and practices, including the basic choice between contributing to science, or to design (of new interfaces, products, services or interaction modes). Despite tensions, HCI education is very much alive and doing well in practice, although, still without generally agreed upon curricula.

Innovation, on the other hand, is known to be hard to achieve in practice, while it is very easy to understand the need for it and the benefits it brings [20]. There are various ways to define innovation. Oslo Manual [13] defines it as: *"the implementation of a new or significantly improved product (good, or service) or process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations."*

It is difficult to teach students to be innovative, creative and inventive. It is not easy to make good frameworks for doing so. The processes related to innovation rely a lot on creativity, but also on both existing knowledge and on technical skills that are already present among the members of the design team and those whom they chose to include in the design processes. In particular, it is hard to define learning outcomes for such processes.

Within HCI, the creativity bit is usually, at least partially, bypassed by two things: framing of the process as a procedure that all can follow on one hand, and relying on understanding of users and their needs on the other hand. It is, thus, usual to develop understanding of the knowledge domain first, and then this understanding is put to test through practical work involving a prototype design, evaluation, and the re-design cycle. However, creative problem solving, a core activity of innovative design [3], [4] is, as mentioned, harder to frame.

Design thinking is but one facet of design. It employs, in part, similar steps to those often proposed in HCI: it frames its process in ways that have familiar overtones to those used in HCI, see Fig. 1.

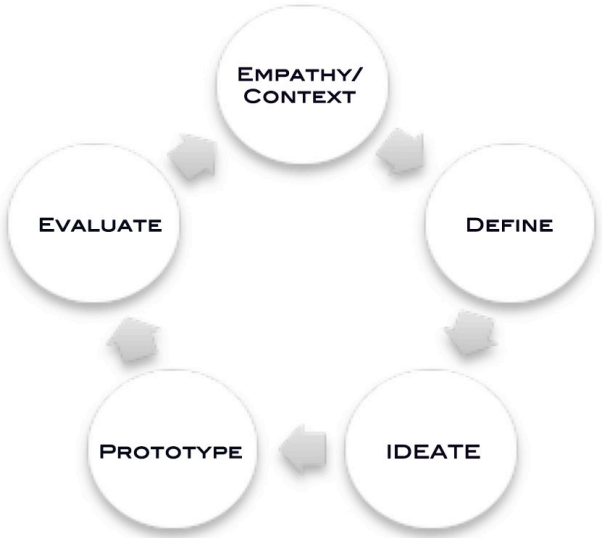

Figure 1. A process that may seem familiar to HCI students, as well as to those using design thinking.

Arguably, differences between design thinking and HCI must be sought by other means than comparing high-level design processes. One needs to consider differences in assumptions, scope and aim of the design process – concerning, for instance, the role of research, requirements specification, questioning assumptions, the consideration of organizational issues, the systematic exploration of design alternatives. Design thinking stands firmly on three main pillars: empathy with users and human centeredness, rapid prototyping to generate large number of alternatives in order

to solve the right problem rather than a problem right (the creative part), and last, but not least, their synthesis leading to best viable and feasible solutions that incorporate desired values [6]. IDEO [21], a design and innovation consultancy, has made a 60 minutes version of the process shown in Fig. 1. Even though the process appear to be simple and short, its power rests in its capacity to initiate deeper engagement with the problem space, that may last over time in some other form.

As mentioned in the Introduction, HCI students need to master numerous and diverse types of knowledge and gain practical design experience. Why make teaching of HCI even more complicated by introducing a creative proposition through design thinking and innovation explicitly?

III. THE CASE: TEACHING HCI WITH A CREATIVE WREE

A. Previous Classroom Experiences with Design Thinking

During the fall semester of 2013 two student project teams from a combined bachelor-master course in interaction design were introduced to design thinking. These teams worked with service design in the context of the University Library. They were given additional design thinking workshops, using service design cards and customer journeys as tools [22].

In addition, during the fall semester of 2013, a small graduate course of ten students, mentioned in the Introduction, adopted the design thinking approach and the studio based teaching. There, three student groups were taught about design thinking and focussed explicitly on nurishing creativity [15], [16]. They also were requireld to read articles like [23]–[28], in order to gain deeper understanding and knowledge of research through design, and design-centered research. In addition, successful examples of applications of design thinking were discussed [6], as was the work on reflection over the design practice as well as possibilities for understanding daily living practices as a design material, e.g., [29], [30].

Experiences from both classes indicated strongly that cultivation of creative thinking and making has a potential in teaching of HCI.

B. The Course Setup

The teaching approach that we argue for here is carried out within the combined bachelor-master course in interaction design. The course in question teaches traditional HCI research methods [31], and has two prior HCI courses as prerequisites. In addition to teaching research methods through lectures and small group learning sessions, the course aims to address the real-world problems, by offering a semester-long project in cooperation with external, local organizations. Usually, the class leadership involves ten or more organizations, soliciting two distinct proposals from each [32]. Students then form design teams and select one of the proposals, based on a first-come first-serve basis. The project work is, thus, anchored in a real need of some local company or organizations. Sometimes this need is not clearly formulated, rather, the company wishes to renew its offerings and they ask for new, open, creative solutions. Students may experience such open requests as intimidating at the start, as indicated by the fact that problems with narrow scope and clear goal tend to be selected first, while explorative problems are chosen last.

