

HOW TO EDUCATE FOR CREATIVITY IN CREATIVE TECHNOLOGY?

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ABSTRACT

Creative Technology is a new BSc programme at the University of Twente. Its goal is to design novel applications and products to improve daily life of people, with ICT as design material. Applications range from everyday life to health support, from playing and entertainment to serious gaming and socializing, from working and learning to art, while using instruments of stimulation, motivation, or support. The goal of the BSc programme is to give students the skills, methods and tools that enable them to design such products.

A paradigm of Creative Technology is that existing technology has a potential that is not yet fully explored. This potential lies in the novel use and ways of integration of existing technologies into new and innovating applications and products. This perspective is different from classical technical education, and, consequently, requires also a shift of design methods and teaching approaches.

How to stimulate creativity is not a new question. However, it mainly is addressed in other domains. Moreover, most of creativity stimulating techniques aims at different target groups, like children, artists, designers or managers, not technology students. And certainly they are not meant as relevant skills within scientific education.

The contribution of this paper is a structured analysis of our attempts and experiences with five cohorts of students in teaching Creative Technology. We will discuss the implications for the teaching practice of Creative Technology and will outline the possibilities and limitations of our practices for other technology oriented design curricula.

Keywords: Creativity, teaching methods, tinkering

1 INTRODUCTION

In Creative Technology, a new BSc programme at the University of Twente, novel applications and products to improve daily life of people are developed, with ICT technology as design material. Applications range from everyday life to health support, from playing and entertainment to serious gaming and socializing, from working and learning to art, while using instruments of stimulation, motivation, or support. The goal of the BSc programme is to give students the skills, methods and tools that enable them in the design of these products.

Creative Technology integrates different disciplines, basically technology, design and business. Art is considered as a source of inspiration and a platform for experimentation. A paradigm of Creative Technology is that existing technology has a potential that is not yet fully explored. This potential lies in the novel use and ways of integration of existing technologies into new and innovating applications and products. This perspective is somewhat different from classical technical education, and, consequently, requires also a shift of design methods and teaching approaches.

In the curriculum, project courses play an important role, taking about a third of the time. The classical courses are arranged around the project courses that the knowledge and skills needed for the practical work is available at the right moment. Creativity is a core ingredient here, for the identification of new areas of applications, and also for the way of using technology.

This paper contains an analysis of experiences in teaching. Starting from different activities that characterize the work of a Creative Technology professional and student, we try to distinguish different roles and forms that creativity takes here. Next, we map these to teaching approaches, helping the students to develop creativity. The concepts of creativity (stimulation) discussed here are not new. The contribution of the paper is to put them into the context of Creative Technology, a technical, academic setting.

2 CREATIVITY IN CREATIVE TECHNOLOGY

Basic characteristics of creative products are that they are novel and valuable. In the literature these aspects are extensively refined and extended, which. For the purpose of this paper it is sufficient to take these basic characteristics that are our reference point when evaluating students' work. Novelty, for us, is an unexpected element, either in the use of technology or in the application.

As sources of creativity are knowledge, thinking skills and motivation [1]. Also here, more fine grained definitions exist (e.g. [11]). Relevant in the first place is, that these components can be developed, implying that creativity can be taught, which is the consensus in the literature.

Our intention is to be as specific as possible, for the context of Creative Technology, in order to get practical examples and principles. Even if our context is an engineering faculty, we do not have to introduce new creativity concepts in a traditional engineering context as in [4]. The goals and tasks of Creative Technology in themselves are already different from the traditional engineering programmes. Making this explicit, we start with a differentiation of the activities of Creative Technology on a more detailed level. Methods to stimulate creativity will depend on the sort of activity and its specific goals. The following is a list of tasks of a Creative Technology student and/or professional, that address knowledge and thinking skills:

- 2.1. The task that Creative Technology does not share with other disciplines is to investigate existing and new technology from the view point of usability in human centred applications. In this line, a habit should be to use material (also) in different ways than it was intended. This requires a different perspective on products and concepts than trained in a classical technology or engineering education. An example for different usage is an old video-recorder, which either can be seen as old video-recorder (traditional perspective, black box view), or as a programmable motor that could possibly be used for an automatic cat feeder¹ (creative technology perspective, understand working principles).
- 2.2. Material mastery is a basis, where the material is technology, ranging from programming to design tools, from electronics to dynamic system modelling, is only gained by hours of experimenting and exercising, next to basic theory forming. A pure black box view on the building blocks or components is too limited in our context. For both, the adequate use of existing components, and for the exploration of future ones (2.1), understanding the working principles of components is crucial.
- 2.3. A Creative Technologist should be able to define and extend her/his own tool set, driven by the area of interest, by challenge or by external factors. Working within a defined tool set requires a different kind of creativity for problem solving. One example here is the kinetic artist and engineer Theo Jansen², building his sculptures only from PVC. The common solution to a wind-driven vehicle being able to move over a beach would lead to a sail-and-wheel solution. The restriction to only one material can lead to very innovative (and aesthetic) solutions.
- 2.4. Creative Technologists have to provide building blocks for other designers, who may not be technology experts, but have, e.g., stronger roots in the health domain (for a health support application), or in education (for a learning game). Identifying and constructing new building blocks is an activity in its own, not part of a user-driven design process. In user-driven design, starting from requirements, product ideas are generated and iteratively refined. At some point, ideas are translated to technological solutions, which are taken from the building blocks available for the designer. This translation moment is typically not a moment where new technology is explored. Examples for existing tool sets are developer platforms like MaKey MaKey³ with a very broad target group ranging from children to artists, or the Sifteo cubes⁴, which are for playing games, but also a platform for game developers. A very prominent building block is the Arduino⁵, allowing the connection the physical world of sensors and actuators with a PC. Other examples are the Cubelets⁶, LilyPad Arduino⁷ sets, or littleBits⁸. The common characteristic is

¹ http://cachefly.oreilly.com/make/television/VCR_CatFeeder_FINAL.pdf

² <http://www.strandbeest.com>

³ <http://www.makeymakey.com>

⁴ <http://www.sifteo.com>

⁵ <http://arduino.cc>

⁶ <http://www.modrobotics.com/cubelets>

⁷ <http://lilypadarduino.org>

that they are designed by creative engineers to enable other designers to create much more easily new products. For Creative Technology students the development of a toolbox is a typical assignment [6] [10].

- 2.5. Together with exploiting existing technology, the identification of novel application domains is a prominent goal of Creative Technology. Much more social and cultural skills are relevant here, in addition to the technical ones. A vision on qualities of life, reflection on culture, the ability position oneself in the society, together with an understanding of technological feasibility is needed here.

3 HOW TO STIMULATE CREATIVITY

3.1 Breaking Patterns

Breaking the patterns of the standard perspective and design approach is a meanwhile well-known technique, that is propagated by, e.g., Design Thinking⁹ and Lateral Thinking approaches [2]. These techniques include reversal of an idea, exaggeration, random connections, alienation, scamper [3] (substitute, combine, adapt, modify, put to other use, exaggerate, reverse), etc.

Practically, it means that the paths of well-known strategies get closed, such that new paths have to be explored, leading to novel solutions. This principle can be supported by methods, and be trained. From a teaching point of view we experienced that we have to force students getting out of their comfort zones (which is sometimes appreciated only much later), until they understand the benefit of the approach. Below, we discuss two techniques that we use in more detail.

Quantitative Idea Generation In the project course “Living and Working Tomorrow” 100 ideas as combination of two topics (e.g. chair and chocolate) have to be produced within one afternoon. After the first couple of ideas, creating such an amount of ideas is hard work, requiring time and focus. In the following, the lecturer together with the students evaluates the ideas, combines them and distils one resulting idea. Next to driving out of the comfort zone, this method follows the creativity concept “quantity breeds quality”. Even years later, the students mentioned this exercise as an eye-opener.

