

# EDUCATED BY DESIGN - LEARNING BY DOING - OUTLINE OF A HCI-DIDACTICS

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**SUMMARY:** *What is the right mix of workshop-learning and lectures, e-learning and face-to-face dialogue in teaching Human Computer Interaction at university level, where academic reflection is supposed to go hand in hand with learning basic skills in interface design and usability testing? A didactic pattern for teaching Human-Computer Interaction is outlined based on experience from a course in Human Computer Interaction taught by the author for three consecutive years at Information Studies at Aarhus University. The pattern is based on the paradigm of experiential learning, and inspired by the tradition of Moholy Nagy's design curriculum for New Bauhaus in Chicago. The pattern is intended as a tool for the teacher when to determine what type of knowledge to convey in what mode of interaction, in what kind of setting in order to help the learner to develop as much of a competence as reflective practitioner as possible.*

**KEYWORDS:** *human computer interaction, undergraduate course teaching, didactics, experiential learning, reflective practitioner*

## 1. COMPETENCE IN HUMAN COMPUTER INTERACTION TAUGHT AS EXPERIENTIAL LEARNING, AND THE CONSEQUENTIAL DIDACTICS

Human Computer Interaction (HCI) covers from tactile interaction with the keys on a keyboard and sensory impulses from movements on a screen to the social interaction among people who use the same mail system or the same content management system, or who are playing the same computer game. The keyword is interaction and this word has been conceptualized in many important ways by academic scholars in the field of Human Computer Interaction in the course of the evolution of the task-artifact cycle first pointed out by Carroll (1991). Since the interaction sits at the center and the technology keeps opening new doors of opportunity, while the human condition as a cognitive social realm stays more or less the same, teaching HCI cannot be founded solely in the workings of the technology.

Humans 'deutero-learn', as Bateson (2000) expressed it, meaning that we learn habits of learning while we are busy learning whatever specific chunk of knowledge or skill. Whether the curriculum is about learning how to test a specific computer interface or about learning how to design it, the teaching includes a mode and model of behavior, which inevitably will spill over to the learner's way of solving the same sort of problem in future situations. Hence, the goal of teaching does not justify the means. Because, if learners reach a goal by means of bad behavior, the bad behavior may stay with them, also when a initial achievement has faded away completely. The *way of learning* must therefore be at the center of interest for all teachers, including those of Human Computer Interaction: it is not the quality of the varying outputs per se, it is the way the students arrive at an outcome that qualify them for future design tables. The challenge is to make sure that the way the students acquire their knowledge of HCI is in coordination with the kind of competence they are supposed to develop.

The dissemination of Donald Schön's book 'The Reflective Practitioner' into the curriculum of HCI courses and the degree to which his work is cited in HCI papers indicates that he has managed to set a standard as to the sort of competence which is required by academics in fields of engineering and design. And his view is supported by a number of scholars from Alexander (1964) to Simon (1996). It is, however, not easy in a traditional university environment to realize the ideal of teaching students to become reflective practitioners: Oral lecturing and paper based evaluation, university buildings laid out as auditoriums and classrooms, and teachers trained to work in the classical university environment presents a challenge, and so does the didactic paradigm. This paper is the beginning of my quest to found a coherent pattern of explicit knowledge and techniques of the field of HCI weaved with ways of teaching, the outcome of which will tentatively form a basis for the students to eventually

become reflective practitioners within this field. At the root of this endeavor lies of course the choice of didactics, and here Kolb's experiential learning paradigm (Kolb 1984) seems right at hand as inspiration.

