Between the Ivory Tower and Babylon – Teaching Interaction Design in the 21st Century

Gerrit C. van der Veer
School of Computer Science,
Open University Netherlands, Valkenburgerweg 177,
6419 AT Heerlen, The Netherlands
gerrit@acm.org
WWW home page: http://www.cs.vu.nl/~gerrit

Abstract. A brief history of interaction design shows that there is an ongoing cultural change in the relation between people and computers. This results in a structural need to include new disciplines in interaction design approaches. The concept of experience is analysed, and the need for new curricula is shown. One example of a curriculum is illustrated, with its successes and failures.

1 Introduction

Interaction design is now a common concept in those modern Information and Communication Technology (ICT) curricula that include a focus on users. However, beyond the concept there seems to be a wide variety of content and meaning. The main *aim* might be the design of technology, or, alternatively, the design of people's environment and opportunities. The *format* of the product of design can vary from formal specifications, requirements, or running prototypes to sketches and scenarios. The actual *meaning* of the end-product of design may be a specification of functionality, or an intention towards the prospective users' experience.

It makes sense to briefly consider the history of technology design. Early technology tended to be designed and produced by the users themselves. Early hunters build their bow and arrows, European musicians, at least till the 13th century, cut their own flutes or harps, and in most 'primitive' cultures people make their own clothes and dwellings. Even in the early 20th century technology users tended to control their own tools: The first photographers were chemical experts; the first car

drivers fine-tuned their own engines; the first sewing machines came with a tool kit, and the first computer users loved to program. But as technology develops, the situation always changes. Users are no longer by default designers and builders, and separate roles develop: the professional designers, as well as the technical producers of the tools, are different from the user who acquires a tool and applies it.

The following sections deal with: a brief history of interaction design (section 2); a change in culture (3); the need for new disciplines (4); the concept of experience (5); how to integrate this in an academic curriculum (6); and the development of one such curriculum in interaction design (7). Finally, in section 8 the conclusions are summarized.

2 Brief History of Interaction Design

With ICT this historical development took a short period. Till about 1980 computers were used by professionals (mathematicians who needed to calculate complex functions, psychologists who validated formal learning theories and models of human problem solving [1]). The main issue in getting technology optimally used was to make the users accept it, for which 'user participation' turned out to be a major design focus [2]. Once the technology was accepted, the users happily learned to fine tune their system to their job. In some cases this developed into the professional pride to program, and these users enjoyed the possibility to formally specify, test, and iteratively improve their attempts to solve their professional problems, or to mathematically prove the correctness of their solutions.

The 80s saw the development of general systems for office work (starting with word processors and spreadsheets), as well as the availability of the PC and microprocessors. The main design issues now concerned how to deliver the system ready for the job of the user. The user interface was the main focus with systematic approaches towards its architecture [3], its functionality (Tauber's concept of the user virtual machine [4]), early approaches to analyse the (command) dialogue [5], and successful implementations of representation like the desktop. Users were considered in all these approaches, and even the concept of 'user participation' continued to be advocated but with a changing meaning. In most cases users were not considered to co-design but to be involved in all stages, from early envisioning to field-testing the delivered product. And, consequently, knowledge of psychological concepts and models was compulsory for design curricula [6]. Still, some professional users needed, and were provided with, tools they could and would adapt to their individual way of use [7].

The 90s saw the explosive expansion of ICT availability and use. ICT use for *professionals* still expanded. Hypertext and the World Wide Web supported quick collaboration and availability of remote sources and facilities. At the same time, ICT started to play a vastly growing role in the *consumer* context: as a time and place independent entry to public administration, private banking, and health care, as a tool for participation in society (news, entertainment) and politics (blogs, voting), for private buying (Amazon.com) and selling (eBay). New theories entered the library of user centred design, like Distributed Cognition [8] and Contextual Design [9].

The 21st century came with even more challenging developments. Apart from the still growing professional and consumer market, *leisure* applications became a major business. The total sales number of Apple's wearable juke-box iPod (first sold in 2001) passed 100 million in the 2nd fiscal quarter of 2007 [10]. At the same time, ICT is increasingly embedded in our *environment*; in vehicles for transport and in traffic technology, and in buildings [11].

3 Computers and People, a Changing Culture

For the early users of ICT the computer was a work bench that allowed them to develop their own tools. Command languages and operating systems like UNIX were a preferred environment since these gave them control. The professional wanted to know what was going on behind the console, paper tape or punch cards. A user interface would have been considered an unnecessary layer in between the user and the tool.

