HCI and Design Research Education

A Creative Approach

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Abstract. This paper describes the latest insights in HCI education inspired and informed by the creative disciplines, how education is implemented, and how it could be fed back into the artistic fields. It contains examples, contrasts different methods, and discusses and concludes the findings for HCI education in general. A course on HCI is described which is supported by a creative approach, related to art, architecture and music. Experiences are described in of HCI tools and insights such as structured design methods, interaction frameworks and interface design heuristics relevant to the arts fields.

1. HCI and Education

The domain of Human-Computer Interaction (HCI) is a multidisciplinary area involved in research, development and design, which should all be reflected in the education of HCI. HCI is a relatively new field combining human sciences, engineering and design. In addition to developing its own knowledge and practices, it draws knowledge from a number of more established disciplines, as shown in Fig. 1 below. On the left hand side of Fig. 1 a number of relevant human science disciplines are shown, on the right hand side relevant engineering disciplines are listed while the list on the top gives an overview of the design disciplines. In the middle it is stated what it is about in this broad approach: the interaction between people and technology. The outer circle gives what can be called the meta-disciplines: philosophy, art, mathematics, and science [4].

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The three main approaches to HCI historically are from (cognitive) psychology, computer science, and design. Although many research centres and HCI courses still reflect one of these biases, in the last years particularly we have seen the field mature to a new discipline combining the different approaches. Some of the major text books in this field are written by multiple authors from a variety of backgrounds reflecting the main approaches mentioned above [8, 25]. Even though the course described in this paper is based in a Computer Science department (at the Vrije Universiteit in Amsterdam), it is set up and taught by people with various backgrounds and expertise in psychology, technology, design, and the arts.

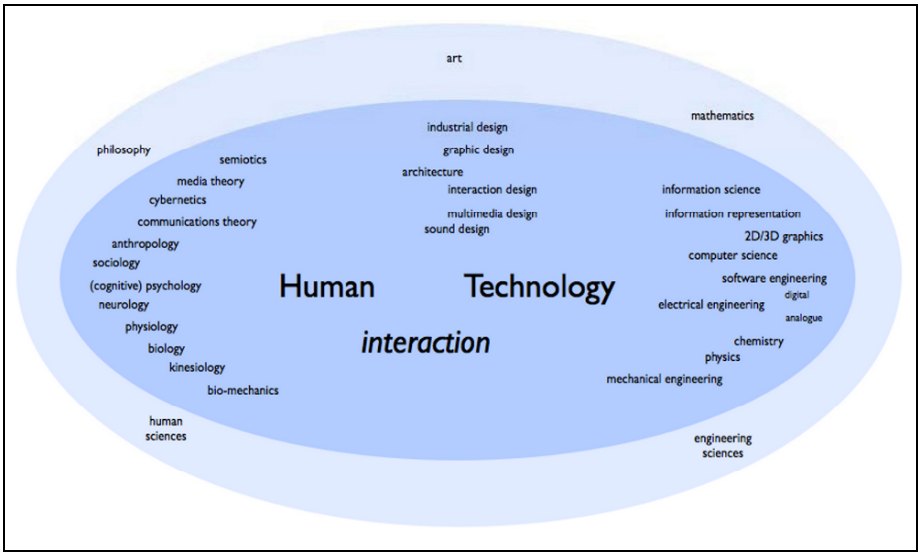

Fig. 1. *An overview of related disciplines and HCI*

As it is increasingly understood that the design of interaction is about creating experiences, the HCI field can often borrow from the knowledge that creative disciplines have developed, such as theatre, music and video art. Methods, processes and approaches from these field inform the HCI field, while at the same time HCI teaching can help the artistic and design disciplines to develop interactions in a more user / audience centred, structured and formal way. The way the courses that are discussed in this paper are set up, reflects this interrelation between HCI and creativity.

2. Teaching HCI

In order to develop better interfaces between people and technology, knowledge is required about all partners involved in the interaction: humans and technology, or in a broader sense, the natural and the artificial. From the human mind(s) it is not possible to directly influence the environment. We use our bodies to express

ourselves in speech, movement, etc. The physical world comes in through our senses; light, sound, smells, movement etc. New technologies develop fast, and have the ability to profoundly change the way we live, work and play. Mankind has always developed technologies, created artefacts, reshaping the environment. Computer technology is intertwined with other technologies, our whole environment, real and virtual.

