Prospective analysis of innovative uses for tabletops in classrooms

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Abstract: This paper focuses on the anticipation of future uses of innovative technologies in the case of tabletops and tangible interactions in education using an approach inspired by prospective ergonomics. A preliminary study helped restrict the scope of tabletops uses before conducting a creativity session with teachers to collect propositions of uses in scientific subjects. The propositions were analyzed and three general categories emerged: simulation, visualization and collaboration. Two of them were associated with specific properties of tabletops, namely simulation with tangible interaction and visualization with the large size of the screen. The results were discussed in view of the potential benefits for education and we conclude on the interest of doing prospective ergonomicsto provide key information in for the design of innovative technology.

Keywords: prospective ergonomics, education, tabletop, tangible interaction

1. Introduction

Innovative technologies in Human-Computer Interaction (HCI) often come with new forms of interaction between users and technical systems, but the end users are not always clearly identified (Nelson & al. 2014), as are the specific contexts of use. This is especially true when a technology is developed without predetermined situations of use (“technology-push” design projects). As the technology matures, designers can ask potential users for help in finding concrete usages. However, given the innovative properties of the technology, adapted methods are required to assist them in apprehending the technical or interactive specificities of the technology and to enable them to anticipate future uses.

This paper focuses on an example of innovative technology, the interactive tabletop, and investigates its potential uses in a specific context: education in primary and secondary schools. We describe our approach to narrow the scope of potential uses of this technology and to collect and analyse them in the perspective of a future design process.

2. Related work

Tabletops are innovative technologies that offer a physically large surface area with direct-touch input in a horizontal plan (an illustration of an application on a tabletop is displayed further in the paper). Initially, the main motivation behind research and development of tabletops was to support multiuser collaboration and interactions (Scott & al. 2006). Later on, Benko & al. (2009) observed additional common tasks including viewing entertainment media and visualisation applications. Creative problem solving also emerged as an interesting application on tabletops (Buisine & al., 2007; Catala & al. 2012).

Tabletops may support tangible interactions that allow the manipulation of physical objects (the tangibles) as a mean to interact with the system that displays digital objects on the screen. Numerous examples have been studied for theories and frameworks to be built upon (Mazalek & Van den Hoven, 2009). Kubicki & al. (2012) listed 6 key interactive properties of a tabletop: a large screen, its horizontal position, the shape of a table, tactile detection, tangible interaction and multiple inputs (i.e. multi touch). Kubicki described the main scope of demonstrators for existing tabletop technologies, supporting or not tangible interactions. Most concerned entertainment (music or media visualisation) and few proposed applications for education or simulation (Kubicki, 2011).

Recently, Computer Supported Collaborative Learning (CSCL) researchers have been increasingly interested in tabletops. Applications have already been developed for educational purpose and the basis of frameworks for their design and analysis have been discussed (Dillenbourg & Evans, 2011). Additionally to the potential benefits of collaborative activities in classrooms, Manches & O’Malley (2011) described in their review valuable aspects of tangible interaction for education, notably the contributions of physical objects in providing conceptual metaphors to students. Recent applications on tabletops have been deployed in classrooms in various cases such as logistics, symmetries, carpentry (Cuendet & al. 2013) or supply chains processes (Jalal & Tenney, 2014) that illustrate specific cases of implementation of tabletops in classrooms.
On the one side, the literature shows that tabletops can be versatile tools in multiple situations. However, existing applications are often the results of technology-push design projects. On the other side, the general public might find it difficult to express specific needs regarding this technology. In this context, prospective ergonomics, defined by Brangier & Robert (2014) as the anticipation of future needs, usages and behaviors to create adapted products, represents an interesting intervention modality for the design of a future application on this innovative technology.

This paper focuses on the assessment of the possible uses in classrooms. In a preliminary study, an online questionnaire was used to explore the potential educational subjects of interest for tabletops. Secondly, a creativity session was organized to prospect for ideas of uses with teachers. The results were analyzed in the perspective of the design of an innovative tangible application on tabletops in an educational context.

3. Preliminary study on the potential subjects of interest for tabletop in education

3.1 Context

Education in primary and secondary schools covers a diversity of subjects where different teaching methods are implemented. A questionnaire was designed for teachers to provide general data concerning their current methods with and without numerical tools and also to gather prospective uses of tabletops for education, in order to orient our approach towards specific subjects. This part focuses on the prospective uses and the general results of this questionnaire will not be detailed in this paper.

3.2 Subjects and method

39 teachers were recruited in professional and personal networks of the authors. Because of the random diffusion of the online questionnaire, the repartition between teaching subjects was not balanced. The participants were multidisciplinary teachers in primary schools (9) or teachers from various subjects in secondary school: biology (10), physical education (6), physics (5), mathematics (4), history and geography (2), English (2) and social sciences (1) in secondary school.

The tabletop was introduced by a brief technical description. Possible interactions and functions were illustrated with pictures of tabletops and examples of tangible application in general contexts.