Our world changed, and ICT became available and used by a broad range of non-expert people, workers as well as consumers, for serious tasks as well as leisure. It became part of living in our society, and a core element of our culture, sometimes visible but increasingly embedded in the environment. Apart from the ICT experts, most users do not care 'what is inside'.

Using technology should serve the user's purpose, whether this concerns functionality and user control, or excitement and surprise. Requirements, from the user's point of view, always will include:

- Usefulness – it should support reaching the user's goal or the goal of the 'community' (employer, culture, government) the user intends to comply with. In this respect a further distinction can be made between effective and efficient [12];
- Usability – it should fit the user's possibilities [13] (which often are different for different users or users in different roles), i.e., provide universal access [14];
- Safety – use should involve an acceptable risk for the individual and the community [15];
- Motivating – using the technology should be convincing the user this is the right thing to do (providing satisfaction, in terms of [12]), should provide the intended and expected emotions (e.g., fun for leisure applications) and motives (warning for certain political or ethical communications) [16], or be to a certain extend unpredictable in this respect (games, the iPod shuffle, cultural performances).

All of this still may include aspects of control, as the traditional example of the 'programmable' video recorder and the currently newest 'high –end' mobile phone show us:

- Usefulness is limited to the individual user's ability to access the intended functionality, which, for many people, turns out to be no more than a rumour on availability;
- Usability is limited by people's ability to read small screens, understand the proper language and icons, press small buttons, remember sequences of actions and identification codes;

- Safety is a function of the chance to loose data objects or stored information, accidentally or through misinterpretation of storage and retrieval functions;
- Motivation is influenced by both physical appearance of the gadget, by its cultural image ('all my neighbours have one'), as well as by the obvious success or failure to use the thing.

4 New Solutions Require New Disciplines

In the early days of computer use, user centred design mainly developed from three disciplines: Computer Science (this discipline originally was referred to with labels like 'the art of computer Programming' [17]), Cognitive Psychology [6], and Ergonomics [13]. Cognitive Psychology originally focused strongly on usability of program languages [18] and on planning and problem solving in the case of time related monitoring processes of process control [19]. Ergonomics came into view as soon as large quantities of input and output had to be processed *by the user*. Consequently, the first contributions of this discipline concerned hardware, posture, and workplace design including lightning [20].

Since computers became small and cheap, microprocessors turned up in offices, and PCs appeared at people's desks. Design had to focus, in addition, to software design. Software industry developed applications for a large variety of jobs, e.g., text processing for secretarial work, spreadsheet for financial and planning tasks, and profile programming for lath turners. These users were professionals in their own domains. Cognitive Psychology supported design with knowledge on perception, motor skills, and learning. Human-Computer Interaction (HCI) specialists provided models like GOMS and the Key-Stroke Model (see [6]), developed design guidelines [20], and supported to standards [12]. Classical Ergonomics was considered basic knowledge, HCI is sometimes (especially in Europe) labelled 'Cognitive Ergonomics' [22].

Once universal usability and access becomes a design issue, attention is required to Culture [23, 24]. And when ICT is being used to support people working in groups (Computer Supported Collaborative Work, CSCW), Ethnography is a new source for design knowledge and techniques [25]. These new disciplines have contributed considerably towards the scientific basis for web-based applications and for software for organisations and public administration.

The newest developments, however, have again new characteristics. Current technology allows for rich and intuitive interaction with representations in many modalities and many media: very small or vary large screens, camera, speech recognition, input with gestures and tactile output, etc. Again new disciplines and expertise is needed. Knowledge can be found with industrial design (since ICT gets embedded in 'things' like furniture, consumer products, gadgets and household appliances), and architecture (for technology in 'smart' buildings, vehicles, and our physical environment like roads and parking lots). Theories and techniques have to be borrowed from Cinematography (how to induce understanding of causality and time interruption and flow), graphic arts and crafts, and semiotics (how to represent meaning).

Users (if one can still call people with this label) often are no longer explicitly, knowingly, or intentionally controlling the technology. Sometimes mastery of control is a challenge: the game industry is booming. Sometimes users explicitly refrain from control: the popular iPod shuffle slogan reads 'enjoy uncertainty' [26]. Experience is a new concept that certainly covers more than understanding.

5 An Old Story: Experience as Design Focus

'Experience' has all characteristics of a buzzword. The concept will be illustrated first of all from domains that are not connected to modern ICT, to show it is not new at all to aim a design at an audience. In both examples, the artist (the designer) aims at a representation that challenges the audience to perceive something that is a combination of what is physically presented to the human senses and what is interpreted. In both cases the audience is (correctly) expected to enjoy the sensation of the perceiver contributing to the physical stimuli in developing the total experience.