The discipline of HCI research looks at ways to further improve the interaction between people and computers. In order to do this, it is necessary to have a good understanding of the human mind, body, and social interactions. At the same time the technology must be understood, how things function, what is possible and what is not (yet), and how to develop interfaces. Artistic disciplines are studied: in music, visual art and architecture we can find important and inspiring developments, including the application of new modalities in the interaction between humans and environment. This has lead to new insights in interaction, combined with knowledge of the field of communication and media studies.

2.1 A Course on HCI

The HCI course at the Vrije Universiteit in Amsterdam has been originally set up by the second author as part of the *HCI, Multimedia and Culture* program within the department of Computer Science. The course is also compulsory for other undergraduate students from the courses on Information Science, Artificial Intelligence and Business Informatics and is further attended by students from other departments such as psychology, and international exchange students. The course has been taught by several people and since 2003 mainly by the first author, with guest lecturers and a student assistant. In the last years about 100 students are involved in the course per year. This is a rather theoretical course followed by a practical course “User Interface Design”, in which teams work on a specified project developing an interface in a structured design approach.

The teaching method aims at developing understanding, insights and the ability to reason about the HCI topic rather than purely learning facts and fixed methods. While the main part of the teaching is about structured design approaches, the emphasis on the creative elements is supported by many examples and case studies from artistic and design disciplines such as electronic musical instrument design, video performances, installation art, art history, interactive architecture, etc. Many image materials are used, gathered particularly over the last few years. For instance, to illustrate interactions between people and technologies the use of little video clips can be very illustrative.

The course consists of 14 lectures of two times 45 minutes. Practical experiences are gathered through assignments. The course is assessed by a written exam and writing an academic paper. An overview can be found on the course web site. This serves increasingly as an e-learning environment. Section 2.1.3 provides details and the URL.

2.2.1 Thematic Structure

To cover the broad field of HCI the course consists of four themes. These themes reflect the three approaches as mentioned above (human sciences, engineering and design) as well as the independent knowledge of the HCI discipline. The themes are:

- Technology for interaction.
- Human factors in interaction.
- Design of interaction.
- Structured design methods.

The first two themes provide background information about the two entities involved in the interaction: humans and computers. The physical aspects of the interaction are emphasised, and technology in general is discussed. While these themes are to a large extend informed by the traditional disciplines (as shown in the right and left hand sides of the diagram in Fig. 1), the other two themes are mainly covering the knowledge and insights in the independent field of HCI. The course starts with two lectures to introduce the field of HCI, its relevance (illustrated with many examples of human-computer struggles), and an ecological design approach for UbiComp and pervasive computing paradigms in the course. Throughout the course, many examples from the field of art and design are used (music, video, installations, architecture). Many images, movie- and video-fragments are used. All lectures are supported by examples from the authors' own recent research practice. Furthermore, a number of 'advanced interaction' topics are covered within the themes.

In the sections below the themes and the lecture content is described in more detail.

Technology for Interaction

In two lectures the history of technology is briefly described, starting from the first pre-historic human artefacts. It is argued that, in a way, the first designers were the early hominids who designed their tools such as the stone axe both functionally and ergonomically. Technological categories are introduced, from mechanical systems (objects, passive mechanics, active mechanics), electrical (electric, analogue electronic, digital electronic) to computer technology (which is programmable). Other technologies are discussed as well, such as optical, chemical and magnetic technology. The discussion on the relation between people and technology is informed by the work of writers such as Lewis Mumford [16, 17], Marshall McLuhan [15], Neil Postman [23] and Malcolm McCullough [14].

This theme then focuses on the computer category, with the strongest need for a good interface as it is the least physical (most invisible) and at the same time functionally the most powerful technology. The interface is described in sensors and actuators, and a framework is introduced to describe and analyse the physical layer of the interaction. This framework, the Physical Interface Design Space (PIDS), describes or designs the interaction by splitting the movements up in Degrees-of-Freedom and for each DoF determine the *range*, *precision*, and *haptic feedback* [5, chapter 6]. An assignment is given in which the students practice the analysis with several devices of their choice. In this Device Parsing exercise they are encouraged to literally take devices apart, determine the technologies used (mechanical,

electronic etc.) and describe the interface in the terms of PIDS. The assignments are handed in through the course web site, and marked by the lecturer. Fig. 2 shows a collage of devices in parts in the course in 2006. In the following lecture the work is presented by the students, based on selections made by the lecturer and a student assistant.