First of all, Kolb has demonstrated that there is an important link between undergraduate teaching and the development of future expertise: *'undergraduate education was a major factor in shaping individual learning style, either by the process of selection into a discipline or socialization while learning in the discipline, or, as is most likely the case, both.'* (Kolb, 1984, p.125). Second, Kolb asserts that integration of personal experience and handed down experience is the way to prepare the learner to move from one state of competence to the other, and he suggests this integration to be shaped as guided shifts between externalization and internalization of experience: *'learning, and therefore knowing, requires both a grasp or figurative representation of experience and some transformation of that representation. Either the figurative grasp or operative transformation alone is not sufficient. The simple perception of experience is not sufficient for learning; something must be done with it. Similarly, transformation alone cannot represent learning, for there must be something to be transformed, some state or experience that is being acted upon.'* (Kolb, 1984, p. 42).

While Kolb is dealing with individual learning and sticks to the standards of psychology as a science, Nonaka & Takeuchi (1995), coming from a philosophical background, present a more pragmatic approach. They focus on how tacit and explicit knowledge merge into creation of new knowledge in organizations. They argue convincingly to view knowledge as both epistemic and ontological, both an act and an object, both explicit and tacit. Knowledge creation happens, they claim, when knowledge travel from one state to another out of four in what they term the 'knowledge spiral', each conversion forming a characteristic social situation 1. tacit to tacit as *socialization*, 2. tacit to explicit as *externalization*, 3. explicit to explicit as *combination* and 4. explicit to tacit as *internalization*. This framework has become widely accepted as a platform for strategic consideration in learning organizations – not to be followed as a recipe, but as a thinking tool to help planning intervention and considering change. Change itself, Nonaka & Takeuchi emphasize again and again, is a process, situated, practical, and not to control, but to guide. Their emphasis is on the contexts of learning, and they hypothesize that tacit knowledge is shared through the creation of a field of interaction, followed by an externalization mode triggered by meaningful dialogue or collective reflection; through networking newly created knowledge and existing knowledge from other sections is combined and crystallized into new things, whereby the actors learn by doing. This 'knowledge spiral' resonates with Kolb's idea of learning through socialization via apprehension (concrete experience) followed by transformation via intention (reflective observation), followed by grasping via comprehension (abstract conceptualization), in turn followed by transformation via extension (active experimentation) into accommodative knowledge, the kind of knowledge that academic education strive for, because here lies the springboard to development of knowledge of a higher order, and thereby ability to both generate and reduce complexity, a hallmark of academic excellency.

Based on analysis of an undergraduate course in HCI, designed to scaffold knowledge creation, this paper outlines a first draft of a way to weave explicit knowledge and techniques of the field of HCI with ways of teaching into a pattern for experiential learning of HCI.

The basic pedagogic idea deployed to implement this didactic paradigm is that of a dedicated place as the fundamental prerequisite for the different modes of learning to take place. Behind this idea is the phenomenological notion of space as power over space (Christiansen 1997): a place can contain you, it is a place to depart from and come back to, and it is a horizon to transcend.

Metaphorically I term the places dedicated to each of the four modes of experiential learning 'chambers'. The course is designed so that the students, in teams formed around a design problem, will spend time and be active in all four rooms during the course. In one chamber, the *'experimentarium'*, they are asked to undergo the consequences of somebody else's design, and to subject their own designs to test. Here they apprehend product quality and here they are forced to conceptualize product quality in ways comprehensible and testable for others. In *'the lecture hall'* they are introduced to theoretical reflections, the history and major lines of thought of the discipline together with the most prominent techniques of design and evaluation. In the *'colloquium'* the students are forced to discuss experiences gained through activities in *'the experimentarium'* in the light of the ideas presented in *'the lecture hall'*, and they are required to post their reflections in compelling ways on a project website. And then finally, in *'the writer's room'*, they are required to individually accommodate their experiences and reflections, their readings and experiments, into a critical analysis of a text that express new and

