Designing a Technology–Augmented School Desk for the Future Classroom

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Abstract. Technological advancements and contemporary learning theories dictate the need for redesigning the school environment to emded technology in a seamless way. This paper describes an approach towards the development and modernization of the future classroom, by redesigning the student desk. A technology-augemented desk was designed following an iterative approach, leading to the creation and evaluation of several alternative solutions.

Keywords: school desk, future classroom, smart classroom, ambient intelligence.

1 Introduction

Information and Communication Technologies have been attributed with the potential to change and restructure the educational process, while a lot of studies have been devoted to discussing their role and uses in education. For example, ICTs have been claimed to improve the quality of education by motivating students to learn, facilitating the acquisition of basic skills and fostering inquiry and exploration [1].

Regarding the learning process, ICT can enable new ways of teaching and learning, moving away from the traditional teacher-centered pedagogy towards the direction of learner-centered approaches, by promoting active and collaborative learning [2]. This approach is supported by the constructivist theory, according to which technology takes a special place as a powerful tool for children's learning by doing, while it constitutes an integral component of the curriculum, a chameleon-like tool that can be used with almost any content [3]. On the other hand, in most contemporary learning theories, emphasis has been given to co-operative and social learning, as well as to the construction of knowledge from the students themselves [4].

As a result, the school environment needs to be reshaped in order to address the aforementioned needs by: (i) redesigning the learning spaces themselves, (ii) redesigning furniture and introducing technology-enhanced objects that facilitate learning and (iii) supporting knowledge-based communities in virtual and physical learning spaces [4]. This paper describes an approach towards the development and

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modernization of the future classroom for the improvement of the educational process, by redesigning the most essential classroom artifact, the student desk.

From a technology perspective, and in accordance with current learning theories, the notion of smart classroom has become prevalent in the past decade [5], supporting new means of interaction such as interactive whiteboards, touch screens, smartphones and tablet PCs. An initial approach towards investigating the role of technologies in the educational context and in the smart classroom environment was presented in [6], suggesting among others an augmented school desk. Evaluation of the first school desk prototype indicated that children were interested, and in some cases enthusiastic, about having such an artifact in their classroom; however, they expressed interest in a more aesthetically pleasant appearance of the desk [6]. Further to this initial evaluation, informal interviews conducted with target users of the desk indicated the overall "look and feel" as a key factor for acceptance of technologically enhanced artifacts in the classroom.

As a result, besides the high-level goals motivating the design of this new artifact, additional objectives deriving from the lessons learned from the first prototype, were to:

- preserve the traditional functionality of the school desk, allowing students to use typical school equipment, such as books, pencils, etc.
- embed technological devices, such as a multi-touch widescreen personal computer, headphones, keyboard, and a depth camera
- hide the technological complexity, by seamlessly embedding the equipment in the furniture
- create an appealing, easy-to-use and vandal-proof artifact.

The next sections describe in details the design of the proposed future classroom student desk by describing the design method that was applied (section 2), presenting the artifact itself (section 3) and providing a discussion and future directions (section 4).

2 Design Method

An iterative design approach was followed, driven by studying the target users and the intended context of use. Based on the design requirements, various solutions were proposed through the method of brainstorming, which were then combined in the creation of several concept mockups. These mockups have been evaluated in discussion groups, concluding with the design of a final desk concept.

Research regarding the users focused on their individual characteristics and preferences, their relation with technology, and the cognitive process behind the learning experience. An important parameter of an ergonomically designed desk, and therefore of this study, was the anthropometry attributes of young students, as they change across the various ages from primary school children to teenagers and young adults.

The context in which the artifact will be used is another important design parameter. Under this perspective, several learning theories and classroom arrangements have been studied, focusing on innovative proposals, aiming to support the major

drives of change in education in the near future, such as [7]: developments in education dictated by the need to spread the expertise of the most able teachers more widely, and the need to stimulate children to achieve more; changes in the organization of the classroom environment – to enable, for example, a range of group sizes to be taught effectively in one space; developments in ICT; as well as the need for flexibility and adaptability. Furthermore, the most common currently used classroom layouts and the role of each one in the learning process have also been taken into account.