Fig. 2. *A selection of 'parsed devices' by students*

A lecture on musical instruments illustrates the technological stages, and shows how intimate and precise these instruments are. Particularly the developments in electronic instruments serve as inspiration for interface design [2], [5, Chapter 2].

Human Factors in Interaction

In the lectures about the human side of the interaction the senses, memory and cognition, and action are described. The emphasis is on the human as a multimodal being, using many senses and output modalities simultaneously. Particularly the tactual modalities are discussed, to establish a firm understanding to support physical interaction paradigms. Models of human information processing are described, with a focus on the abilities for multitasking as well as an experiment demonstrating a low-level bottleneck in this (the PRP-effect) [1], [21]. In addition to cognitive psychology, physiological factors are introduced because of their relevance for understanding physical interaction.

Particularly, visual, auditory and haptic perception is described in detail as *activities* (based on the ecological approach to perception of Gibson [10, 11]), which is more relevant for HCI than the more *passive* modes as considered in other fields of psychology). Also recent insights in the role of affect and emotion in the interaction are discussed [19], [22].

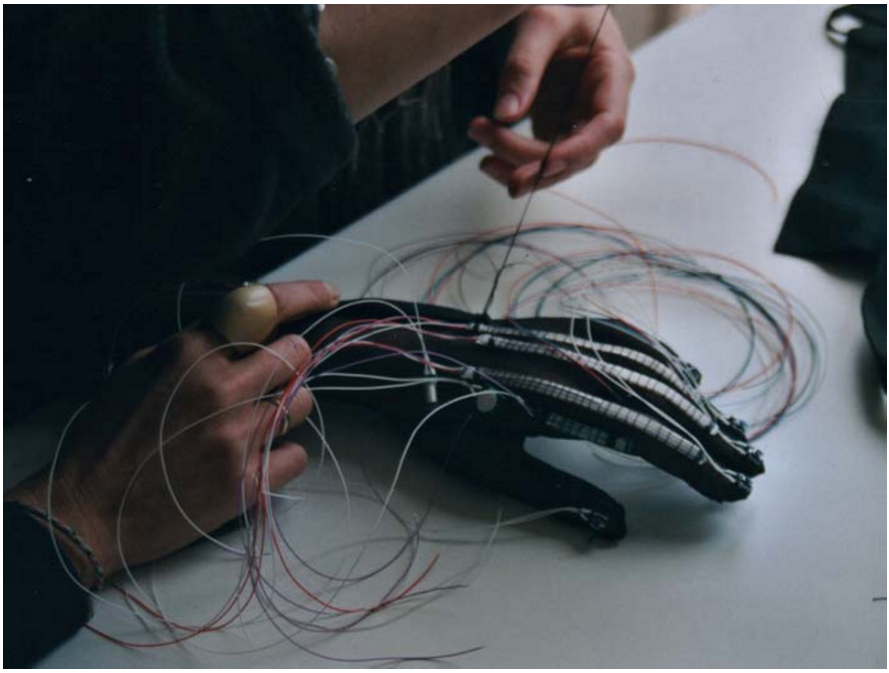

Fig. 3. *The making of an electronic musical glove*

The Design of Interaction

Several lectures on information representation [31], communication theory [26] and multimodal interaction [27] constitute the theme on the design of interaction. Some basic semiotic theory is introduced, extended with the notion of affordances from the field of ecological perception [9], [11], [18]. The aim is for the students to gain insight in reading our environment (natural and artificial) as a rich source of information, both explicit and implicit. By giving examples from everyday life, students are encouraged to translate this view to the design of interfaces. In the display of information from the system, both, the information representation, and various kinds of feedback are described. A framework for analysing and designing multimodal interaction is presented [6].

The relevance of UbiComp and Pervasive Computing paradigms is accentuated [7], following an ecological approach to HCI as an electronic ecology or *e*-cology [4], [5]. A lecture on Interactive Architecture is part of this theme, presenting

historical as well as recent work on interactive buildings the first author has been in involved in [20], [30], [12]. Fig. 4 shows an interactive architectural structure as developed at the Hyperbody Research group at the Delft University of Technology.

Two assignments are part of this theme. One is about observing and describing information and signs in our everyday environment (Sign Subversion). The other is about analysing interactions using the frameworks presented.

In this theme one presentation is about a conference (such as the CHI or UbiComp), to give students insights into the experience of a conference visit.

