Laser Cutter and Needlework: Tinkering Projects in Class

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Abstract
Creating interactive things involves more and more a lot of tinkering but also involves a lot of knowing how to design and implement interactive systems. In this paper, we present our experiences in teaching the design of interactive systems at an MSc level employing the tinkering devices in our fab lab but also designing a creative interactive solution for a given challenging problem.

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learning, teaching, personal fabrication, wearable computing, lasercutter, 3D-printer

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
With the availability of small and reasonable low-priced micro-controller boards such as the Arduino, lots and lots of sensors and actuators and also the arrival of fabrication tools such as laser cutters, 3D printers to the HCI labs, it became natural to experiment with them and also teach students how to tinker [4]. As an HCI lab we aim to teach user centred design of interactive systems. In our courses Pervasive Interaction Lab and Interaktionswerkstatt we

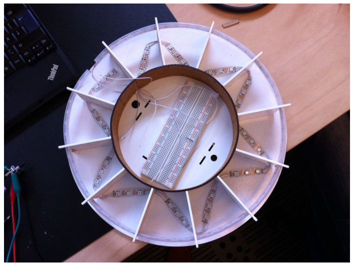

Figure 1: Top-view of clock prototype with breadbord and leds

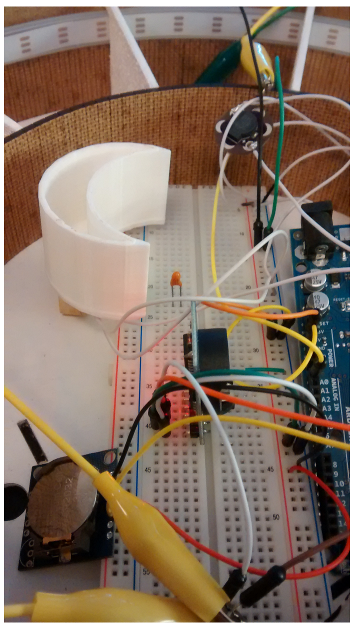

Figure 2: Prototypical wiring and the 3D-printed moon

teach students how to design and develop an interactive system based on the Arduino platform and different available sensors. We allow and embrace the students' creative design ideas and help them to bring them to live during the term. Teaching how to tinker in our understanding is also teaching how to achieve reasonably well solutions in a given time frame. In result our students can finish the course with an exciting prototype while having experienced all different stages of the human-centred design cycle from requirements engineering to design to prototyping and first study results [1].

Teaching to Tinker

Preparing the Fabrication

We understand teaching essentially as the challenge to provide an infrastructure for students that enables active and individual engagement with the subject matter. Modern fabrication tools allow us to expand this infrastructure with hands-on learning experiences. For the material and devices we have bought and planned for the courses we ourselves held a series of tinkering workshops. For example, in a first session for Arduino we collaboratively developed the *Elch* (Figure 3). The reasons for these sessions are manifold. First, when we acquire new material which we aim for teaching we consider it to be natural to really understand the technology but also the feasibility to use is by the MSc students during the term. As a result of the first Arduino tinkering we developed a basic set of material that was in our eyes the needed from which the students can start their term projects. We bought and instrumented five tool boxes for each students team with a set of Arduino hardware, prototyping material, sensors and actuators that would be a good basis to implement several kind of wearable and pervasive interactive systems, similar to the EduWear-Kit [3]. The same procedure happens for all the devices.

Figure 3: The Elch turns red when placed upside-down and green when shaken. Other sensors and actuators were used to make different sounds and vibrations depending on the interaction with the Elch.

Figure 4: Clock before final assembly showing laser-cut face

Figure 5: Prototype displaying one of the colourful patterns

Cool and Feasible Student Projects
Prior to the start of the lecture every member of the research group is invited to provide project settings that are considered rich and interesting sub-topics of actual research projects that would make a good tinkering project for a group of three MSc students over a period of 14 weeks. At the beginning of the semester these topics are presented within class to the students. The students can decide according to their own interest which topic to pick and with this which group to join. The member of the research group who provided the topic becomes the supervisor of the students that decided to work on the topic. Ideas for projects are discussed within the group of students and the supervisor. All groups join regularly during the semester to present and discuss their projects. To support iterations of the design and prototype and help the students with their time frame of one term, we are meeting every other week in the plenary group of twelve students and invite the students to come and meet their individual topic mentor in the team in-between. Every two weeks the students both give a presentation of their ideas, concepts, failures and successes in the plenary and show the hardware and software they developed.

Fabrication times were fixed during the week to make sure that the hardware gurus (see next paragraph) for the devices such as the laser cutter, 3D printer or hardware lab were present to aid the students during the fabrication and any questions or problems that occurred. These were not considered a limitation but helped the students to focus on the fabrication times and also plan what they want to curate in these times for their prototype. Most of the development and testing and so on was done by the students in the university labs or at home.