Fig. 1. *Visitors at Panorama Mesdag*

5.1 Panorama Mesdag, 1881

Our first example is about visual art. The panorama illustrated in Fig. 1 is a cylindrical painting, oil on canvas, over 14 meters high with a circumference of 120 meters. It shows a view on the North Sea, sea dunes and the village of Scheveningen.

It has been painted by one of the most famous artists from the 'The Hague School', Hendrik Willem Mesdag, assisted by his wife Sientje, by Théophile de Bock, George Hendrik Breitner, and Bernard Blommers. The graphics may look like a color photograph taken from a dune in 1881, but that was not the intention of the designer. The picture is still on display in its original setting, in a large hall, where one enters through a tunnel and a narrow staircase that climbs to a covered arbor on a sand hill (see picture). The visitors in 1881 needed to walk only10 minutes to view the real scene. Visiting the panorama allowed them to experience and to enjoy the *virtual* environment. Visitors today imagine being on a sand dune and see what Scheveningen looked like 130 years ago, and many are tempted to even smell the salty see air. Only a very small fraction of the 1000s of visitors during the years ever will ever have taken the scenery for real. Most were happy to pay the entrance fee for the pleasure to dwell in a 'look-a-like' environment and to imagine the real scene, knowing it was their own imagination, not reality as such.

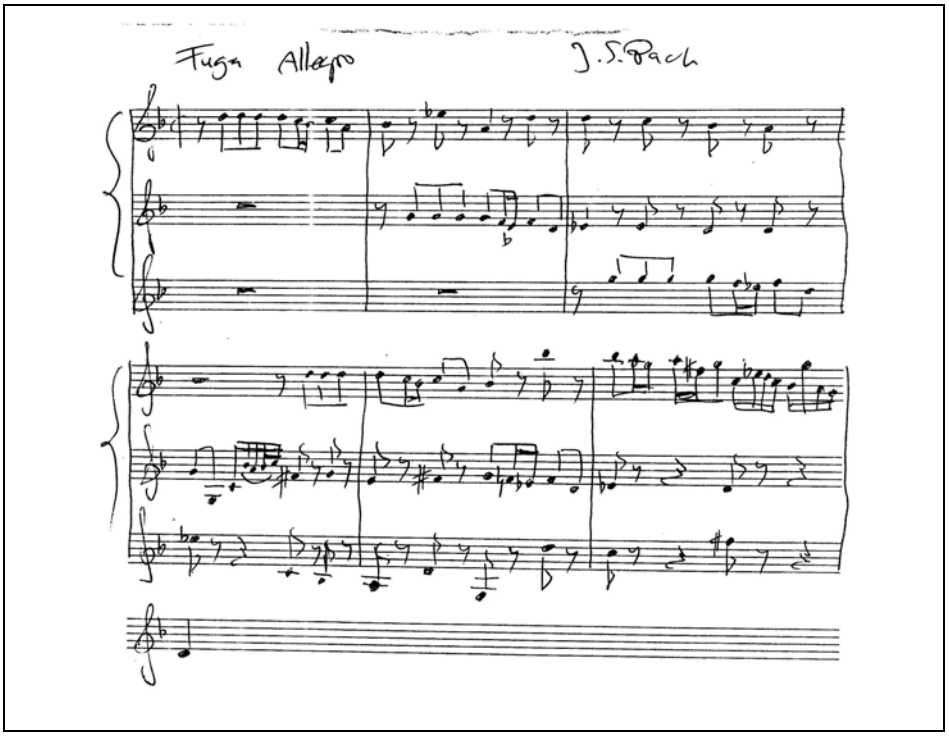

Fig. 2. *Start of the fugue from J.S. Bach, transcription G.C. van der Veer*

5.2 Bach's Fugue for Violin Solo

Johann Sebastian Bach wrote many fugues, compositions for multiple voices that, one after the other, each start with the same theme (beginning at different tones).

Bach wrote for many instruments, and he had many pupils and most of his many children were excellent musicians. The Fugue from Sonata BWV 1003, of which the start is transcribed in Fig.2, is a nice example of the complexity Bach confronted his musicians with.