Fig. 4. *An interactive architectural structure*

Structured Design Methods

The Structured Design Methods theme is strongly based on the DUTCH approach of the second author [32, 33], Designing for Users and Tasks from Concepts to Handles (Fig. 5). It includes introductions to Task Analysis, ethnography, usability testing methods, qualitative research methods, etc. usually taught by the second author.

Also recently developed techniques from design research such as Cultural Probes, Scenario based design, QOC method, Personas etc. are presented, and illustrated by a research project from industry that the first author was involved in [28, 29]. Guest lectures on Experience Design (by Dhaval Vyas) and Requirements Engineering (by Dr. Johan Hoorn) are part of this theme.

The knowledge from this theme is particularly relevant for the design project (see below in section 2.1.2). There is no assignment associated with this theme because of this link with the project, although in a situation where this is not the case an assignment including usability testing can be part of the course.

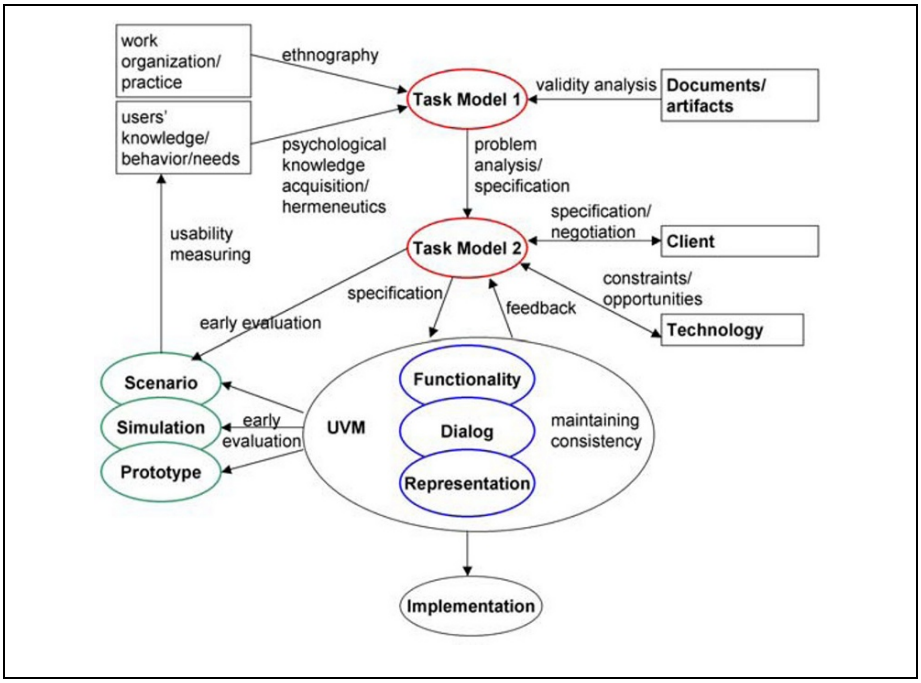

Fig. 5. *The DUTCH design method*

2.1.2 Design Exercises

After passing the HCI course, students can gain further practical experience in the User Interface Design (UID) course. In about 12 weeks students have to work in groups on the design of an interface in a structured method, usually following all the stages of the DUTCH method. The lecturer, student assistants and the students meet on a weekly basis to present and discuss the progress. In the end a final design (prototype at a proof-of-concept level) is presented, including the results of the user tests carried out. Afterwards every group hands in a report with detailed descriptions of all stages of the design process and their experiences. In the last year, the groups could make a choice of topics: a novel communication device, a computer game with physical interaction, or interfaces for a UbiComp environment. Fig. 6 shows an example proposals for an interface of a mobile device made by the students.

Fig. 6. *Mock up of an interface developed by students in the UID course*

2.1.3 e-Learning Environment

The course web site[3] was completely redesigned as a basis for e-learning in 2005 by Marcin Wichary, as a project for his internship for the post-masters programme of User-System Interaction at the Eindhoven University of Technology [34]. It contains not only information about the lectures and the teachers involved, but also background material about HCI, pointers to other sources, and interactive exercises such as a practical introduction to Fitt's Law. The web site is not just *about* HCI, it *is* HCI. The designer has incorporated many examples of good web site design heuristics, and added many explanations on the site itself. The content of the web site is subject to the Creative Commons License, so other parties can extend or customise the material. In 2006 the site was further developed by student assistant Elbert-Jan Hennipman, also an assistant lecturer in the course, and it is now possible for students to enrol in the course, hand in coursework and check their progress. Another interactive exercise has been added, developed by student intern Niels Rietkerk, demonstrating the psychological issue of impulsivity as originally researched by the second author in 1985.