relevant viewpoints, with which they can agree and disagree, and upon which they may express their own new insights, if so inclined. All four ‘chambers’ are designed so that ‘doing’ and ‘undergoing of consequences’<sup>1</sup> meet: In the ‘experimentarium’ the students undergo the consequences of other designers’ choices, and they are forced to expose some of their fellow students to doings of their own. In the ‘lecture hall’ knowledge of the HCI field is confronted with the practical experience gained in the experimentarium. In the ‘colloquium’ the students have to express their abstract conceptualization of the knowledge gained, and receive critique and advice from peers, thereby exploring what Vygotsky (1978) has termed the ‘zone of proximal development’ or ‘the distance between what you can do by the help of a more capable peer today and on your own tomorrow’. Finally, in ‘the writer’s room’, the student is invited into a genuine academic reflection taking a stand in a debate within the research field, drawing on practical design experience, theoretical knowledge of the field, and his or her academic ability to analyze and reflect. In Fig. 1 Pattern of knowledge producing spaces I have gathered these ideas into a pattern of ‘rooms’ and forms of knowledge to indicate what form of knowledge is supported by what learning context:

<p>WRITERS ROOM</p> <p>Accommodative knowledge stemming from extensive transformation of apprehension</p>	<p>EXPERIMENTARIUM</p> <p>Divergent knowledge stemming from apprehension transformed by intention</p>
<p>COLLOQUIUM</p> <p>Convergent knowledge stemming from extensive transformation of comprehension</p>	<p>LECTURE HALL</p> <p>Assimilative knowledge stemming from comprehension transformed by intention</p>

FIG. 1: Pattern of knowledge producing spaces

In each chamber the student should meet a specific form of HCI knowledge:

In the ‘experimentarium’ examples of design of Human Computer Interaction: web sites, PDA’s, or remote controls could be the point of departure. I find the didactics of the preliminary course of the ‘New Bauhaus’ of Chicago a good model for activities in this specific mode of knowledge creation<sup>2</sup>: First the students are asked to consider a line of design problems realized in a variety of tools and materials. Through the building of prototypes and putting these prototypes to test, they have to end up choosing one solution. Next the students are asked to explore of the expressive potential of many materials, or – if that is too time consuming - to explore others designers’ designs, thereby building a repertoire of solutions ‘looking for a design problem’. The first line of assignments – building a prototype - would inevitably lead to the killing of many darling-ideas, and analysis of data from the use context would give rise to many new ideas, growing out of the users’ (mis) use of the prototype as well as of the surprising new solutions that would surface to the eyes of the designers when seeing the prototype in its right environment. Seeing these other aspects requires knowledge about the application domain as well as about the technological possibilities and here theoretical knowledge in the form of lectures becomes important.

In the ‘lecture hall’ basic textbook knowledge should be presented to convey a minimum toolbox of test methods, design concepts and quality measures, together with an outline of theories, epistemologies and traditions of the field of HCI. I am not going to go into this here, since several textbooks presents excellent

<sup>1</sup> According to Dewey these are the modes that mutually constitute an instance of learning

<sup>2</sup> My knowledge of the New Bauhaus pedagogy stems from A. Findeli: Moholy-Nagy’s Design Pedagogy in Chicago (1937-46) in Margolin & Buchanan 1995) The New Bauhaus formula was to work with art, technology and science as elements in each and every activity. This way the tendency for design schools to be either content oriented in curriculum and vocational in training or process oriented in curriculum and humanistic in pedagogy is overcome. In the primary course of the New Bauhaus the designer has to consider two main categories (the content of which of course must be adjusted to fit design): plastic elements/design problems (line, shape, color, texture, structure, volume, motion, space and so forth) and tools and materials (brush, pen, power tools, camera, pigment, paper, clay, wood, plastics, and so forth). The student familiarize with these two categories (plastic elements and tools & materials) through carefully designed assignments. Two types of problems were identified and submitted to the students: a) exploration of one plastic element in different media, and b) exploration of the expressive potentialities of various plastic elements in only one medium.

contributions in this area (Carroll 2003, Newman & Lamming 1995, Preece et al. 2002, Shneiderman 1997 to name a few).