In our courses we use this method for “out-of-the-box” projects and assignments, especially for novel applications as described in 2.5 above.

Limitation We work with limitation of the tool box in assignments, as an “in-the-box” creativity activity. Not having the obvious tools has two effects: one is that new solutions have to be found using the available tools, supporting 2.2 and 2.5 above. The other is that the existing tools have to be extensively explored to identify the possibilities the material offers for new solution, which stimulates 2.1 above. Another explanation for increase of creativity is the following: if the design space is large, much of the creative energy is spent on traversing this design space and evaluating different possibilities in order to focus on a certain subspace. In contrast, in the limitation the designer can immediately spend the energy on the construction of a solution. In the following we illustrate the approach with three examples.

The first assignment was to design a drawing program to be used with only a light sensor and the screen (but no keyboard). A user (lecturer) should be able to draw a naive house with it, at least. The toolset for the students was at this point Processing¹⁰, Arduino and a single light sensor (LDR). To our surprise, the results of the assignment, which was seemingly so limited, were very diverse and creative. After a period of complaining about the assignment, the students invented very different ways to identify positions on the screen and select figures to draw. The results were unexpected, concerning the individual solutions, as well as the range of solutions (moving lines in two dimensions, a half black/half white screen to identify in which half the light sensor is, and the iterating this on the half where it was, different versions of (cascading) grey scale menus etc).

As contrast, the second assignment (in another year), an “out-of-the-box” representative, was to make a digital/physical music instruments, also with Processing and Arduino, but unlimited in the choice of sensors, or kind of instrument, and realization of the sound. The music instrument assignment seemed to allow for much more creativity, a more artistic object to make and not being limited by technology to be used. Some nice results were achieved such as beautifully engineered laser-cut knob-boxes, but

⁸ <http://littlebits.cc/>

⁹ http://en.wikipedia.org/wiki/Design_thinking

¹⁰ <http://processing.org>

mainly unsurprising straightforward solutions were designed, not comparably as creative as in the drawing example. Despite the larger space of possibilities, the overall result was weaker.

The third example is a video-sequence split in single frames that had to be connected to a sensor in a meaningful way. Also in this limited setting very creative solutions were designed. Examples here, were a tomato soup being parted like the Red Sea, which was detected by two distance sensors, (from a film scene¹¹), a bubble gum bubble video, where the bubble gum blew up depending on the force with which the user was blowing on a piezo sensor, or a wheel put in motion, sensed by a potentiometer, triggering the light intensity of a bike light in the video.

Next to the creativity stimulating aspect of the assignments, the examples show that by the choice of the assignment and tool set the domains to explore can be set: for the drawing program a solution required an in-depth analysis of the possibilities of a light sensor, and a solution to be constructed in the software domain. The video-and-sensor assignment gave the technical solution, but the exploration was here more on the conceptual level, i.e. what is a "meaningful" combination of video content and sensor input.

3.2 Choice of the Toolset

In the end, we want to support a certain quality in creativity of novel applications. A way to achieve such a quality is provided by methods, and approaches and examples discussed here could be part of a method. The role of tools is to support methods. However, most discussion is on tools, much less on methods, and even less on quality. Starting our analysis and discussion of tools we also want to recall the observation that good students can be creative with bad tool sets, but bad students still have lousy results with good tool sets. In short, a tool set is always secondary to a method. Even if a well chosen tool set can stimulate, it cannot substitute a method.

In [9], [8] elaborated lists of properties of good tool sets are discussed, which do hold not only for software, but also for technology in a broader sense. The lists include low threshold, high ceiling, wide walls, many paths and many styles, combinability of tools, etc. While we agree on each aspect mentioned, we do not believe that all aspects can be realized in one tool set, and certainly not for a beginner. Instead, we suggest an incremental expansion of tools.