[3] The URL of the site is currently http://fww.few.vu.nl/hci, and will soon be changed but linked from the www.bertbongers.com web site.

Many further extensions to the web site are currently being developed, through the involvement of the Open University in the Netherlands, with the objective to create a full HCI e-learning environment. Fig. 7 shows a screen shot of the HCI Education web site.

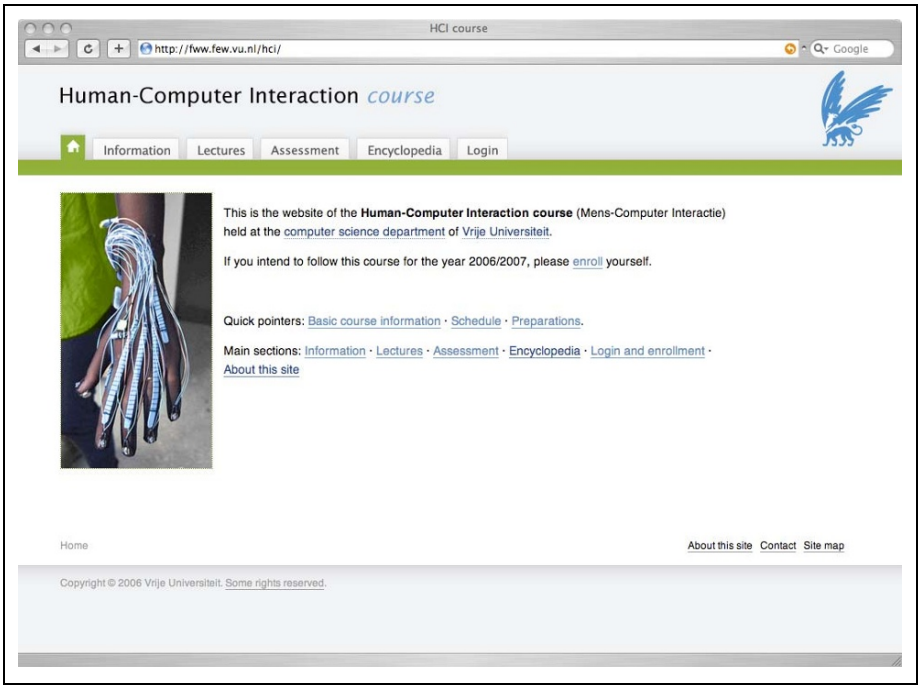

Fig. 7. *The start page of the HCI course web site*

3. HCI Teaching in Multiple Contexts

Further insight in the teaching materials has been gained by presenting (parts of) the courses to other groups of students at other places, including several outside of the general HCI audience. The format varied, but was often presented in a workshop assembled of elements as described in Section 2. Through these workshops new course elements were developed, which were then added to the main course.

3.1 HCI and Technology

The multimodal HCI approach from the human factors theme (including the assignment) was presented in a one week course for Industrial Design Master students at the Technical University in Eindhoven, and as part of a Minor in Physical User Interfaces at the department of Media Technology Bachelor programme in

Utrecht. In the latter school a preliminary structure of the HCI themes was applied. The technology theme (including the assignment) is used in a one week course for the User-System Interaction (USI) post-masters programme at the Technical University in Eindhoven[4]. Part of the workshop was for the students (in groups) to develop physical interaction styles. Functional prototypes were developed of interaction proposals for channel changers (zapping), multimodal feedback on seating posture at a work desk, an electronically enhanced hand shake, a computer game, and the example shown in Fig. 8, a multimodal interface redesign for a coffee machine.