One after the other the voices start, after which a single one remains to embark in exuberant embellishments till the other 2 voices join again. There is, however, something special with this composition. The title page says, in Bach's own handwriting, 'Sei Sonata a Violino solo senzo Basso accompagnato' which means: 'for solo violin only'. Even a professional violin player who studied the performance practice of Bach's time is not able to hit 3 strings at the same time. But it is well possible to *suggest* the simultaneous sounding of the voices. Apparently, Bach intended the experience for the player to make the suggestion succeed, and for the audience (as long as they have some background in the culture of Baroque Music) to enjoy being able to 'hear' what they well know cannot be sounding. In that case, the performer is a designer her/him self, and the choice of the music hall with its acoustics certainly should be part of the design of the performance. Experienced readers of western music even enjoy reading the score and imagining what could be sounding and what could be 'heard': many copies of the score are bought by music lovers who do not pretend they are able to play it. In fact, a famous violin player that should be unnamed recorded the Fugue in the '70s with multi-track recording in order to sound exactly what was written. Many music lovers abhorred the 'mutilation' of the design.

5.3 Designing for Experience

An experience is something that, in the end, is created by the audience, based on information that reaches ones senses and on knowledge about this information ('this painting is 130 years old', 'the score indicates 3 voices, but the player can only play one or two at the time'), and on actual needs ('I want to "feel" being on a sand dune 130 years ago. I do not want to use this view to predict tomorrow's weather'). Each member of the audience 'lives' the interaction with the artefact.

The designers (painter, composer, or performer) need to apply expertise from their arts and crafts to seduce the audience (maybe 130 or 280 years in the future!) to have the intended experience. The designers / artists need to understand the effects of their techniques including the cultural meaning of the signals that represent the information. They also need to understand the possibilities and restrictions of human perception, attention, knowledge, memory, and thinking.

6 Interaction Design as (Part of) an Academic Curriculum

A scientific base for ICT supported experience design (which cannot be the design of experience, but the design *for* experience) requires input from a multitude of disciplines:

- Computer Science, Industrial Design, and Multimedia technology – for applying the engineering techniques and making sure the resulting product complies to the intentions of the design;
- Human sciences, from Psychology (both Cognitive and Emotional Psychological knowledge), Sociology, and Ethnography, for understanding theories, approaches, techniques and tools for analysing and understanding single and multiple people in relation to the use of technology, and Ergonomics for matching the design to human size;
- Design disciplines ('Arts and Crafts') for professionally creating representations that aim at the intended experience.

Industrial practice was there long before Academia. Multidisciplinary teams, and projects that systematically covered multiple sciences, were common practice decades ago, e.g. at Xerox PARC (since 1970), IBM Science Centres (first research in Speech recognition in 1971), Apple Advanced Technologies (1986-1997), and Philips Design (since 1991). Leading visionaries in those settings felt responsible for interaction design that was at the same time useful, usable, and focused on experience.

6.1 Conditions and Ingredients for an Academic Level

Educating designers at an academic level requires multidisciplinary knowledge to be integrated in a single curriculum, with some strong conditions:

1. A systematic approach, i.e., design based on a solid academic theory with scientific quality that supports methods, techniques, and professional use of tools. This could mean providing enough insight and a conceptual framework in alien disciplines to request expert assistance;
2. Each multidiscipline needs a solid base in a mono discipline that acts as ground for developing theory and methods;
3. Designers educated in this way need to be willing and able to apply knowledge and techniques borrowed from other disciplines in an arguable way.
4. In the end each design discipline will need to aim at three goals:
   - design for human size possibilities and restrictions;
   - specify the system completely as far as relevant for all (types of) users and stakeholders, i.e., specify the Users' Virtual Machine [4]; and
   - aim at experience, (users' understanding, activity, sensations, and emotions, in their context and culture) [27].

Interaction design education requires a combination of the discipline groups as mentioned in section 5.3. Until the '90s the basic discipline mentioned in condition 2 was most frequently either Computer Science or Cognitive Psychology. This last discipline still plays a role in rather traditional Cognitive Ergonomic approaches

where mainly single user interaction for professional tasks is concerned. Generally speaking, however, Cognitive Psychology is no longer a default home for a curriculum in Interaction Design. The main current options appear to be Communication Science, Industrial Design, Computer Science (especially Software Engineering), and Interaction Design (or Multimedia Design) as a specialisation of Artistic Design.

6.2 A Case: Interaction Design in Computer Science

The case illustrated here is based on experience in a Software Engineering section of a Computer Science department. Requirements engineering is a major design activity in good industrial practice. Moreover, in industrial design processes there is a considerable amount of user interface building involved. Consequently, there is a need for Interaction Design of a type strongly related to Software Engineering and formal modelling [28]. In that line, courses in Human-Computer Interaction as well as in User Interface Design were implemented [29]. An iterative design process was developed labelled DUTCH (Design for Users and Tasks, from Concepts to Handles [30]) and a task analysis method GTA (Groupware Task Analysis [31]) to support analysis of complex multi-user task domains as well as envisioning of changes in the task domain prior to implementation of new ICT.