In the 'colloquium' the student teams, since working in parallel, meet each other's conceptualizations of experiences from similar tasks and get a chance to develop a peer culture and professional jargon of the field. According to Dewey, one of the founding fathers of the concept of experiential learning (Dewey 1916), learning has two steps: a. the outgoing activity, where the human being reaches out to grasp the world. Dewey calls that *trying*, and b. the feedback, where the human being feels the outcome, which Dewey calls *undergoing of consequences*. The 'undergoing'-part is the part where something inside the human is 'reset' so that the next challenge is met by a different trying, now building on an enhanced repertoire, stemming from the preceding 'undergoing', and so forth. The 'undergoing' contributes to the deuterio-learning, the habit of learning. Since HCI practice is mostly a collective endeavor involving people from several disciplines, it is important that the students acquire a habit of negotiating understanding of events, and a habit of presenting their arguments, clear, convincingly, and to the point. As already mentioned, the colloquium benefit from having a show window on the web, as the part of the course web, where the teams can post their assignments and present their projects in various ways. The students gradually learn that presentations from the colloquium, well designed, works nicely on the web, so that preparing a good power point presentation in the colloquium is a way to also make a nice web update. An example of the small practical things, that prepare the students for their 'after life' outside the walls of the university.

In the 'writer's room', on the other hand, the academic requirements have the top priority. As the point of departure for the assignment the students should be given a research paper to analyze. The intention behind this is to make the student feel approached as a potential researcher, an academic, who is supposed to be able to contribute to the development of the discipline, because this is the deuterio-learning which matches the accommodative form of knowledge which is supposed to be the outcome. In the 'writer's room' the students experience two important conditions in academic professionalism: a. the triad of a loneliness, thoughts and means of expression, and b. the deadline that force you to make hard choices and finish up.

## **2. TEACHING HUMAN-COMPUTER INTERACTION: EXPERIENCE FROM THREE TRIALS OF A 15 ECTS COURSE MODULE FOR THIRD YEAR UNIVERSITY STUDENTS AT THE HUMANITIES**

To give some flesh and blood to the didactic paradigm introduced above, this section accounts for my experiences from three consecutive years, 2000-2002, where I have taught Human-Computer Interaction for third-year undergraduates at Information Studies at Aarhus University (<http://www.imv.au.dk/eng/academic/bainf.html>). I make this account by describing the course management, the presentation of the content to the students, and the formation of the environment of learning. The description as presented here is a generalized version of what has emerged over the three trials, and would be my platform for a fourth run.

### **2.1 Course management**

In Denmark the academic year normally consists of two semesters: fall and spring. This HCI course has been taught in the fall semester from September 1 till Christmas, with examination in January as a 15 ECTS course module, in parallel with another 15 ECTS course module in Design. The design course requires the students to go through a design process from initial idea to a substantial prototype through at least three iterations from mock up to first and second prototype. Human Computer Interaction is taught to be an inevitable aspect of IT design, and of design competence, and the two courses were managed in collaboration between the two course-teachers, assisted by two instructors.

At the end of the previous term, ending the second year of their studies, the students who signed up for the courses received a welcome 'summer-letter' with a goal statement, an outline of the course description, course literature, information about the study form and where to meet for the first lecture, and most important: an assignment to read Don Norman's seminal book 'The design of Everyday Artifacts' plus an equally foundational book for the design course.

The group of teachers met during summer and planned the first two weeks in detail. On the first day, the students received an hour-to-hour program for the first two weeks together with a list showing to which design team they

would belong for the first two weeks. Also the teachers made sure that the physical surroundings (the design loft, the necessary computer and video equipment) were in place from day one.

The first two weeks of September were conducted in full collaboration between the four teachers and the about 60 students signing up each year, and with full time activity on campus. Here, a teamwork-culture and a group-oriented identity would already begin to take shape. In the following ten weeks, the two courses ran in parallel, each with a weekly lecture and a weekly exercise seminar in groups of 20 students. In this period, the development of the spirit and ideas generated during the first two weeks was sustained through conduction of two joint workshops and a joint festival at the end of the semester.