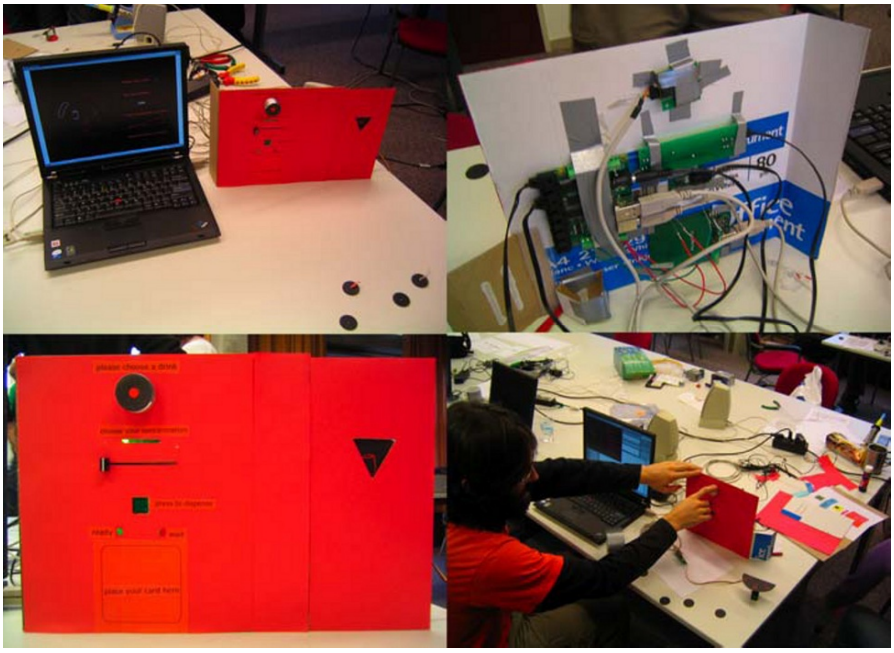

Fig. 8. *One of the results of a physical interface proposal at the USI course*

The assignment of designing an interface for a UbiComp environment has also been carried out by 2nd year Bachelor students of Industrial Design at the Technical University in Eindhoven, coached by the first author in 2005 and in 2006 [24].

3.2 Architecture

The discipline of architecture has always been concerned with the design of spatial layout. It is an essential source of knowledge for interacting with the building environment and for developing interfaces on a larger scale. With computers

[4] See the programme's web site for more information: http://usi.tm.tue.nl

becoming increasingly embedded and networked in man-made environments, it is no surprise that architects have been involved in the same issues as the UbiComp sub-discipline within HCI. Long term collaborations between the first author and architects involved in Interactive Architecture, led to the development of spatial interaction paradigms [3]. Particularly at the Hyperbody Research Group of prof. Kas Oosterhuis at the Architecture department of the Technical University in Delft[5], practical experiments have been carried out in relation to several years of teaching in workshops.

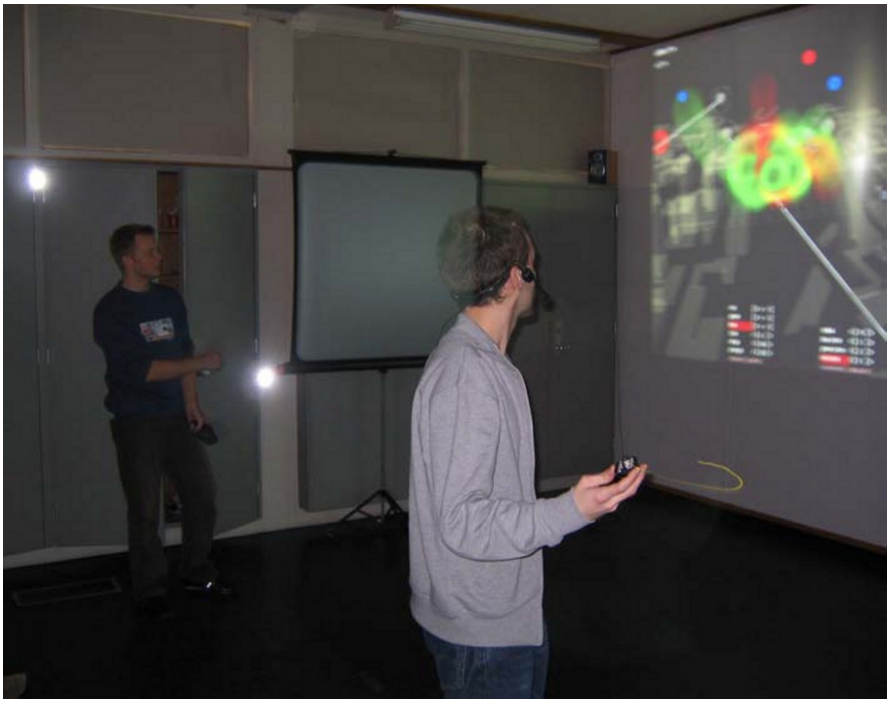

Fig. 9. *Spatial interaction with architectural models in Protospace*

3.3 Music

Considerable inspiration in HCI teaching and research comes from musical instruments, and from teaching workshops on instrument building by the first author.

