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Ambient and Pervasive Design: HCI Education from UbiComp to Creative Design

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ABSTRACT

This paper discusses the design of the Ambient and Pervasive Design course as a practice-oriented course to introduce students to the basic techniques for building Internet of Things applications. AmbiPerv derives from a more extensive theory-oriented course entitled DevThis and we discuss the differences between the two considering the transition of the Media Technology curriculum towards a focus on Human-Centred Creative Technology.

Author Keywords

Ubiquitous computing; ambient intelligence; pervasive computing; social media; sensory applications; education; curriculum development.

ACM Classification Keywords

K.3.2: Computer and Information Science Education. H.5.2. User Centered Design.

INTRODUCTION

Developments in the area of HCI are proceeding in rapid succession with the consequence for teaching HCI curricula, that factual knowledge, book knowledge and the know-how to use particular programming languages and tools are gradually becoming less important whereas the ability to keep track of developments in the application area, the ability to do research to support design, and the ability to know how to develop conceptual solutions and translate them into demonstrable products are becoming more important [6][7][14].

HUMAN CENTRED CREATIVE TECHNOLOGY

Media Technology is a BA curriculum of Rotterdam University of Applied Science which focuses on Human-Computer Interaction in area of Media Design with a technical but user-centred focus. Based on the vision that HCI is rapidly moving out of the personal computer and out into the (real) world at large utilizing open data, sensory information, location-based awareness and intelligent interfaces, a course, entitled DevThis (short for: Development in Media Technology) was designed to address these changes and familiarize students with the new developments. The course was also designed to implement, albeit independently of the vision, a number of ideas concerning education, research and development in Media Technology. DevThis attempts to put teaching, designing a product and doing research in one course (see: [5][6]).

In DevThis, students are introduced to a number of new developments in the area of HCI and Media Technology. They are taught about applied scientific research with application development on the basis of scientific literature and resulting in a concept poster, a product prototype and a short scientific paper. Finally, the course itself acts as a facility for research and development.

In the past two years, some of the ideas with which DevThis had been developed did become common in Media Technology but also a relatively new concept arose: HCI or media design as *Human Centred Creative Technology*. With *Human Centred Creative Technology*, an additional focal point is introduced: the creative application of technology beyond the proverbial 'textbook'.

Teaching creative design requires, among other, extend the design practice with techniques to support novel solutions, such as, creative research tools, exploratory design and co-design. To facilitate creative design, often special workshop forms like pressure cookers are used and design laboratories like an open data lab, a sensor lab and a fablab. Finally, the notion of design as creating a product should move to the cyclic process of concepting, demonstrating and prototyping.

To support the transition towards the creative application of media technology, a new course was designed, based on DevThis but earlier; in the second year of the curriculum: Ambient and Pervasive Design or AmbiPerv.

DEVELOP THIS

Development in Media Technology (DevThis) was originally designed as an 8 credit research and development module for students in their third or fourth between the internship period and the BA thesis project. It was designed to achieve two educational goals at once: to teach advanced students to do scientific research and introduce them to the technological, design and scientific developments in the area of Human-Computer Interaction, such as social media and co-creation, personalisation, context sensitivity and location-based services, agile development, co-design, and the use of living labs and emergent design practices.

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DevThis was also intended as a vehicle to perform research with two goals: first, to teach how to do research by actually doing just that. DevThis students were asked to develop a social, mobile and context-sensitive system to increase social cohesion, with the results that knowledge was gathered about how to do this, see: [5][6]. Similarly, when the new sensor lab/fablab/open datalab was opened in 2011, students were asked to create intelligent sensory applications to help manage the laboratory building and its facilities and devices. In this case, the research projects were used to acquire knowledge about how to do this. Also, a number of demonstrators were build to show what one can do with such laboratories.

In addition to gathering knowledge, DevThis also attempted to make the results of education projects useful beyond education itself. To avoid wasting effort, creativity, knowledge and actual results, the second research purpose of DevThis is to facilitate the accumulation of design knowledge. According to Troxler and Wolf [13], the concept of accumulation of knowledge (or ideas, creativity ...) is common to fabrication labs aiming to serve as innovation ecologies. Likewise, DevThis students are requested to leave behind documentation and examples for future re-use and extension of their product designs.

Develop This setup

The basic design for DevThis was that the module consists on the one hand of theoretical instruction about ubiquitous computing, including learning to read, study and possibly write scientific papers, and on the other hand it consists of a practical component where students work in teams of 3 or 4 on a ubiquitous computing project in which they have to develop a demonstrator and whilst motivating all their design choices considering software architecture, the frameworks used, the development methodology chosen, etc. etc. The classical teaching takes place in a number of lectures about developments in the research area and about research methodology which are supported by regular student assignments; so much as possible, assignments are setup to allow the students to link the our teaching at the scientific- and technological levels to recognisable elements in their own 'everyday' level of their experience, which is very much oriented towards the developments on the market and in the media. Among the concepts that students choose are automated attendance lists, information adapted to situated displays, tagging of clothes for suitable combinations, etc.