Hardware Gurus - or everyone should be an expert
For all the hardware there is at least one team member that can be asked on the details of the hardware and who has typically also selected and ordered the hardware for the lab. For example, the process of buying a laser cutter was using up a reasonable amount of time by one of the team members. This team member collected all the requirements and was also responsible for getting the offers in and comparing the different features with regard to the lab's requirements. During the first semester with the fabrication tools the set-up with a small group of experts for one machine proved to be useful, as knowledge-sources such as manuals and special tools where known to be found at a certain office. Furthermore the small group of expert supervisors was able to keep track of the use of the machine and hence being able to initiate for instance necessary maintenance. Yet everyone in the group should have a basic knowledge of available tools and techniques to be able to point students into the appropriate direction. Therefore regular tinkering sessions where organized to facilitate the inter-group knowledge transfer. During these sessions members can get an introduction to the machines and have the opportunity to present new processes, materials or ideas. Experiences with lab-tools, materials and techniques were collected in a group-wide wiki. This enables all members to learn the use of lab-machines when needed or to look up configurations for different materials and techniques.

Do not hide your tools
We decided to position the laser cutter and the 3D printer for example on the same floor close to the team members' offices. With this, every use can actually be followed by the team. It causes attraction and finally also emphasizes the exchange on the tinkering on the floor as the members of our group can follow and discuss what results the

others achieve and what experiences they make.

Example Project - The Interactive Child Clock

One of the examples is the interactive child clock. The goal of this project is to develop a clock that helps small children to understand questions "how long is that I can read before I have to go do bed", "how long until we leave for the birthday party" but also providing information about night and day such that a child that wakes up in the night could see if it is still bed time or if one can get up and wake up the parents. The students did an interview with people working at kindergarten and pre-school for some requirements. For the tinkering they decided to stick with the traditional form of a clock but augment it with different light concepts to present the time of the day but also an LED-based progress bar. The results was a watch with traditional 12 hours that was augmented by LEDs for hours and temporal progress along the minutes as well as day and night displays.

Figure 6: Interactive Child Clock

Iterations of Hardware and Software prototypes

Even though the time frame of a term is short, most of the students actually developed three kind of prototypes. All students developed conceptual prototypes, paper prototypes or at least design sketches that show the hardware layout to get a feeling for the size and look and feel of the prototype. Also most of the students reiterated the fabrication of their prototype. The first prototype typically was trying out different kind of materials for the hardware. Some groups developed a smaller version of their future prototype to understand the general layout and then scaled it up in a later more sophisticated prototype. The same also happened to circuits and programming. Following a conceptual plan of the sensors and actuators the prototypes were developed and tested independent of the concrete system. Circuits were for example intentionally tested with breadboards to develop and evaluate before the students entered the more error-prone installation within a fabricated device . The interactive child watch even stayed with the bread board for their final prototype as the circuits were more stable and they did not want to introduce error due to loose connections or so (5).

A few conclusions for teaching how to tinker

For teaching how to tinker we would like to list a few conclusions for the teaching that will make tinkering in class for master students a success, both for the students and the teachers.

- Have regular tinker session for peer teaching among the tutors.
- Name at least one "hardware guru" who is responsible for one machine.

- Have your research team provide well-defined topics that are both highly novel and challenging but also feasible and that are promising exciting results during the term.
- All hardware, tools, software and devices need to be used and tried out by the team before to get an understanding of its practical use but also the effort and time needed to use them for a tinkering project.
- Do not hide your tools.
- Conduct a focussed brainstorming and early prototyping session with the students in the beginning.
- Have students collaborate in project teams. Encourage every student to engage in all aspects of the development process.
- Conduct bi-weekly sessions including student presentation and group discussions of ideas.

Project for the Tinkering workshop

One proposal for the hands-on tinkering session during the workshop is the Illuminating Drinking Reminder System. A bottle of water is placed on the device. Depending on time passed since the bottle was last removed the device lights up. Equipment needed: LEDs (for instance chainable NeoPixels to compose LED-strips[1]), self-made pressure sensors (build during the workshop with conductive foam [2]), pre-cut plywood parts for placing the bottle, cardboard, Arduinos (or Atmel's 8-bit ATtiny85 as a cheap alternative so that participants can actually take the fabricated device home), wires, crocodile clips and generic tools like scissors. With this project we demonstrate for one how we use our machines to build small prototypes. Furthermore we believe that participants of the workshop gain an idea how we integrate our focus topic "information technologies for health care and medicine" into the projects, providing an opportunity to discuss how other areas of interest of the participants could be linked to the field of personal fabrication.

[1] www.learn.adafruit.com/adafruit-neopixel-uberguide/

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