The relationship between instrument design and general HCI has been addressed in the yearly conference New Interfaces for Musical Expression (NIME) since 2000[6].

[5] www.protospace.bk.tudelft.nl
[6] www.nime.org

Presenting recently developed HCI lecture materials to students of musical topics resulted in additional insight. For instance, during a two day workshop at the Institute for Musicology at the University in Cologne, students and staff members actively participated in groups to develop new electronic musical instruments after discussing the technology theme.

Currently a new workshop is being prepared to confront HCI structured design methods and instrument design.

4 Discussion and Conclusion

In this paper a creative approach to HCI has been illustrated with an interdependent relationship, of inspiration and application of knowledge from artistic and design disciplines in HCI, which has then been placed back in some of these contexts such as in Interactive Architecture and Electronic Musical Instrument design. We intent to keep developing this interdependence cycle as it yields fruitful research approaches.

As HCI is a relatively young and fast developing discipline, a lot of flexibility in teaching is required. Although a number of heuristics and structured approaches have been developed, which are a great help for the novice, rules are not cast in stone but subject to constant development. We found that young students, with their constant involvement and practical experience in the latest interactive technologies and new media, are a valuable source of information for our HCI research. Not only in direct feedback during teaching (which has to be more explicitly solicited for in larger groups such as at the VU in Amsterdam than in smaller groups such as at ID in Eindhoven), but also structured involvement during experiments (qualitative contributions such as in interviews and questionnaires) and examinations lead to new insight in HCI as a teaching domain. Essays and research papers produced by our multidisciplinary students stimulate new insight and often contribute references that inform our HCI research. Explicitly targeted exam questions yield insights in this diverse population's varied approaches to new technologies.

As always, teaching a structured course can be an excellent way of developing and validating a certain body of knowledge, as for instance Donald Norman acknowledged with the content of his book on Emotional Design [19]. We found this effect strongest at post-graduate student levels and beyond.

Over the last years, the teaching about new interaction paradigms based on physical interfaces and multimodal interaction has been greatly facilitated by the increased availability of sensor and interface hardware such as the Phidgets, the Making Things Teleo modules and other PIC chip based solutions [13]. In the electronic arts and particularly in music such interfaces were available for a long time (often based on the MIDI protocol, such as the iCube of Infusion Systems), but the current USB based interfaces are often easier to use and work with general tools such as Flash and Visual Basic, as well as with dedicated development environments such as Max/MSP for audio and Jitter for video manipulation.

The current student generation tends to be rather visually oriented. The lectures therefore were thoroughly aimed to encourage students to open up their other sensory modalities. However, a lot a visual material was used, both in pictures as in

videos. Using a small digital camera, the first author has acquired a rich vocabulary of images to illustrate the topics taught, in addition to a large amount of textual media offered. A side effect may be that students are encouraged to acquire their own images in order to express themselves, rather than using stock photography. In the results of the assignments (particularly those on everyday interaction with technology, and the one on sign subversion) it was shown that students had successfully taken up this challenge.

It was also very relevant and interesting to see how the same content was interpreted and picked up by various communities. Particularly the design exercises were approached in different ways. For instance the assignment to design an interface or interaction style for a UbiComp environment was developed in an analytical and structured way by Computer Science students (creating the necessary extensive overview of functionality of such an environment), while Industrial Design students were more solution and product oriented and less structured (although in one case they developed their own wildly iterative design approach partially based on insights from the discipline of marketing! [24]). This is a challenging assignment anyway, as it is often too easy to come up with the design of yet another remote control.

In comparing the results of assignments and coaching of students, we see a difference in the teaching model at "traditional" Computer Science Departments like at the VU, based on the classical model of teaching lectures, and a competency-based teaching model as used at Industrial Design curricula. In the latter the students are more independent and more apt to search for their own resources, where in the former the students tend to be more structured.

Architecture, video art and music have been a source of inspiration for the presented HCI teaching method. And in these artistic fields it was found essential to introduce HCI methods and knowledge. Students and scholars in the fields of musical instrument development, media art and architecture are increasingly looking for design aids which HCI can provide, such as structured design methods, frameworks for interaction analysis, and interface design. It is this reciprocal influence that we intend to develop further.

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