The phases in the DUTCH process are:

- a client's original requirements and intentions;
- (task) analysis: knowledge elicitation, ethnography, task modelling
- task envisioning: negotiations with client and technology, modelling again, confronting stakeholders (with scenarios);
- specification: envisioning technology (functionality, dialogue, representation), formal specifications;
- confronting stakeholders: mock-ups, simulations, rapid prototyping;
- evaluation of resulting requirements for engineering: claims analysis, usability studies, experiments;

where each phase may trigger going back to any of the others, in an iterative way.

The total design process starts with requirements (from the client of design), as well as ends with them (for engineering and implementation).

Starting from this situation, the challenge was to develop a complete academic curriculum in Interaction Design. Section 7 will provide the story, and show some illustrations.

7 Development of a curriculum

The department of Computer Science of the Vrije Universiteit of Amsterdam, the Netherlands, decided for a complete and separate curriculum in Interaction Design, within Computer Science. The New curriculum should pair with an existing specialisation labelled Business Informatics, and both would be divisions of 'Information Sciences'. Graduated Information scientists of both types should be

experts in their specialisation and, at the same time, should understand enough of the whole field of Computer Science to be able to collaborate at a professional level.

7.1 The mission

The curriculum should consist of a 4 year education that included a Bachelor as well as a Master degree. The department aimed at attracting a 'new' type of students, interested in people as well as ICT, that could be prepared for a practical design job in industry (moreover, the Masters degree should be of an academic level that allowed a PhD follow up trajectory).

Market research focused on two populations: highest level high school students (interview and focus group data were collected from 750 students and 25 student supervisors from 50 schools,), and relevant industries (20 multi media design companies, broadcasting companies, museums, etc).

A list of requirements for the curriculum was specified:

- contain enough Computer Science to allow students to actually engineer (and 'build') the products they designed;
- provide extensive multimedia and web design hands on experience;
- integrate artistic and cultural aspects of design, as well as knowledge of history of modern cultural developments;
- integrate human sciences and theory of interaction design; and
- provide experience in team design for real clients and real users / customers.

Based on the market study the curriculum was labelled 'Multimedia and Culture'.

7.2 The Curriculum

A core set of Computer Science courses were identified for inclusion, e.g., full programming education, data base classes, and software engineering, all of which were standard part of the other curricula in the department. Enough Business Informatics was included to prepare students for insight in their future markets and apply analysis techniques.

A total of four courses in Multimedia were included, from introduction of state of the art tools to the design of complex productions. The existing courses in human-computer interaction and user interface design were kept as core courses and a new course in groupware task analysis was added, as well as a practical group project on web design for a real client.

Relevant classes in history of modern culture could be 'borrowed' from the Faculty of Literature and Arts.

New courses were developed in Human Information Processing, in Information Representation, in Visual Design, and in the Design of Music and Sound. All courses developed complied with a general course structure:

- introduction to a systematic design approach, and theory behind this from the relevant disciplines;
- guest lectures from practitioners;

- design for a real client, where students are collaborating in several competing teams for the same client; and
- whatever the topic (visual design, music, website, user interface) the design process takes the whole way from original requirements till presentation and documentation of the design product.

The Bachelor education finishes with two projects where the student participates both in ongoing (PhD student's) research, and in a practical design project in industry. The Masters finishes with a thesis based on 6 months of work, either in industry or with an academic researcher where the student completes a well defined task and writes up the process as well as a scientific analysis or a related piece of research, in the format of an academic publication.