The item of the questionnaire concerning the potential uses of a tabletop in their classroom was labeled: “Describe a concrete example of possible enhancement if you were using tabletops in your teaching activity”. This formulation was chosen to help teachers detail an imaginary application based on their current activity.

3.3 Results

Among the 39 teachers who answered the general questionnaire on their teaching activity, 16 participants proposed uses of the tabletop in their classroom. 23 participants did not answer this item or explained that they did not see any concrete use of tabletops in their courses.

Almost half of the participants were science teachers (19 out of 39) and 9 answered the item. As a consequence, 7 of the 16 propositions referred to science (for example: manipulating a 3-dimensional model of a molecule, setting up an experiment with tangible objects, comparing measures of a natural phenomenon) while 2 concerned the study of a map in geography or for orienteering and 7 were multidisciplinary or not linked to specific contexts (i.e. regrouping students productions to synthesize them; collaborative activities; board games…)

This preliminary study did not aim at giving an exhaustive view of the potential interest of tabletops in every subject taught in primary or secondary schools. Instead, it was supposed to orient our research of potential applications for tabletops towards specific subjects. According to the results, scientific subjects such as mathematics, physics, biology and chemistry seemed promising and were chosen for the next study. This does not presume that other subjects could not benefit from this technology.

4. Investigation of potential uses of tabletops in science courses

4.1 Introduction

Interviews conducted with science teachers and the other items of the questionnaire revealed a large diversity in the teaching methods used in sciences such as experiments, paper/pencil tasks, computer
assisted simulations, individual or group activities, documentary analysis, etc. A brainwriting session was conducted to collect potential uses of tabletops in these contexts.

4.2 Subjects and method

10 science teachers participated to a brainwriting session: 4 from primary school and 6 from secondary school: 3 in biology and 3 in physics. The tabletop was first introduced by the experimenter. The participants were free to interact with the tabletop and to manipulate tangibles in a demo application. The demonstrator (figure 1) was developed on a Samsung SUR40 tabletop with tangibles designed by the authors. The application allowed to interact on different media (pictures and videos) with tangibles and to explore elementary actions such as saving a configuration, modifying the volume of a video, zooming and analyzing parts of the pictures... The objective was to show the basics of tangible interactions.

Figure 1. Demonstration application used in the brainwriting session.

The participants were asked to individually write down as many ideas of use of the tabletop in classrooms as possible (15 min), according to Osborn’s rules for idea generation: no criticism, quantity is better than quality, freewheeling is welcome, as well as combination and improvement of other propositions (Osborn, 1957). Then each participant briefly described his/her ideas to the others. Finally, they were asked, in 3 groups of 3 or 4 participants, to further describe three of the propositions (one per group) (15 min). Each group chose a proposition among the ones described after the individual restitution and developed the potential use in terms of content and implementation.

4.3 Results

The brainwriting session with 10 participants provided 53 propositions of use, which were added to 14 initial propositions from the questionnaire. The 2 propositions regarding uses with a map were removed because they were explicitly not related to scientific subjects, namely geography and physical education. The others were considered valuable for further analysis in view of the 53 propositions that emerged from the creativity session. Two qualitative analyses were conducted. In the first one, the propositions were related to the interactive properties of the tabletop. In the second, the pedagogical or didactical objectives underlying each proposition were analyzed.

The first analysis aimed at identifying the interactive properties of the tabletop mentioned by the participants. Indeed, given the complexity of the system, it seemed relevant to consider its specific features to observe whether they were mobilized in certain uses or not. 28 propositions explicitly mentioned tangible
interactions and 11 referred to the large screen of the device (2 mentioned both tangible interaction and the large screen). 30 ideas did not specify any particular property of the device concerned by the use.

Secondly, the different purposes relative to teaching and learning contained in the propositions were grouped in three main themes: simulating scientific phenomena or concepts, supporting collaborative work between students and interacting with multiple digital objects displayed on the screen (pictures, videos, texts...). 8 propositions implied more than one of these themes. One of the propositions detailed in the second part of the session concerned for example the collective investigation of the simulation of the digestive system using tangibles as tools which refers to both simulation and students collaboration.

25 propositions referred to the use of tabletops to simulate real phenomena (like the implantation of a tangible building in a virtual city or the effect of tangible lenses on virtual rays of light) or abstract concepts (like manipulating tangible geometric objects to observe their intersections displayed on the screen or studying the physical model of a chemical phenomenon). Simulations could also be used by teachers to deal with complex subjects (such as the human organism or a volcano) for security reasons or because of scale limitations (placing planets on their right orbit in the solar system or manipulating virtual molecules). Tangible interactions were mentioned in 18 of the 28 propositions. In most of the propositions, teachers offered to design the tangibles as scientific instruments or concrete objects to provide students with tools to interact with simulated phenomena.

17 propositions concerned the use of tabletops as a support for collaborative tasks (like the collective construction of a diagram or the realization of a specific task in which each student has a specific role). Among these ideas, 9 referred to serious games, mainly under various forms of board games or card games to explore complex situations with a ludic approach (for example preparing diet meals or working on the human body immunology). No feature of the tabletop was particularly related to collaborative learning.