In addition to classical teaching, arrangements have been made to have students teach each other by means of lecturing their classmates, and presenting their own specific areas of expertise in workshops. Following Pask [10] this mode of learning is referred to as 'teachback', assuming that learning is facilitated by actively explaining and working with learning material. These are some of the lecture topics:

- Arduino as a development platform
- the psychology of design
- use of digital maps
- face recognition
- user profiling with sensors
- object recognition algorithms

Finally, students learn by being actively engaged in team research projects, which prepares them for their final thesis project and for working life, and they have the opportunity to do and learn from doing their own research project.

On the basis of a literature study, student teams develop their own conceptual solution and present these as a research poster about halfway though the module. Next, making a substantiated choice of development platform (Arduino, Apple, Android, etc.), tools, frameworks and the design and development methods (co-creation, Scrum, XP, etc.), the teams develop a prototype as a proof of concept. Finally, the teams present and document their findings in a report for re-use in follow-up research projects, and they may receive a bonus mark for writing a short paper equivalent of their regular project report. These are examples of concept demonstrators:

- Wifi broadcasting @ site
- Building access control
- Mobile money with NFC
- Indoor climate control
- A Bluetooth remote for old TV's
- Ubiquitous game with sensor data

DevThis evaluation

DevThis modules have been successful in teaching students how to do research in combination with doing research in relation to the new developments in the field. Compared to a few years ago, students know much more about the tools, techniques and frameworks for developing mobile and ubiquitous computing applications and both, the knowledge of the research and the ability to use scientific resources and methods have significantly improved [5].

There is one major disadvantage in DevThis with respect to supporting the *Human-Centred Creative Technology* approach, common to many 'knowledge-centric' approaches to creativity and creative design: the notion that creativity should be preceded by expertise [3][4].

Evidence in the ICT and Media area seems to suggest that successful application of creativity does not require complete knowledge of the application area but rather that it requires just a basic understanding of the area in combination with accessible tools [3][4][8]. As such, in order to support the development of creativity within a regular HCI or media curriculum, courses might better not focus too much on knowledge but on resources and tools.

AMBIENT AND PERVASIVE DESIGN

The *ambient en pervasive design* (AmbiPerv) course is a 2 credit second-year course which exemplifies how a course like DevThis which demonstrates various aspects of the vision of Human-Centered Creative Technology, may be used to guide the design of other courses. Second year MT students have been introduced to e.g. user interface design, software engineering and (PHP) programming but they have not yet been introduced to more advanced topics like e.g. research methodology, design patterns or sensory interfaces.

In AmbiPerv, students use the Arduino toolkit ([1]; see: http://arduino.cc) to work with sensors and effectors in IoT applications, running on the connected pc or as stand-alone on the Arduino board.

The purpose of AmbiPerv is to let students get acquainted with the Internet of Things (IoT) within the areas of HCI and Media Technology. First, students are introduced with the concept of IoT using video material from Bassett et al. [2] and other examples. IoT is related to the 'Make' movement and a link is created with the Arduino development platform with the well-known presentation of Massimo Banzi at Ted [1] exemplified with building the 'Blink' application with an Arduino kit. Experimenting with the Arduino kits is supported with references to resources and Arduino Crash Courses (e.g. [9][14]). Some of the students who had already followed the first-year optional FabLab course [12] sometimes acted as student-teachers.

Subsequent lessons introduce students to the basic concepts of working with electronics and stepwise refine the blink-application to reading sensors, transferring sensor information to a pc over the serial port with PHP and Node.js (see: http://semu.github.io/noduino/) and presenting the results in a graph that may be accessible over the internet, using the 'processing' programming language (see: processing.org). Lessons are designed such that students are not merely taught about how to get things done but rather where to locate additional resources and examples to create their own solutions.

In addition to introducing the concept of the Internet of Things, further explanation deal with various subtopics in more depth such as a brief history of Ubiquitous Computing, the semantic web and linked data, and various new approaches to designing media applications, such as co-creation and co-design [11], agile design, and IoT-specific design notions such as mashups and exploratory design [7].

In parallel to introducing Arduino and the Internet of Things, students do three assignments of increasing difficulty. Assignments start with copying or rebuilding the Arduino applications which deal with the basic techniques for building IoT applications in general:

- connecting the development board
- reading sensors
- writing effectors
- transferring data
- presenting information elsewhere

Next, students are requested to develop their own concept idea for building an IoT/Arduino application to sense whether the atmosphere is healthy, guided by a worked out example (see: http://learn.adafruit.com/tmp36-temperature-sensor/overview). The concept must utilise multiple sensors and use social media to influence the behaviour of people.