The students in the course are further supported (or challenged) in their learning efforts as follows: they are free to make mixed master-bachelor student groups, but master students need to read, understand and be able to use in their project previously published research in the domain that their projects cover. All teams have a regular, hour-long design feedback sessions during the conceptual design and prototyping phases of the project. A senior researcher and a representative of a company for which the students are designing participate in these sessions. In addition, all groups make an in-class, mid-term, presentations of their design efforts. The presentations are open to anyone from interested organizations, other faculty members, professional designers and any other relevant parties, sometimes also younger students. All present could give constructive feedback to presenters.

The course ends with the best project design competition. An independent jury of three HCI and design professionals judges the contest. The criteria for the jury are novelty, clarity of presentation, a potential impact of the designed prototype (relevance), validation of the prototype with users and overall design. This exact setup has been run for three consecutive years and has included surveys at the end of the semester. The surveys were individual and optional previously, but this last year they were focused on cooperation with the industrial partners, innovation and creativity, and thus were conducted in teams (team members were filling the survey together, having enough time to discuss and agree (or, sometimes not) on a common point of view.

Although the course addresses real-life problems, which would be typically solved by multidisciplinary teams within professional circles, this was not always possible to achieve in the context of the course. In other words, despite the presence of the senior researcher and company representatives, teams were not truly multidisciplinary, although, some teams came close. For example, some students had background in psychology, some in graphic design, others in arts. In such cases, they were encouraged to understand the assemblages of skills and knowledge that they had within the group, organize work so that their skills could be well used, and focus on knowledge production forms from which the team could benefit the most.

C. The Use of Creative Thinking and Innovation

The teams were free to choose and follow an approach of their choice, as long as they complied with general course requirements, as described above. The challenge was how to support best creativity within each team. A lecture on creative thinking and design thinking was given at the start of the course, introducing concepts of assemblages of skills and practices. The idea that one can design a set of practices that support creativity was introduced. These were further

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practically demonstrated and re-enforced during design sessions.

In addition, all external opportunities were sought and used to motivate students. For example, every year, during the fall semester, the dean of the University offers his annual innovation challenge to all the students at the University of Oslo, whether they study science, politics, social sciences or entrepreneurship. The challenge runs through several selection processes, until the winner is chosen among the best projects that made the final round of selections. The student teams in the course were strongly encouraged to participate. Two teams took up the challenge. This has, in addition to the usual interaction design course work, involved making a financial proposal and a business plan for implementation of the proposed innovation. Both teams made it to the final round. Judged entirely independently during the final competition for the best project in the course, they won the first and the third place.

The two student teams consisted of four second year undergraduate students each, and were supervised by a PhD student whose research relates to elderly living in a smart house. Thus, both projects address design for and with elderly, see [33] and [34] (both projects were delivered in Norwegian, but one group also posted the abstract in English of the paper that they are writing for HCII 2015 conference [35]). The latter project, see Fig. 2, developed a high fidelity interactive prototype utilizing frequency based technology (iBeacons) that helps elderly with cognitive difficulties to navigate complex buildings indoor.

Figure 2. SmartWalker: design and testing. Photos from [34].

Clearly, the effective use of the smart-walker requires mastery of the technology, but enables self-management to an increased degree, for the users that it is designed for.

The second project [33], see Fig. 3, focuses on self-management and bodily mastery [36]. The solution is based on a motion sensor (Kinect), and tracks exercises needed for bodily mastery and maintenance of the physical ailments.

Even though these two groups have achieved very nice results, they were certainly not the only ones that pursued the goal to be innovative and creative. Different ways in which this focus on creative thinking and innovation affected the work of the project teams is discussed in the next section.

Figure 3: An exercise system that enables correction of movements during the exercise session. Photo from [33].

IV. DISCUSION

The contextual differences among briefs presented to students by organizations that participated in this educational endeavor were substantial. Some teams were required to find new application domains for existing technologies, others to design new applications involving new technologies, yet others had to use old applications and old technologies, but find new ways of working with them. For example, a team had to work with the latest technology such as Google glasses and their potential use in crises situations by police or paramedics. Another team had a complex web-based software used in the oil industry that required creative thinking around how to help users to customize it. The vast majority of teams benefited from being inspired by at least one of the three main components of design thinking: empathy with users, rapid prototyping, or abductive thinking. The use was never enforced, so teams could choose to use any component of design thinking, none or a combination of design thinking with other practices used in industry. Reflecting on possibilities and knowing why design process (for any given project) involved certain tools, techniques, and methods, was required.