During the semester the four teachers would have regular meetings to monitor the achievements of the students and accommodate adjustments to the program. The examination was in the form of an oral presentation for the design course and an essay for Human Computer Interaction course.

## 2.2 Course content as presented to the students

The course content was presented to the students in terms of goals, assignments, methods, and outcome.

*The goal statement* tells why this teaching is offered, what is offered, and what is required to pass the exam.

With regard to the course in Human-Computer Interaction, the goal statement says that students are expected to acquire Human-Computer Interaction skills, including a conceptual framework built around the concepts of 'feed back', 'mapping', and 'transparency', skills in designing and evaluating Human-Computer Interaction using specific techniques, and – through continuing communication of sub-results – ability to produce critical formative reflection within the domain.

The goal statement frames *the assignments* and serves as a benchmark for teachers, students, and censors and guides the course implementation as a whole:

1. A website for communicating the work in the design project (the assignment in the Design Course) should be designed before the end of the second week (immediately after student groups for the rest of the semester had been formed in the design course) and made subject to HCI testing.
2. A 'Usability 1' test, testing if the design vision is actually realized in the prototype, featuring GOMS-modeling, 'cognitive walk through', 'heuristic evaluation' and 'thinking aloud' laboratory testing, due after 6 weeks.
3. A 'Usability 2' test, testing the reception of the prototype in its real-life context with its unpredictable use situation, featuring participant observation, video observation, video analysis, and narrative description developed into use-scenarios, due after 12 weeks.
4. An essay (15-20 pages) comprising a critical analysis of a research paper where the student put design team experiences into a critical perspective based on the curriculum literature, and preferably extended studies of literature, due primo January.

The *methods* that were required in the assignments were taught and exercised in the course of the lectures and exercises. The overall pedagogical idea: learning through the design experience, formed the backbone of the course program. The ability for critical academic reflection was assumed as a precondition.

The *outcome* of the course was measured in the essay. As already mentioned, the students were here supposed to individually demonstrate that they commanded the skills and conceptual framework of Human-Computer Interaction at textbook level, that they were able to present and reflect on their test-experiences, and that they were able to discuss these experiences in the light of a research position in a paper included in the essay assignment. The average grade had an upward trend over the three years, being around 9 (B+) for the 55 students of 2003, and the external censor wrote a very positive evaluation of the results. Of course the real outcome with respect to the goal of making the students reflective practitioners can be measured only in the future practice of the students, but that is unfortunately out of scope here.

## 2.3 The learning environment

The immediate learning environment consists of a. literature, lectures, exercises, and reputation in the student group, b. the 'places' (experimentarium, lecture hall, colloquium and writer's room), and c. the design project, which the students come to take as their immediate object.

In the physical world the design teams were assigned a working space within a design loft, so that they could overlook and be inspired from each other's work, and in the virtual world the course web was an important mean of expression for the teams. The course web, because of these postings, did also play a role in the formation of the reputation of the two collaborating courses: older students would tell younger students what was going on, on Friday-cafe-hours, for example, and refer to the web postings. Younger students would check the course websites from earlier years, they would attend the exhibition, and they would be involved as testers of the prototypes. In the third year, when we sent out the 'summer-letter,' it was received in a context of expectations, and we felt it much easier to get started.

The idea to have a common design loft, a room dedicated to these specific 60 students for this semester, originated partly from inspiration from the School of Architecture in Aarhus, partly from the experiences from MIT's design education (personal conversation with professor Sara Kuhn, University of Massachusetts at Lowell in 1996). Its *raison d'être* is that (1) in order to be creative, the students need a safe place to experiment, (2) in order to learn that design is fundamentally a social activity they need to be together, and (3) in order to learn from practice they need to have access to each other's projects. The design loft also increased the possibility to get inspiration from other projects and offer itself as a forum for giving and receiving critique. In Goffman's words (Goffman 1959) the loft formed the 'back stage' while the team presentations on the course web was the 'front stage'.