For a beginner, a limited number of components offers a lower threshold, that allows to explore its components sufficiently. A huge toolbox may be intimidating. Our beginners get Processing and the Arduino board and a limited set of electronic components (breadboard, wire, resistors, LED¹²) as toolkit, as in many other places. The basic skills with these environments are taught in a classical course (Programming and Physical Computing). Students use the tools also in project courses. A laser cutter and small 3D printer (makerbot) are available in the lab as tools students learn to use on the fly. Experience showed that for most of their projects on this level this tool set is sufficient.

In the course of the study programme the toolset is extended, by electronic components taught in different courses (Introduction to Electrical Engineering, Sensors, Control Systems), and by a more powerful programming environment, Open Frameworks¹³. Different courses add other tools to the tool set as well, for example the course on interactive visualization uses Blender¹⁴ and Unity¹⁵ as tools.

As discussed also in 3.1, a small toolset and a limited assignment stimulates 2.2, material mastery: if a solution has to be found with very little material, the students have to explore very well the possibilities of the material. The technical skills to extend the personal tool set, 2.3., are taught in more classical courses. The stimulation for creativity here also comes in by, e.g., project work, where the product idea of a group needs solutions outside the current toolbox. In contrast, it seems that, e.g., in [8] only "outside-the-box" creativity, as in 2.5, is considered when talking about toolsets. Then, other kinds of approaches and methods are relevant, such as tinkering, which will be discussed in the following section.

3.3 Stimulating Tinkering

Tinkering is a mindset, a method or a habit, it is a playful bottom-up way to explore technology and its possible applications. Concerning the Creative Technology tasks above, it contributes to material

¹¹ <http://www.imdb.com/title/tt0315327/>

¹² http://www.scintilla.utwente.nl/assets/stores/protobox_quickref.pdf

¹³ <http://openframeworks.cc>

¹⁴ <http://blender.org>

¹⁵ <http://unity3d.com>

mastery 2.2, use of technology in novel contexts 2.1, and novel applications 2.5. On an academic level its benefits are training in the loop of identifying new questions, designing experiments to answer the questions, observing, interpreting the results, and deriving a new question to investigate.

Tinkering is not an approach that comes “naturally” in our educations¹⁶. Even for our Creative Technology students having already tinkering experiences it is not the approach they would choose first to explore new material. In an extra-curricular workshop on wearable technology, where the relevant material was available, like Lilypad sets and lots of extra material, the students did not start exploration of the material. They applied the usual top-down approach, “inventing” some project to do, and then getting frustrated, because the material did not allow for the precise realisation of their ideas. We conclude from that that tinkering is something that has to be taught, or at least stimulated.

There are many toolsets that have potential to stimulate tinkering. Most people have tinkering experiences from playing with toys like LEGO¹⁷. However, even in the LEGO series a distinction can be made between sets for building mainly one space-ship with detailed step-by-step instruction (which can potentially kill tinkering attitude - of course the parts can be used differently) or sets (Creator and Inventor series) aimed at tinkering. One conclusion here is that while a toolset can hamper or stimulate tinkering, it is the mindset, method and environment that really trigger the playful exploration.

Many of the recent (technical) toolkits such as the littleBits or Cubelets have children as target group, or people with little knowledge in technology. Such toolkits may have a value in the very beginning of our programme, but are quickly too limited for our context. Eventually students should be able to turn anything (the world) into their toolset. A great example is the tinkering workshop described in [5] where literally any type of electronic toy is used as system component. One of the vital *skills* in tinkering is expanding the own toolset with enough types of “glue” (fluid experimentation - easy to connect, see below). Making connections on a mechanical level (sometimes there is the need for a universal connection kit¹⁸) or at an electronic level using an Arduino as electronic glue. Considering the academic approaches to tinkering, the choice of toolset should not be limited to (technical) construction, concepts can also be material for tinkering, or tools from design. In a number of project courses also moodboards, personas, scenarios and storyboards are used as toolset in order to try out and test user aspects of designs.