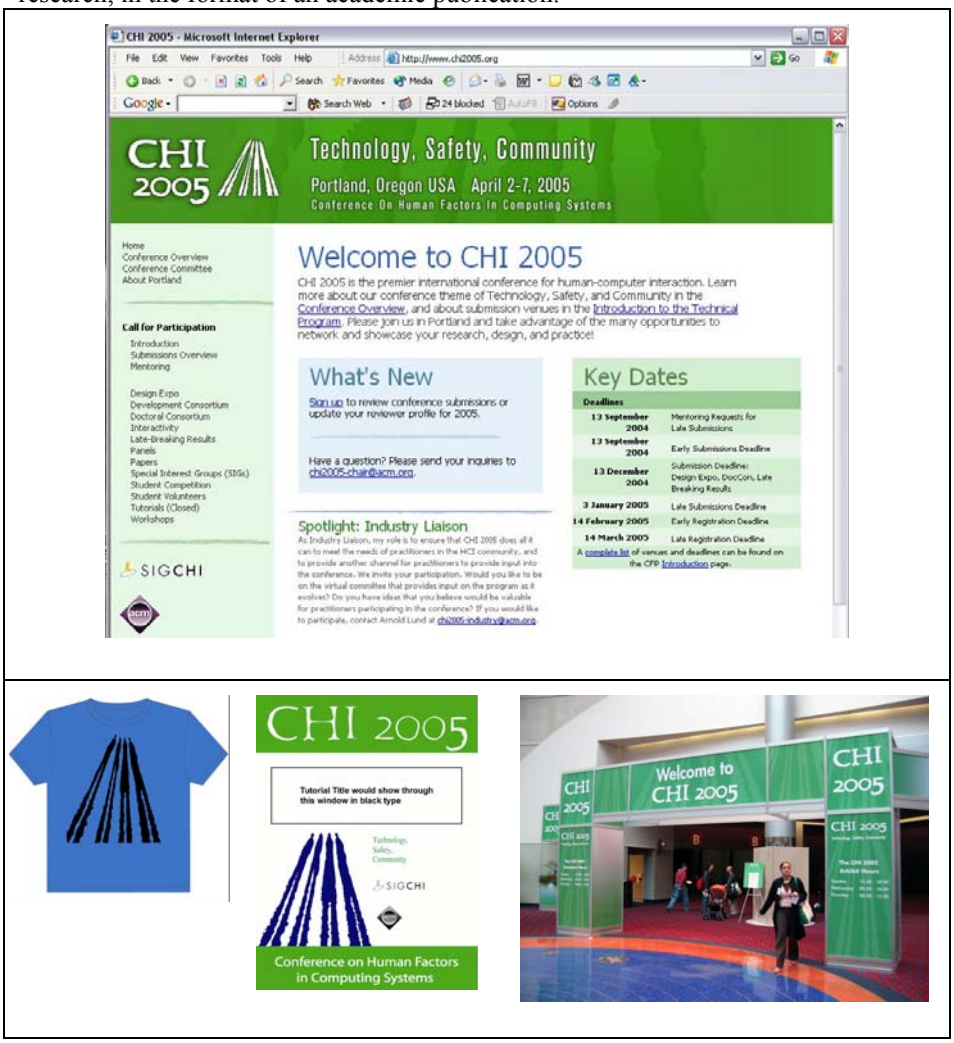

Fig. 3. *Sample of 'winning' design products for CHI 2005*

7.3 Example Student Project for the Course Visual Design

In 2004 three different student groups (each composed of 3 students) chose to work for the conference CHI 2005 to develop and implement a house style.

After studying visuals from previous CHI conferences, extensive communications with the management of the 2005 team, and analysing the theme of the conference, each group developed a logo with several variants as well as example applications for the various conference products: publicity (flyers, postcards, advertisements in magazines), website, printed material (program book, proceedings, tutorial notes), merchandise (mugs, t-shirts), on site decorations, and animated video clip to announce the conference one year out, including a hip-hop beat and a rap. All groups had to develop the full set of decorations and products, one design was chosen based on the presentation to the conference team and the reactions on this. Fig. 3 shows some of the products of the winning design. In fact, all three groups passed the exam of the course based on their products and presentation.

7.4 Example Student Project for the Course User Interface Design

Based on a collaboration of five students that intended to develop a start-up company, on a market research among the domains of dance education and of physical rehabilitation, and on support from the Faculty of Human Movement Science, two students choose to bring their own project to the course. Their aim was to develop a take-home device with interface for unsupervised training (e.g., at home of movements that had been introduced by teachers or physiotherapists to dance students or impaired patients. The users were supposed to practice between supervised sessions, the market of training institutes did not appreciate stand alone solutions.

To this end, the students developed a business model (as part of another course), analysed many existing types of representations of movements, iteratively worked through several design cycles according to the DUTCH approach, and developed a full formal specification as well as an interactive mock-up (running on a PC) for a single example, the basic Salsa step. In addition they developed a mood board for the dance to guide them in their graphics, and they developed moving figures based on photographs of themselves and a system of stick figure movement decomposition (see Fig. 4).

