Design Toolkit: Shaping Design Thinking in Elementary Education

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ABSTRACT

In this paper we present the design of a toolkit that has been designed to provide schoolchildren in grades 4th-6th with tangible tools that trigger creative learning processes within the classroom. The toolkit consists of five different compartments containing tangible tools that we argue are essential in educating students to posses an imaginative and reflective mindset. The tools will help children to become more aware of how to build on top of the knowledge accumulated in school, as well as learning how to apply that knowledge in new and different contexts. What we therefore primarily argue in this paper is that embodiment and playfulness are two essential elements of children's personal and cognitive development.

Keywords

Tangibility; Elementary Education; Design Thinking.

1. INTRODUCTION

Knowledge has been an ongoing debate in the field of epistemology as there are many ways of defining and understanding it. However, apart from that vivid discussion, knowledge is undoubtedly one of the fundamental resources to foster economical growth and wealth in a society. All the more important is the understanding of how knowledge is acquired in the world. *Knowledge acquisition* was coined back in the times of Aristotle, who, just as Plato, proposed that all knowledge and meaning is inherently created in the mind. In this sense, the body is a very distinct matter and all actions are ascribed to the mind. In contrast to the cognitivist understandings, the philosophical notion of *embodiment* proposes that the mind and existence is fundamentally determined by the human body. Knowledge is acquired by the aspects of the body such as the motor- and perceptual system as well as the interaction with the environment. Looking from the perspective of embodied cognition, the body is considered as a part of our cognition where meaning is created during actual, physical interaction. Embodiment argues for a re-appreciation of the body, and that meaning in interaction is best understood as being created during bodily interaction. Under this notion the famous philosophical statement "I think, therefore I am" by Descartes has to be revised to "I do, therefore I am".

Whilst there has been a major turnaround in the thinking of our *being* in the world, the educational mandate of schools and universities faced in general a rather prosaic development. The roots of the Danish education system can be traced back to the industrial revolution, which main purpose was to reduce illiteracy by educating people in reading, writing and speaking. Although it has been adapted over time, such as considering the prevailing scientific and technological progress, the core concept of the education system is still persistent. There are many alternative concepts to the neglected education system and here is not the right place to open another controversial debate. Instead, we would like to take a step towards a teaching approach that involves students beyond lingering in their chairs or memorising and recalling information on a blank paper.

Whether it is cooking a four-course meal, walking on stilts, going for a bungee jump, or playing a board game, humans are characterised not just by their thinking or achievements. Based on the notion of *embodied cognition,* we designed a physical toolkit that addresses students as humans beings that are characterised by their playfulness, their curiosity, their love of diversion, their explorations, inventions and wonder. It involves the students not only on an intellectual, but first and foremost on a sensual and emotional level that creates inherently meaningful and worthwhile experiences. With this toolkit, we forget about the engrained legacy of cutlery, follow Walter Benjamin and "bite into mortadella as if it were bread, or bury your face in a melon as if it were a pillow" to embrace our world with all its facets and gain worldly wisdom.

In this study we investigate how to design a physical toolkit for young students that is able to link the notion of *embodiment*, elements of *play* and the prevailing institutional *teaching practice* in schools.

2. MATERIALS AND METHODS
2.1 Designing for School Children

From the beginning much focus was put on the investigation and understanding of the users and the contexts in which the toolkit possibly could be applied. As the toolkit is directed towards school children they were the primary users, however, since the teacher will be the one initiating the use of the toolkit within the classroom, s/he is the secondary user. The intention is for the toolkit to be applied without influence of the teacher, and allow the pupils to apply it differently each time in a way that helps them build on top of the knowledge they gain during their educational process.

The user studies were carried out through semi-structured interviews, participant observation and an engaging workshop, during which video and field notes were used as the main means of documentation. As the user studies were partly carried out with children the aim was to look beyond their spoken words, and look for hidden clues that might indicate their true thoughts and everyday practices within the classroom.

From the user studies it was discovered that children enjoy teaching each other, even if it means the older pupils have to

spend time teaching the younger ones. This kind of gesture provides them with a feeling of pride and responsibility, and helps them in retaining the knowledge they gain. It was additionally found that children have a clear understanding in how they learn personally, and that it can differ from the learning styles of their classmates. However, generally it was shown that children learn best at their own level, which means that they prefer the teachers customizing the teaching to the individual student. Nevertheless, as it was explained by a teacher during one of the conducted interviews, it is almost impossible to meet the needs of every student in a class of 28, and that clearly results in a lack of interest by some students in each subject. In this matter, the students' preference of a specific subject depends much on how the teacher handles the lessons, and on whether or not s/he is aware of the individual student's need. Apart from those reflections, they are also very excited about being able to decide for themselves how to do things, as they do not find interest in being restricted solely by the ways in which the teachers want them to complete different tasks. As Fernaeus [5] argues, it is important to give students objects that can support their learning and help them in engaging themselves in activities that otherwise would be out of their reach.

These findings helped us in defining the main principles of the tools, the issues that the toolkit would be expected to address, as well as the values it would have to live up to.