The close collaboration with the design course has been an important driver in the development of this HCI course in several ways: The sparring and co-teaching has been an inspiration. Making design part of an HCI course is not too common, quite often the only practical element in academic HCI courses is evaluation assignments. Building an identity as designers themselves, some even with real customers, the students are inspired to take themselves seriously as professionals. Designers need constraints, and the prime constraints are the project description and the deadline. The design project drives both the action and the reflection and it presents the challenge and the frustration that forces the students to learn. Judged from the experiences I have for now, I consider the design dimension to be of intrinsic value to a course of HCI.

### **3. LESSONS LEARNT, UNRESOLVED ISSUES AND FUTURE DIRECTIONS**

The ultimate goal of the teaching of HCI presented here is to help the students develop a competence as reflective practitioners within the field of Human Computer Interaction. A reflective practitioner is according to the theory of experiential learning the outcome of a successful dynamic relation between apprehension and comprehension. Kolb expresses it as follows: *'Immediate apprehended experience is the ultimate source of the validity of comprehensions in both fact and value. The factual basis of a comprehension is ultimately judged in terms of its connection with sense experience. Its value is similarly judged ultimately by its immediate affective utility.'* (Kolb, 1984, p.106). Taken as such, competence as a reflective practitioner is a personal 'thing', that according to Kolb's terminology 'happens' in the fourth quadrant of his learning circle model, a tacit dimension, outside reach for traditional academic evaluation.

In order to get as close as possible to evaluation of this teaching goal I have designed an evaluation instrument which, admittedly in a heuristic way, addresses competence as a reflective practitioner: Like in the archetypical wedding ceremony, where the maid turns into wife through being bride for a day, the 'bride' being a well defined transitional role, I have designed the assignment for the course exam to invite the student to take on a transitional role between student designer and professional, as 'student researcher for a month'. The students should receive the assignment about a month before they were supposed to turn it in, and the assignment should be composed, just like the bride's dress, of 'something old, something new, something borrowed, something blue', the old being the students' resent experience from the course project work, the new being the research paper that form the point of departure for the assignment, the borrowed being the theoretical and methodological knowledge passed on in the lecture hall, and the blue being the creative imagination the student is able to mobilize in order to integrate these items of learning. What is measured and marked, then, is how well the student succeeds in integrating all this on the wedding day, in this case the month where he or she is in the position of being a researcher of HCI.

This method for evaluation of to what degree the student has developed reflective competence, has proved successful on the following indicators: The students got good grades, the external evaluator expressed admiration of the outcome, the course gained a good reputation among the younger students, and quite a number of students continue to work with HCI-issues at graduate level. It is, however, not possible to attribute this success to the

design of the course directly, and I am not able to document the value of the paradigm of experiential learning as opposed to other learning paradigms. At least the following ideas have to be explored further before a more rigorous argument can be presented:

- Operating with four distinct 'chambers of learning' as a form to be filled in the actual course design is a fruitful way of addressing the different modes of experiential learning.
- Applying the wedding metaphor to the design of the evaluation as a way of conceptualizing the ideal learning experience.

