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 Human-Computer Interaction 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.

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.

In addition, 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 Media Technology, such as co-design, intelligent interfaces and sensory interfaces. Furthermore, students are taught about applied scientific research by means of concept and application development on the basis of scientific literature and resulting in both a prototype and a scientific paper. Finally, the course itself acts as a research and development project for future education and therefore takes place in a living lab environment consisting of an open data lab, a fablab and a sensor lab.

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. Previously, Media Technology took a user-centred but technological point of view: it deals with technology for human ('user') purposes. With Human Centred Creative Technology, an additional focal point is introduced: the creative nature of design. Within the view, media engineers should not design for technology itself and not just create technical solutions to support real people in the real world, but engineers should also be engaged in designing creative solutions; solutions beyond the proverbial 'textbook'.

Teaching creative design requires a little more then adding a few creativity courses; it also means that design should move from a focus on user-aspects by means of user-centred design, usability evaluation and accessibility engineering along with the usual technical topics such as requirements engineering, agile design and UML and extend the design practice with techniques to support novel solutions, such as, creative research tools, exploratory design and co-design. To facilitate the human-centred creative technology, increasingly often special workshop forms like pressure cooker settings are used and design
DEVELOP THIS

Development in Media Technology (DevThis) was designed as a research and development module in the Media Technology Bachelor to achieve two educational goals at once: teach advanced third year 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.

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, and indeed, it is common for fablabs to ask their users to leave behind examples and documentation for future re-use of the design of the products made there.

**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; in the manner, students are engaged in a professional situation which prepares them for the final project and 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 successful in teaching students how to do research in combination with doing research about into topics related 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].
These is, however, a 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, and that is 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 PERSAVIVE DESIGN

The ambient en pervasive design course is a 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. In this course, students use the Arduino ([1]; see: http://arduino.cc) toolkit to experiment with the use of sensors and effectors in computers applications, either on the connected pc or as stand-alone applications on the Arduino board.

The purpose of the Ambient and Pervasive Design course is to let students get acquainted with the concept of 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 (eg. [9][14]). In addition, 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/hoduino/) 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 merely taught about how to get things done but rather where to find additional resources and examples to find their own way.

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 are requested to perform 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 affectors
- 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). For the concept it is required that multiple sensors are used in combination with social media in order 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.

Finally, students are requested to actually build a prototype of the concept 'a demonstrator' to present the feasibility of the concept. Students make a video of their demonstrator 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 advances in their studies then students are who follow DevThis and because an introduction to the basic (programming) techniques for building IoT applications replaces the research goals of DevThis.

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

Regarding opportunities for research: these are indeed missed. Hopefully, when students are technologically better equipped in later-on, more interesting investigations may be possible. Regarding the differences between the two courses AmbiPerv and DevThis, not all evaluation and performance data is available and, as such, only conclusions may be drawn from most of the actual lessons.

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. 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 -early in their carriers- students are 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.

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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**REFERENCES**