To develop a concept it is necessary to do both theoretical research, to establish what to measure for what purpose, as well as technical research, to establish how to measure and implement the concept.

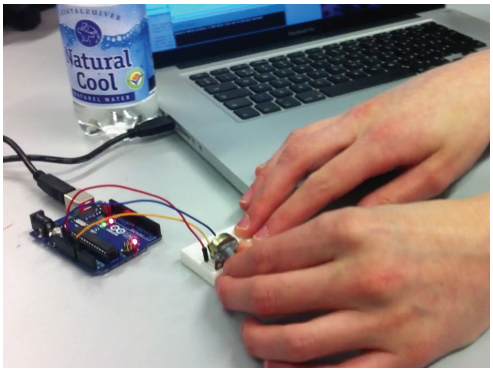

Figure 1. Cool Arduino project

Finally, students are requested to actually build a prototype as a 'demonstrator' of the feasibility of the concept, and make a videotape which is handed-in for evaluation.

AmbiPerv versus DevThis

In the ambient and pervasive design course, three aspects of the DevThis approach were skipped to address the fact that AmbiPerv students are less advanced in their studies then the DevThis students and because an introduction to the basic (programming) techniques for building IoT applications in AmbiPerv replaces the research goals of DevThis.

First, there is no need to provide a more or less complete overview of the new developments in HCI, such as agile and co-design methods, intelligent interfaces and metadata. Instead, rather 'tangible' examples are presented in an easy to grasp manner, like YouTube films.

Secondly, students are not requested to create a design based on extensive theoretical research; they are not required to read scientific papers, to argue why a particular solution has been chosen, and neither is there a requirement to scientific paper alongside the end-result in the form of a prototype application.

Thirdly, it is not required to follow and evaluate a particular design method and consequently, it is not possible to investigate the utility of various design approaches. Instead, students are led through a development process in which, in a step by step approach, all the essential or basic techniques to create an Internet of Things (IoT) application are presented, explained and evaluated. Student may focus on building without being bothered with scientific research.

DISCUSSION

The design of Ambient and Pervasive Design differs in various aspects from its origin Develop This. These changes have been introduced in order to meet the demands of presenting an IoT course in an earlier year in the Media Technology curriculum in combination with the wish to focus on solely proving students with the technical necessities to start building Internet of Things application rather then provide a scientifically more-or-less complete overview of the area in combination with opportunities for applied research.

Research opportunities are lacking in the current development of the course. In subsequent versions, it may be possible to introduce some form of research. Hopefully, when students are technologically better equipped, more interesting investigations may be possible, later on.

The evaluation and performance data about AmbiPerv is incomplete and, as such, only conclusions may be drawn from most of the actual lessons and from personal impressions.

Two conclusions are prominent: first, second year students enjoy building things with their hands as opposed to studying research papers. In this respect, we may conclude that a practise-based approach has a noticeable and very positive influence on student-motivation. This conclusion supports the notion that education should support rather than hamper creative exploration and experimentation as suggested by [3][4] about learning in children and by [8] regarding design students. Even thought second year AmbiPerv classes are more crowded then the third year DevThis classes, it turned out both easier and more pleasant to teach AmbiPerv.

A second effect of AmbiPerv is that students become familiar with notions such as sensory systems, intelligent interfaces and mashups much earlier in their studies which creates better opportunities that students are eventually going to design creative and innovative applications. It is remarkable how much these students differ from the DevThis students who attempted to develop Arduino applications, a few years ago, without any teaching support. AmbiPerv shows that a tightly structured course that takes students by the hand makes it possible to teach the technical skills for creative design early on in the curriculum. It remains to be seen, however, if the increased skill levels in an early stage will eventually compensate for a diminished level of abstraction and less knowledge, later on. In similar vain, one may ask what will remain of an advanced course like DevThis when it is stripped from advanced topics like research methodology, design methods and, with AmbiPerv, interfacing with sensors and effectors is put in a separate course.

Develop This and Ambient and Pervasive Design differ in their position in the curriculum but also on ideas about how creative design should be encouraged in design courses, such as: based on minimal examples or a complete overview, self-guided scientific exploration or guided by assignments, directed at research or at basic how-to-do-it skills to stimulate creativity.

Overall, it seems safe to state that presenting students with the basic techniques earlier-on in their studies will have a positive effect on the levels of creativity in the design capabilities in future students, supporting the transition from knowledge-based design to media design as *Human Centred Creative Technology.*

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