In [8] three core principles necessary for a (technical) toolset to stimulate tinkering are elaborated: immediate feedback (see the result, see the process), fluid experimentation (easy to get started, easy to connect) and open exploration (variety of materials, variety of genres).

We identified a number of additional aspects necessary for facilitating tinkering that have been found vital during courses in the programme where students had to realize or construct something. These aspects address the environment and context next to properties of the toolset components: accessibility, availability and visibility, which are elaborated in the following.

Accessibility means, e.g., that tools are in the same lab, the process or software tools do not have a steep learning curve, many examples and best practices can be found and easily shared, software easily installed, that there are enough licenses. Availability means, e.g., that the student are allowed to operate a laser cutter themselves, or ask the ever-present lab manager, the machine is dedicated for student projects, nothing else, or, for software, there are enough licences. Visibility means, that students see, e.g. the laser cutter working and cutting every day, they see the results of their fellow students who used the relevant tools. We illustrate these aspects by three examples below.

The first example is the laser cutter: While we have a well equipped workshop located in the same building (availability, but accessibility with the effort of going there, and no visibility), students only started building physical devices when we stationed a laser cutter in the lab (more effortless accessibility, and visibility). It took one full year before a method (untaught by lecturers) of designing plywood boxes and shapes entered the “toolset” of the students, passed through by some pioneering students (visibility).

The second example is the electronic toolkit: during the first years of the programme we supplied the students with all the necessary electronic materials (accessibility, but availability groupwise only). In later years, the students had to acquire their own toolkits¹². Availability was increased, as the students

¹⁶ http://www.ted.com/talks/ken_robinson_says_schools_kill_creativity.html

¹⁷ <http://lego.com>

¹⁸ <http://fffff.at/free-universal-construction-kit/>

could use their sets at any moment. Also visibility improved, as all students had most of the time their toolkits lying around doing some projects with them. In the end, besides the savings on buying equipment and organizing, the students improved on getting to know the material and, eventually, the tinkering process.

The third example is software tools, where mainly open source, multi platform tools have been chosen. Availability here includes easy distribution and deployment, the software tools run on the own laptop, they can be used any time or place. Accessibility here is that there are (often) no steep learning curves, many tutorials and examples are online. Visibility here includes, that many examples are provided in lectures and online, and work by fellow students.

Further criteria for designing context of tinkering are elaborated in [8], that perfectly meet our experience: emphasize process over product, set themes - not challenges, highlight diverse examples, tinker with space, encourage engagement with people, not just materials, pose questions instead of giving answers, combine diving in with stepping back.

Summarizing, tinkering is a mindset that has to be learnt. Toolsets can stimulate tinkering, where the properties of the components play a role, but also the environment and context.

4 CONCLUSION

Our challenge is the education for creativity in the academic, technical context of Creative Technology. In this paper we identified typical tasks of a Creative Technologist that require creativity, bridging between technology and the design of user-oriented, novel products. As means to stimulate creativity we discuss methods, assignments and tool sets, which, in the end, are not independent of each other. The approaches and aspects suggested are illustrated by examples from our teaching experience.

As method behind assignments we discussed breaking of patterns, which is well known from various creative thinking approaches, specifically quantitative idea generation and limitation. Our contribution here is the translation to specific assignments, and an understanding of, e.g., how the kind of limitation, in technology or concept, effects the design space to be explored, the creativity needed and the goals achieved.

We observe that most existing toolkits are developed and designed for children and artists, not for academic needs. The scope of such toolkits is too small, when we want to bring students so far to recognize the whole world as source for designing their own toolkit. But even if existing toolkits are too limited, the design principles or supporting activities, especially those of tinkering, are more general. They can also be applied in our context, requiring translation steps and extensions.

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