12 propositions referred to using tabletops to work with multiple digital items in various cases. The most recurrent one consisted in manipulating a large number of documents on the tabletop to synthesize them (for example to design a poster, to prepare a presentation or to analyze data collected on the field in biology). These uses may also imply different types of documents (i.e. video, picture, text...) or large pictures (for example in the study of interactive maps in geology). 7 propositions referred to the large size of the screen as a tool to develop their actual methods and to exceed limits they might currently face such as scale.

5. General discussion

5.1 Contribution of the investigation of the potential uses of tabletop in education

Kubicki & al. (2012) listed 6 key interactive properties of a tabletop: a large screen, its horizontal position, the shape of a table, tactile detection, tangible interaction and multiple inputs (i.e. multi touch). Among the 67 propositions of use of tabletops in classrooms, 30 did not mention any of these interactive properties. In particular, the propositions referring to collaborative work of students around the tabletop were not linked to specific interactive parts of the tabletop. Our hypothesis is that the participants implicitly considered the table-like form and the horizontal screen as relevant parts of this type of use because it naturally fosters people to gather and to socially interact. Moreover, the concise nature of the data and the focus on the quantity of ideas instead of their quality, and thus their level of detail, may also have prevented these two properties from emerging. In terms of uses, both collaborative tasks and serious games on tabletops emerged as possible opportunities to diversify teaching methods in ways only this type of technology offers.

Tangible interactions have been broadly mentioned, especially in simulation-type uses, to manipulate representations of real or abstract phenomena in a 2D-virtual environment. Indeed, science teaching activities often involve the manipulation of physical objects or instruments that may be difficult to implement because of time, material, safety or feasibility limitations. Moreover, it is argued in the literature that tangible interactions allow a potentially strong degree of coherence between physical and digital objects (Koleva & al. 2003) and the use of metaphors (Fishkin, 2004). Thus, manipulating ideal virtual phenomena, as it is already available with existing simulators, is needed by teachers and tangibles might help students relate to reality.

The size of the screen was explicitly mentioned in 7 of the propositions about studying or treating numerous or large digital objects such as pictures, videos or texts. It is coherent with other applications developed on tabletops such as creative problem solving (Buisine & al., 2007; Catala & al., 2012) where users interact with a large number of items. Displaying different information at the same time and allowing students to interact with them could help teachers and students in tasks currently realized on computers
such as presentations. The size of the screen might even offer new possibilities, for example the design of a real size poster.

Although particular subjects such as history, language or philosophy might seem poorly relevant for simulations, collaborative activities and activities capitalizing on the large screen can be transverse to most subjects in schools. Thus the results of this exploration of tabletops uses in educational context should not be considered as restricted to scientific teaching.

5.2 Limits

The propositions were analyzed regarding the properties of the tabletop or the types of use they explicitly mentioned. Still, it would have been useful to develop these ideas deeper to identify more detailed themes and to specify the features of the tabletop they concern. It is probable that the proposed uses would share more themes or interactive features. Among the 67 ideas, only 8 implied more than one of the three types of use, thus combining simulation, collaborative work and/or interaction with multiple digital items. Again, this result might come from the focus on quantity instead of quality. Still, it would be interesting to work on an application that would combine the three of them in a coherent and relevant way for both teachers and students.

The difference between the results of the two studies can be explained by different factors. First, the creative dimension implied by the item considered in the questionnaire may have been difficult to assess without having manipulated the tabletop, while the others concerned their actual teaching activity. On the other side, in the brainwriting session, participants were fostered to manipulate the tangibles directly. Secondly, in the questionnaires, a single proposition of use was expected while it was explicitly asked to produce as many ideas as possible in the brainwriting session. However, the small number of exploitable proposition might be due to a lack in the description of tabletops or tangible interaction.

6. Conclusion

The exploratory nature of our approach led to the identification of potential uses of tabletops in classrooms that reflected general uses in the state of the art, namely collaboration, visualization and simulation. Furthermore, the creativity session helped teachers anticipate uses based on their current activity that provided concrete examples of applications that could be reused and developed for future design purposes of tabletop applications, even out of the scope of education. For example, the serious games principles could inspire entertainment applications.

The results suggest that tabletops could help develop current teaching and learning activities by providing alternative ways of addressing currently constrained practices for existing pedagogical or didactical objectives. For example, studying a real physic phenomenon is part of physics programs, but students tend to have difficulties to understand the underlying scientific model. Tangible simulation might help teachers illustrate such concept or provide them with flexibility to improve their current practices depending on their needs.

Anticipating future uses of an innovative technology can be challenging and prospective ergonomics provides valuable support, in particular when it comes to involving potential end users. The creativity session we used resulted in key data regarding both uses of an innovative technology, its interactive properties and their articulation. These data have been reinvested into the design process of a tangible application on tabletops in the Tactileo project, as an illustration of the possible articulation between prospective ergonomics and ergonomics for design (Brangier & Robert, 2010). These data participated to the definition of relevant features of the application and to the learning of technology basics by the teachers involved in a participatory design process.

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References