Next time I am teaching this course, I am going to improve along the following lines:

The objectives of lectures and formal tests should be made as explicit as possible before, under, and after the course in order to continually allow students to combine knowledge elements

- Test-sheets, score-cards, checklists, etc. are helpful tools, together with teacher's notes, and there should be space enough, virtually as well as physically, to put up posters with memos and intermediary results
- The creative sessions should be conducted in a playful atmosphere of trust and confidence accommodated by a room suitable for physical as well as mental change and relaxation
- The analysis and scenario writing are ways to let the students express what they have experienced as part of the ongoing creative process. These activities should be accommodated by suitable assignments and introduction to useful tools. Instant feedback is an important part of facilitating this process
- The essay writing is (apart from the institutional *raison d'être*: examination) an activity, which facilitates internalization through externalization. The pressure of examination is important, because this activity is where explicit knowledge becomes personal (tacit) and where the foundation for the next round of learning is established. The student is in the reflecting mode, considering what was learnt, or, in other words, considering the habit, 'the way'. This mental 'double-looping' is difficult and stressful. Hence, the pressure is useful. Frustration is unavoidable, as is the reward when the student has successfully digested the experience. It would ease the pressure to be able to offer counseling during the writing process

As stated in the beginning, *the way of learning (deutero learning) must be at the center of interest for all teachers*. I have presented a didactic pattern of knowledge forms and learning environments for teaching undergraduate students to become reflective practitioners of Human Computer Interaction. This framework has gradually emerged in the course of three years of teaching.

Apart from the obvious need to research more rigorously the applicability of the learning environment framework, an obvious further development is to devise an inventory of design and evaluation techniques that can be taught effectively within the limited time and space frame of a university course the size of from 15 to 30 ECTS.

Most important is however to avoid viewing the academic education of HCI as a process of knowledge transfer, and instead let the building of academic reflection go hand in hand with learning basic skills in interface design and usability testing. Now, the challenge is for the teacher to embrace as a fact that academic lectures have their place, that knowledge have to be constructed in a collaborative way, and distributed through a 'spiral' process of socialization, externalization, combination and internalization, and that web-based learning media are supposed to be used. Textbooks come and go, courses have to adapt to changes in curriculum, the whole field of HCI is moving. To build a didactics in these troubled waters, the teacher need a conceptual tool to help decide which type of social situation to establish when a new subject comes up in. This is what the title of this essay refers to: 'Educated by design' alludes to the responsibility of the institution of education to educate good designers by putting them through carefully designed design-experiences. 'Learning by doing' implies that the designer-students should experience the consequences by trying out design ideas. And besides the 'experiential learning' paradigm ethical concerns is an issue here. Regarding the consequences of implementation it is hard to get usability on the agenda for a company's quality assurance and product evaluation procedures. The return of investment has to be proven over and over. By designing courses that drag the students through reflections that they experience as productive to the quality of the project is creating a good habit, which the student will carry further as tacit knowledge.

Following Dewey, the suggested paradigm should, however, be treated as a pattern to be realized according to situation, not as boxes to be filled schematically. The sessions in the design loft, where all the student-designer groups were sharing workspace, displaying ideas, doing brainstorming etc. together, accommodated socialization, but also combination. The design events through which the mock ups turned into a prototype that turned into another prototype were a deeply personal experience that supported internalization as a by-product of the obvious externalization. The formal testing of the prototypes, the presentations on the project-group web-site, as well as the various inputs from lectures and guests, and the students' recall of knowledge gained prior to the design- and HCI-courses were combined, thanks to the problem-orientation and project organization of the design-work. The project-group-web, together with the course website, and the final essay writing, provided the externalization of knowledge, although the most important outcome was internalization.

It is a huge challenge for education-builders to make sure that education actually contributes to the students' knowledge creation. At a moment in history where companies world wide try hard to become learning organizations and to facilitate knowledge creation among employees, time should be ripe also at the universities, to fully acknowledge the insights gained from research in experiential learning, and consequently to design courses that not only aim at presenting and examining knowing that and knowing how, but also has the ambition to provide a foundation for knowing 'why' and 'what', the strategic and motivational aspects that best is taught and learned by doing. As stated above, Dewey saw 'the undergoing of consequences' as where the development happens. Bateson would say that 'the undergoing' is where habits are formed, where the deuterio-learning happens, and as I have argued: deuterio-learning holds just as prominent a position as the learning of a specific body of knowledge: The journey of learning should be the destination of education.

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