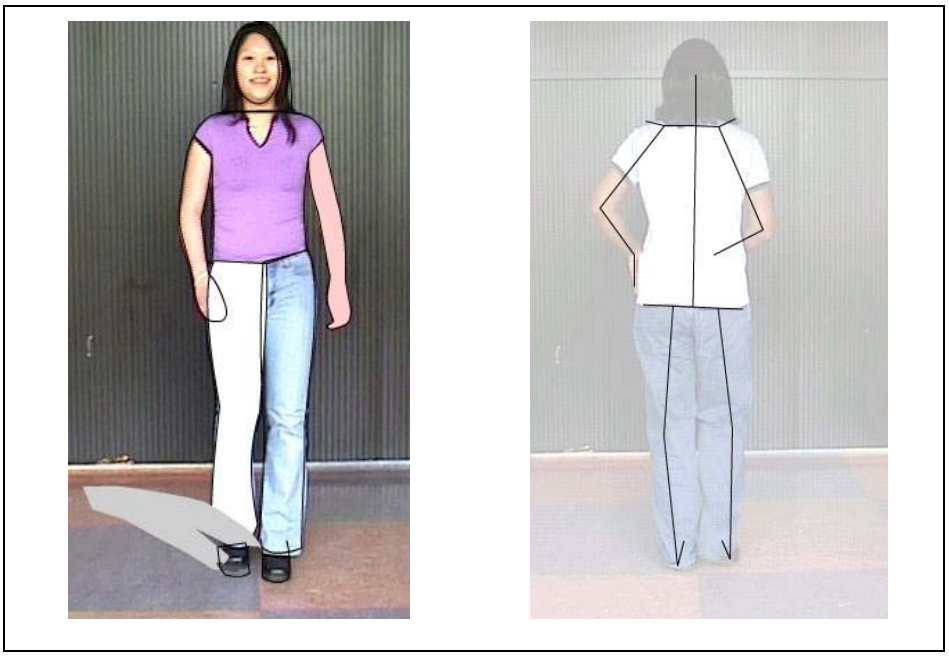

Fig. 4. *Development of a moving dancer for the 'Virtual Dance Tutor'*

The full prototype (see Fig. 5 for the main screen) as delivered allowed a choice of dancer (male, female, pair) or feet to be represented in the movements, a possibility to choose sound (simple or complex melody, with or without counting), the adjustment (slowing down) of the speed, and the optional labelling of the individual steps.

7.5 Successes and Failures

The curriculum attracted a considerable number of students (after the first two years, the number was over the yearly number of new students for either the departments of Physics, Chemistry, or Mathematics!). Students earned their degrees in time and either found jobs in industry or embarked in a PhD study.

On purpose the concept of 'creativity' was never mentioned, not even by the visiting 'artist' lecturers. In every course the methodology of systematic design approaches and explicit design decisions was stressed. Still, creativity was never banned, though a design rationale of some sort was asked for all decisions.

Students liked it, clients for the design courses liked it, and employers liked it. The Faculty of Sciences, however, that is the new higher authority of this curriculum, and with them the department of Computer Science, did not like the multidisciplinary character of the new team of lecturers and the curriculum. A financial crisis in the department led to the decision to cut back on the number of curricula, and 'Multimedia and Culture' was decided to die. One of the Professors of Computer Science stated 'My students do not need to talk to people'.

Since the original curriculum started several other Universities started curricula that are rather similar. The good news is that most of the courses developed are now adopted in other Universities, in some cases in rather concise format, in other cases without major adjustments.

Fig. 5. *Main interface screen for the 'Virtual Dance Tutor'*

8 Summary and Conclusions

Interaction design is a label with a multitude of meanings, depending on the time in the history of ICT, and on, both, the contributing disciplines, and the adopting academic discipline. 'Experience' has been identified as a leading concept in current approaches to Interaction Design. In order to illustrate the possibilities, the history and structure of one example curriculum, positioned in Computer Science, has been discussed in detail. This shows how such a curriculum can be developed, what possible successes are, and how an academic context may also lead to the destruction of it.

References

[1] A. Newell, and H.A. Simon, *Human Problem Solving*, (Prentice-Hall, Englewood Cliffs, NJ, 1972).