Figure 1: Playful workshop at a free-time club for school children of ages 9-14.

2.2 Concept of the Toolkit

The concept is manifested in a physical toolkit, which captures the essence of our preliminary user research. The toolset is intended to enable students to possess a design-driven mindset that will then help them become more aware of how to build upon the knowledge accumulated in school, and learn how to put that knowledge into real-life contexts. Based on the insights gained through the user research and the notion of embodied cognition, the concept is built upon following aspects, which we consider as fundamentally important for the decisions we make:

Since humans are characterised by their playfulness, the toolkit was designed with the element of play in mind. As Gaver [3] points out, "Play is not just mindless entertainment, but an essential way of engaging with and learning about our world and ourselves". It is a natural aspect to "find new perspectives and new ways to create, new ambitions, relationships, and ideals". Play goes beyond entertainment and an essential aspect to get students engaged with their environment. As our contextual interviews with teachers and pedagogues have shown, there is a strong ambition in using alternatives to the traditional teaching methods. Educators tried to bring more playful elements into their

teaching such as throwing a ball in a bucket coupled with learning german vocabulary. Although those activities provoke physical engagement, they can be rather considered as a form of aesthetics in order to ease the process of learning. It energizes students and helps to achieve the ends they pursue just as singing during hard labor [6]. The toolkit tries to address this shortcoming and makes an attempt to provoke intrinsic activities that contribute to the actual goal of creating meaning. Designs for bodily interactions can fail just as designs for the intellectual can. We believe the way actions and activities are carried out, can be optimised and stronger coupled with the intended learning goal.

The provided tools are considered as part of our cognition as they are distributed in the environment. However, they are not just reduced to mere representations of understandings. First and foremost they are intended to provoke reflective activities, which is essential to elicit new patterns of meaning [7]. They must allow a certain scope for students' interpretation of meaning it might have for them. Instead of defining semantically specified tools that constrain the scope of negotiation, we pursue the possibility of interpretative appropriation [4] that enables students more or less determining their own meanings. Generally, we believe that novelty in meaning emerges out of interaction with the environment. For this reason the toolkit is designed to propel engaging activities in a collaborative setting so that accumulated knowledge is build on top of each others actions. We consider our tools as facilitators of interactions among students so that new meaning arises in the light of complex responsive processes of relating [2].

On a more pragmatic level, our interviews have also shown that the toolkit has to be easily applicable in everyday teaching practice as the curriculum is time-wise strictly regulated. Consequently it requires on the one hand a certain degree of openness without unnecessary initial induction. On the other hand teachers have to see relevance, progress and contribution to subject-specific goals.

2.3 Implementation

In practice the toolkit will replace the traditional 'on paper exercises' after the teacher has taught a lesson of theory. The children will be divided into teams, where each team can choose their compartment, and the tools to work with. The toolkit then becomes a help at the moment of reflection on what they have learned during class. In this sense, their understanding of the lesson taught shines through their practical application of the tools.

In essence the toolkit contains four main compartments that help students in communicating conceptualizing, modeling and reflecting upon the lessons learnt in class. We argue that the tangible tools help the students develop their skills within self-expression, social interaction, ideation, co-creation, imagination, creativity, co-analysis and reflection. The last compartment, which is an energizer activates the students through play and movement.

This toolkit has been built up upon the tangible interaction framework, which was introduced by Buur and Hornecker [1]. The framework addresses four main themes, first of which is Tangible Manipulation. This refers to the direct manipulation of objects, as these "appeal to our sense of touch, and provide sensory pleasure". In the toolkit we have been focusing on providing tangible items that the kids can manipulate themselves

in various ways, and express their thoughts through materials with tacticle qualities.

The second theme is called Spatial Interaction and focuses on interaction situated in real space. This does not rely on the objects themselves, but rather on bodily movement, which is one of the qualities embedded into the toolkit as well. Especially the 'energizer compartment' is focused on activating the kids, by giving them a break during which they are asked to do different tasks that require them to get up and move within the space.

Embedded Facilitation, which is the third theme introduces the notion of group behavior, and how this is affected by space as well as tangible artifacts. The tools presented in the kit are intended to be used in groups, and the aim is to trigger creative collaboration between the students through the application of either one of the compartments.

Expressive Representation is the last theme Buur and Hornecker present. It focuses on 'reading' and interpreting different representations, and on that note modify and create them. This also to some extent relates to the collaboration between the students, as they will be able to modify each other's work as well as build on top of the theory the teacher introduces them to, and thereby build their own understanding of it. Our toolkit has been grounded in these four themes, as the framework concentrates on the social aspects of tangible interaction and has helped keep a focus on user experience in stead of solely the tangible objects.

For the toolkit to become an integral part of the teaching the teacher is required to initiate the use of it. It is additionally also an option to use any of the compartments to assist the teacher in his teaching in case it fits into the context.

Each of the compartments can be used separately, and given to the different smaller teams in the classroom. Although the entire class will be relating to a specific topic, each team's outcome and reflections will be different. We strongly suggest the students be creative about mixing the tools of the different compartments to get the exact result they want, and show their understanding and reflections in interesting and new ways.