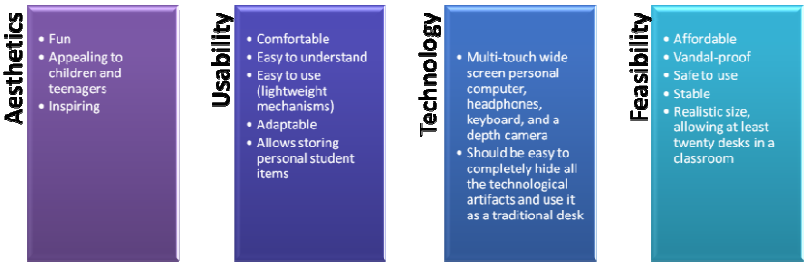

Fig. 1. Future school desk design requirements

Additionally, the artifact itself and its role as a personal object in a public environment have been considered. As a result, the student desk should function both as a personal space (e.g., for reading, or taking a test) and as a collaborative space for classmates' cooperation and ideas exchange.

The above research resulted in a set of design requirements that should be satisfied by the student desk, structured around four main categories, as shown in Fig. 1.

Fig. 2. Alternative desk concepts

Based on the design requirements, several solutions ranging from tablet-based to back-projected implementations have been proposed and evaluated following an iterative approach (see Fig. 2). Each design alternative has been evaluated by discussion groups involving an industrial designer, three software engineers and three interaction designers. The evaluation and redesign process led to the refinement of the initial requirements, based on which a final desk concept has been developed.

3 The Proposed School Desk

The result of the aforementioned research and iterative process was the design of a technology-augmented desk, as shown in Fig. 3, appropriate for use in the context of a smart classroom. The desk features a 24-inches wide all-in-one computer embedded in a rotatable steel frame covered with white-lacquered oak wood. The frame can be tilted from 0^o to 180^o using the available handles, to reveal a typical desk surface and facilitate paper-based activities, while when folded away its back becomes an ideal projection surface. On its top left corner, a steel pillar covered with white-lacquered oak wood is used to mount a depth camera. Apart from hiding the cables connecting the camera with the computer, the pillar features a corkboard that can be used for attaching notes, and a self-powered USB hub and card reader on its side to facilitate connection of external devices (e.g., memory cards, pen drives, portable hard drives, etc.).

One of the requirements that occurred after evaluating the initial prototypes was to design the desk for single use, facilitating therefore the appropriate rearrangement of classroom desks in order to address the changing demands of different teaching scenarios. For instance, given that collaborative activities can enhance the educational process [8], two adjacent desks can be connected to create a larger interactive workspace and promote teamwork.

Finally, the desk offers various practical and convenient solutions regarding daily activities that convey additional contextual information as well. In more details, the desk: (i) incorporates a mesh storage below the desk's surface to hold books and other personal belongings, (ii) integrates a steel hook equipped with a force sensor to detect the presence of the student's backpack, and (iii) embeds distance sensors in its front- and back- facing sides to detect students' presence, and pressure sensors to detect reckless behaviors (e.g., a student is sitting on the screen).

Fig. 3. Alternative views of the proposed desk

4 Discussion

This paper has described the iterative approach that was followed in the design of a technology-augmented student desk. In summary, the desk features attractive

aesthetics and has successfully addressed the issue of technology integration in terms of size and design. The desk will be built of MDF wood and oak wood, with few metallic and stainless steel parts, which is a low cost solution. As a result, the proposed student desk can be easily introduced in existing classrooms, while it can also effectively address the requirements of future classrooms.

Future work will aim to improve the ergonomics of the proposed artifact regarding the screen rotation mechanism, which may be difficult for primary school students to handle. To this end, a prototype of the desk will be constructed and evaluated with school children of various ages.

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