[2] E. Mumford, *Designing human systems for new technology: The ETHICS method*. (Manchester Business School, Manchester, UK, 1983) .
[3] G.E. Pfaff, and P.J.W. ten Hagen, (editors) *User Interface Management Systems*, (Springer Verlag, Berlin, 1985).
[4] M. Tauber, On mental models and the user interface, in: *Working with computers: theory versus outcome*, edited by G.C. van der Veer, T.R.G. Green, J.-M. Hoc and D. Murray (Academic Press, London, 1988).
[5] T.P. Moran, The command language grammar: a representation for the user interface of interactive computer systems, *International journal of man-machine studies*, **15**, 3 - 50 (1981).
[6] S.K. Card S.K., T.P. Moran T.P. and A. Newell, *The psychology of human-computer interaction*, (Erlbaum, Hillsdale, NJ, 1983).
[7] B.A. Nardi and J.R. Miller, The Spreadsheet Interface: A basis for end user programming. Human-Computer Interaction, in: *INTERACT'90* (Elsevier, Amsterdam, 1990) pp. 977 - 983.
[8] E. Hutchins, *Cognition in the Wild,* (MIT Press, Cambridge, MA, 1995).
[9] H. Beyer, and K. Holzblatt, *Contextual Design: A customer-centered approach to systems design*, (Morgan kaufman, San Francisco, CA, 1997).
[10] Apple Inc., Apple Reports Second Quarter Results, (2007) http://www.apple.com/pr/library/2007/04/25results
[11] P.J. Denning (editor), *The invisible future, the seamless integration of technology into everyday life*, (McGraw-Hill, New York, NY, 2002).
[12] ISO 9214-11, *Ergonomics requirements for office work with visual display terminals, Part 11: Guidance on usability*, (International Standards Organization, 1991).
[13] B. Shackel, Usability- Context, framework, definition, design and evaluation, in: *Human factors in informatics usability*, edited by. B. Shackel and S. Richardson, (Cambridge University Press, Cambridge, UK, 1991).
[14] B. Shneiderman, Web science: a provocative invitation to computer science, *Communications of the ACM*, **50**(6), 25 – 27 (2007).
[15] J. Reason, *Human error*, (Cambridge University Press, Cambridge, UK, 1990).
[16] D.A. Norman, *Emotional design. Why we love (0r hate) everyday things*, (Basic books, New York, NY, 2004).
[17] D.E. Knuth, *The Art of Computer Programming, Volume 1: Fundamental Algorithms* (3rd edition), (Addison-Wesley Professional, Reading, Massachusetts, 1997).
[18] T.R.G. Green, Sime, M.E. and M.J. Fitter, The art of notation, in: *Computing skills and the user interface*, edited by M.J. Coombs and J.L. Alty, (Academic Press, London, UK, 1981), pp 221 – 251.
[19] J.M. Hoc, Strategies in controlling a continuous process with long response latencies: needs for computer support to diagnosis, *International Journal of Man-Machine Studies*, **30**, 47 - 67 (1989).
[20] B. Shackel, *Man-computer interaction: human factors aspects of computers and people*. Nato Advance Study Institutes, Series E: Applied Sciences, 44, (Sijthof & Noordhoff, Alphen aan de Rijn, NL, 1981).
[21] S. Smith, and J. Mosier, *Guidelines for designing user interface software*, Technical Report MTR-010090, EDS-TR-86-278, (The Mitre Corporation, Bedford, MA, 1986).
[22] P. Falzon, P. (editor), *Cognitive Ergonomics: Understanding, learning and designing* 1986) *human-computer interaction*, (Academic Press, London, UK, 1990)
[23] G. Hofstede, *Cultures and organizations: Software of the mind*. (McGraw-Hill, London, UK, 1991).
[24] G. Hofstede, *Masculinity and Femininity – The taboo dimension of national cultures*, (SAGE Publications, London, UK, 1998).

[25] S. Knaster, iPod shuffle Tips and Tricks, (O'Reilly, 02/15/2005) http://www.oreillynet.com/pub/a/mac/2005/02/15/shuffle.html

[26] B. Jordan, and A. Henderson, Interaction Analysis: Foundations and Practice, *The Journal of the Learning Sciences*, **4**(1), 39 - 103 (1995).

[27] D. Vyas and G.C. van der Veer, Experience as Meaning: Some Underlying Concepts and Implications for Design, in: *Proceedings of ECCE-13*, (ACM Press: NY, 2006) pp. 81 – 91.

[28] G.C. Van der Veer and J.C. Van Vliet, A Plea for a Poor Man's HCI Component in Software Engineering and Computer Science Curricula, *Computer Science Educational Journal*, **13**(3), 207 – 225 (2003).

[29] G.C. van der Veer, B. Bongers and D. Vyas, DUTCH - Teaching method-based design (*EU CONVIVO Faculty Forum*, Graz, Austria, 2006), http://www.hcieducation.com/pmwiki.php?n=WorkShops.CONVIVIO2006

[30] G.C. Van der Veer and M. van Welie, Chapter 7 - DUTCH – Designing for Users and Tasks from Concepts to Handles, In: *The Handbook of Task Analysis for Human-Computer Interaction*, edited by Dan Diaper and Neville Stanton (Lawrence Erlbaum, Inc., Hillsdale, NJ, 2003) pp. 155 - 173.

[31] M. van Welie and G.C. van der Veer, Chapter 19 - Groupware Task Analysis, In: *Handbook of Cognitive Task Design*, edited by Erik Hollnagel (Erlbaum, Inc, Hillsdale, NJ, 2003). pp. 447 - 476.