The use of toolkit should be no longer than 15 minutes, including a few minutes afterwards for each team to present their outcome, and to allow the teacher and the rest of the students to ask questions and give feedback. The reflection becomes an essential social process, as the students will be encouraged to discuss their understandings of the knowledge they gain in class, and challenge each other. What we also wish to emphasize is that the use of the toolkit is not restricted by specific rules of how to implement it within the classroom, meaning that every subject might support a different way of integration. The most important element is that the tools help in engaging the students, and encourage them to reflect on their own learning process as well as the knowledge they gain during lessons.

The tools included in the kit are more or less self-explanatory. Students within the age group are most likely already familiar with similar tools and toys. This means that it will be easy and fast for them to involve themselves in the process of modeling, reflection etc. Nevertheless, as they tools are taken out of the usual context they are given a touch of abstraction, which will result in the children not restricting themselves by their usual application.

Figure 2: This image shows the tangible toolkit. It consists of five compartments, each with tools that trigger and enhance different kinds of creative thinking.

3. Results

When designing a product it is nessesary to do user testing for the designers to discover whether or not the research is reliable, and to prove the necessity and successfulness in the application of the product. The user testing would prove that the chosen tools fit all the purposes the kit was designed for, but since the project is work-in-progress the actual testing with children in the grades of 4th-6th has not found place yet. Nevertheless, the toolkit has been tested with the project team at the the science center, Experimentarium, that assigned the task to begin with. The employees were given the topic of photosynthesis, and divided into smaller teams with each their compartment. The results were very creative and abstract, and the common impression was that none of them would ever forget what photosynthesis is. The toolkit was additionally tested with a group of teachers, librarians, under-graduate students and professors at a seminar in Aalborg, Denmark. Also there the participants agreed on the notion of the toolkit being very helpful in making knowledge stick as a result of using your entire body to think with. They also referred to the reflection session being very essential to the whole experience of using the toolkit.

4. Discussion

The toolkit presented in this paper has not yet been tested in schools, however in the following section we aim to discuss and reflect on the future application of the tangible tools, as well as the future role of the teacher in a class, of which the toolkit becomes essential in a creative learning process. The discussion also sets out discuss different scenarios that present ways in which the tools potentially can be applied.

The primary aim is for the toolkit to be implemented in school grades of 4th-6th, however there is a vast development potential, and the idea is for the toolkit to grow in a way that makes it applicable across a larger span of grades. Addtionally, the vision is to expand the tools so that new and specially designed compartments can be applied in different subjects, e.g. one compartment for mathematics, one for languages etc. The different compartments will then help students in retaining knowledge in the different subject matters, and trigger their creative thinking to create meaning in the interaction with others.

Imagining a scenario where the tangible tools are applied in different classes it will be the case that the teacher is less occupied

with explaining matters to the students. As the toolkit, apart from a simple sheet of teacher instructions, barely comes with any explanatory help the children will be left to their own creativity and abstract thinking. This will leave all tools open for interpretation by the students, which reinforces our vision of them applying the tools in ways we have not even been able to imagine yet. The main uniqueness of the toolkit comes from the adaptability between subjects and classes, and the fact it is not just a workbook, question cards or solely for the teacher to read and implement.

The obligation of the Danish ministry of Education is, among others, to develop the content, aim and quality of education and one of the issues currently in focus is "Learning in Movement". It is exploring the relationship between learning and movement, which is in line with the major principle of the toolkit—to incorporate and involve body movement and the senses in all learning activities. Thus a cooperation to place the toolkit in the school system is worth exploring, as it therey will be possible to prove the value generated by the tangible tools, as well as the bodily involvement in children's learning processes.

5. Conclusion

Based on the premise that elementary education needs revision, as well as new approaches to keep students interested, we designed a toolkit containing abstract tangible tools, of which the aim is to develop independent and creatively thinking individuals. The essential elements are embodiment and play, as we argue that engagement is primarily triggered by these two factors.

The purpose of the tangible toolkit was not to provide a clear-cut path or surefire way to applying it every time. The carefully thought-out tools were chosen to both enhance and trigger creative learning processes within the classroom particularly in relation to retaining knowledge. The tools are intended and purposefully made abstract in order to leave them open for interpretation by the students using the kit, and encourage creative and unbound thinking. Only one directive, which is a list of guidelines to help the teacher begin implementing, is included in the kit. We intentionally left room for the children to find their own ways of explaining and visualizing their thoughts and ideas, and that we find is essential for students to become independent and stay critical to the information they receive.

The toolkit still allows room for expansion, however, as it is now it can be implemented within classrooms without much further work. It is mainly intended to replace the usual 'on-paper' excersises after a lesson of theory has been taught in grades of 4th-6th, but we do not see any issues in the students and the teacher finding new ways of applying it within the classroom.

The most significant aim of the toolkit is to help provoke reflective and collaborative activities, as well as bring playful elements into traditional teaching methods.

6. ACKNOWLEDGEMENTS

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