Empathy is a multifaceted construct that includes emotional recognition, vicarious feeling, and perspective taking [37]. Empathy was ‘new’ for many HCI students. While students were used to conducting user studies, they seldom tried to take the place of a user themselves and develop empathy with users in that way (through role playing, for example, in the wild). This might, in part, be due to the perception that by including personal experiences, subjectivity in the study would increase. Another reason might be that the phenomenological perspective, a characteristic of the latest wave of HCI, is still lagging behind in education. Regardless of the reason for empathy’s ‘newness’, once tried, the students understood its benefits and could apply it creatively when working with conceptual development of their solutions. For example, a team needed to make a product that could be used in the children’s hospital waiting room. Being an emphatic observers in the particular hospital’s waiting room brought insight that, whatever they were to make, it should be quiet, it should not pass germs around, it could engage others, but should be fun, and OK, to interact with it alone. The result of this team’s design and research efforts, a Leap motion controlled

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water fountain with LED lights, was fun to play with, had a pleasing, very soft sound of water and was nice to look at, see Fig. 4 and [38].

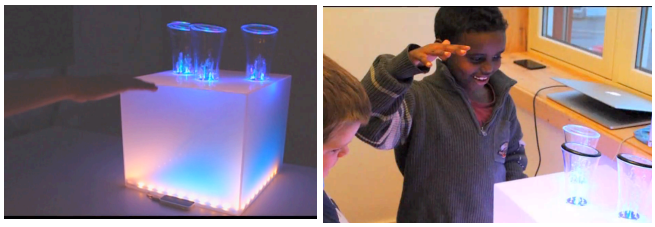

Figure 4. The water fountain project that uses LEAP motion to control the level of water. Photos from [38].

Rapid prototyping was frequently used. Students found that it enables easier communication of ideas, in particular across groups with different backgrounds and levels of knowledge. In one particular case, design meetings were attended by the student design team, a course instructor, a PhD student in interaction design, and a rather large, very interested group of library employees (between 5 and 8 persons at each meeting) with diverse backgrounds. Using pen and paper or tangible items such as service design cards for rapid ideation and construction of customer journeys was found to be helpful in such situations. Visualizing customer journeys using service design cards was valuable for creating a common understanding of certain services as they are today, and discussing points that offer opportunities for design interventions in order to improve those services. Unfolding one of those opportunities further was then undertaken using a workshop format, where all participants focused on producing as many rapid prototypes as possible, fostering good discussions around feasibility of solutions. The library experts could at once provide information on existing solutions and how the proposed new solutions could (or not) fit with the existing ones.

The last pillar of design thinking, abductive reasoning, is related to being able to synthesize solutions and optimize design, seeking to find the best option given the series of constraints. This is something that comes easier to people in design disciplines, rather than those using analytic way of thinking. Yet, some projects, among them the above mentioned [33], clearly show the ability to use synthesis.

At the end of the semester all teams filled a survey, providing 18 sets of answers. There were two questions related to creativity:

1) Do you think that the kind of work you did in this course is also creative?
2) What do you think about group creativity?

All teams answered the first one in affirmative. As for the second question, here are some of the answers (the answers were given in English, as presented, only the very last statement was translated from Norwegian): *"It really helps. Quite often you have some ideas, but you need help to be able to explain them. So in our group we really understood how each other was thinking, and we could really help each other describe and realize our ideas and creativity."* Another team expresses it as follows: *"We have a group of different people with different ways of thinking, stirred together in a creative pot, it's awesome"!* The third considers that the *"group work increases creativity"*. The two most cautious expressions were the following two: *"We feel that the group works very well together, although this experience may vary"*, and *"Very good! Perhaps a bit too creative and ambitious"*.

V. CONCLUSION

The aim of this paper has been to inquire into the interplay between innovation, design thinking and creativity as educational channels that stand out as alternative or complementary to the ones traditionally used by HCI educators. The framework for learning about innovation, design thinking and creativity was introduced and explained. This setup has been repeated for the past two years and may be repeated by others. The concepts that have been helpful in cultivation of creativity were assemblages of skills and practices within multidisciplinary settings, empathy, rapid prototyping and abductive thinking. At the same time, care was taken not to reduce working with them as a specific procedure. Rather, tools, methods and techniques needed to be reflected over, and chosen in accordance with the problem at hand. Experimenting, or at least negotiating choices of research methods and techniques, was encouraged.

Further research is required regarding other frameworks and best practices for supporting creativity and innovation in HCI curriculums, including a comparative analysis of outcomes.

The achievements and learning outcomes in the here described course kept improving over the period of the last three years, as frameworks for supporting innovation and creativity got better and clearer described. The students' understanding of processes has also increased over time. The findings indicate that design thinking contributed to increased focus on innovation and creativity, as well as kept design processes wider and open for a longer period of time, fostering increased flexibility and adaptability in learning processes. The creativity and adaptability may be the best long-term goals that HCI education can add to its curriculums when preparing students for future work practices.

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