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Mind the gap: Impact on learnability of user interface design of authoring tools for teachers

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ABSTRACT

Few teachers include information and communication technology in the classroom, despite their potential for increasing attention and motivation for students. Educational authoring tools are intended to turn teachers into designers and deliverers of technology-enhanced educational content, and increasing the adoption of these tools is a key element for speeding up this transformation. This paper emphasizes the importance of learnability for preventing rejection or abandonment by of such an authoring tool, and how acceptance is deeply affected by the interaction paradigm and the creation metaphor used in the tool. We present an analysis comparing two design paradigms: the widespread menu-based and choice-guided interaction paradigm versus a consistent metaphor with direct manipulation. The latter was implemented in DEDOS-Editor, a novel authoring tool that allows the creation of diverse educational activities that can be performed on different devices, such as PCs, digital blackboards, tablets, and multitouch surfaces. An experimental study shows the tremendous impact that interface choices have on the tool's learning curve. The results provide the first mapping of the choice of a direct-manipulation interface and its effect on the learning curve's entry point, as well as a consistent interaction metaphor with smoother and fast-growing learning curves. This allows users to complete more tasks and gain more knowledge through experience, in contrast to menu-based interfaces. The initial use of the tool is thus made easier for users with no experience or information about the tool, and the advantages of experience and expertize in facing new challenges are facilitating. This work also highlights the appropriateness of learning curves as a tool for measuring learnability.

1. Introduction

Information and Communication Technology (ICT) offers many potential possibilities to teachers for creating educational activities that students can perform in the classroom. "The Survey of Schools: ICT in Education" (European Union, 2013) sheds light on the use of ICT in the classroom. First, most students think that using computers for learning is interesting, they are motivated to learn with them, and they are used to performing tasks with electronic devices at home. Second, school heads and teachers agree about the relevance of ICT use in different learning activities and acknowledge that technologies motivate students. However, despite the significant differences between EU countries regarding ICT and electronic equipment use in the classrooms, "on average across the EU countries […], only between 20 and 25% of students are taught by digitally confident and supportive teachers having high access to ICT and facing low obstacles to their use at school." This information points out the need for teachers who are confident and supportive in effectively using ICT infrastructure and exploiting their potential. In agreement with Levy and Ben-Ari (2007), we believe that this poor use of technology in the classroom is mainly due to teacher limited knowledge of existing technological resources. This problem is worsened by the severe scarcity of educational tools (although this is slowly being solved by the inclusion of tablets in classrooms), as well as the rigidity of available tools, which do not comply with teacher needs in most cases (Hutchful et al., 2010).

One approach to this issue is to steer development of applications specifically designed to support teaching in a particular area of knowledge. However, developing a final application is a daunting task involving a costly and time-consuming process of analysis, planning, coding, and testing (and later support) to target a particular need. Targeting needs poses a new problem of applications not being adaptable enough to teacher needs (Pelgrum,

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2001). In this situation, technical expertize is needed to add new requirements to a certain application, which will require teachers to have a strong technological background or technical support. Usually, teachers do not have technical skills, and since having technical support is commonly expensive, teachers will end up abandoning ICT (Buabeng-Andoh, 2012).

Putting the creative power in the teacher hands requires authoring tools with which teachers can continuously and smoothly improve the creation process. In this study, we aim to highlight the factors affecting the learnability of an authoring tool, which is understood as "the capability of the software product to enable the user to learn its application" (ISO/IEC 9126-1, 2000). As Carroll et al. (2003) suggested, we strongly believe that learnability is one of the critical factors for making teachers adopt a specific technology. In designing an authoring tool, we should improve the familiarity ("the extent to which a user's knowledge and experience in other domains can be applied when interacting with a new system"), the predictability ("support for the user to determine the effect of future action based on past interaction history"), and the generalizability ("support for the user to extend knowledge of specific interaction within and across applications to other similar situations") (Dix et al., 2004). In this sense, learnability can be optimized by measuring the teacher's performance in designing educational activities over time, which can allow us to identify flaws or characteristics of the developed tool and improve it to ease the learning curve. Teachers show different learning curves when using different authoring tools that are affected by both the user interface design (Nicholas, 2009) and the teacher's background skills and prior knowledge (Ainsworth et al., 2004). Thus, design decisions will affect how easy teachers find the tool upon first use, how fast they acquire skills, and how competent they become after using the tool for a fair amount of time. These effects can in turn be observed in the learning curve of each user.

We were thus motivated to design and implement DEDOS-Editor, a novel authoring tool meant to provide a consistent design metaphor to smooth the learning curve for teachers. Our approach capitalizes on the creativity and expertize of teachers in the creation process, as well as the group dimension of the educational system by allowing teachers to access, use, and build over content developed by other teachers. In the design of DEDOS-Editor, we focused on improving learnability through a direct-manipulation interaction style (Shneiderman, 1983) and a consistent interaction metaphor (Nielsen, 1989) for the creation of educational activities. We started with the following questions:

- What are the most popular activities designed by teachers with authoring tools?
- Is learnability affected by the interaction style? What design paradigm improves learnability?
- Which factors impact the learning curve of a tool?

To test our hypotheses, we performed a controlled experimental study with bachelor's students aged 21–30 years old in primary education and early childhood education (future teachers) at Universidad Rey Juan Carlos, Spain. The experiment compares DEDOS-Editor with an authoring tool that can be seen as a fair example of those available. After reviewing the state of the art, we chose JClic-Author (XTec, 2016), which is the most popular educational creation tool for personal computers and digital blackboards in Spain. Both tools were compared to collect information about their learnability, which helps us to comprehend teacher struggles when first facing a new tool in their classrooms and the main reasons they stop using them.

This paper is structured as follows. In Section 2, we analyze the current educational authoring tools and whether they support collaborative learning using different devices. Section 3 discusses how design principles affect the learning curve and which designing principles we have followed. Sections 4 and 5 detail the experimental study, the characteristics of the participants, the methodology, and the results. Finally, Sections 6 and 7 summarize the discussion and conclude the work.

2. Related work

The most frequent ICT-based activities in the European Union are related to the preparation of educational activities, creating digital resources, or using a virtual learning environment (European Union, 2013). However, the resources most used are multimedia tools such as PowerPoint, exercise software, online quizzes/tests, and broadcasts (podcasts, Youtube), among others. Therefore, available tools and devices are not being fully exploited. We strongly believe that this is due to developers overlooking the importance of the learning curve of certain applications. Learning applications should consider short-term efforts and long-term limitations (Papert, 1980) for users to gain knowledge of the application quickly while avoiding boredom for experts. We go deeper into this topic in Section 3.1.

In exercise software, teachers use special authoring tools to create interactive learning activities for students to use through PCs or digital blackboards. In addition, teachers can easily share the created contents with these applications, receive feedback from other teachers, and improve the learning content provided to the academic community (Su et al., 2005). We looked at the design paradigms of the most popular examples that had any kind of evaluation behind them (Venugopal et al., 2005), and we have found that the menu-based interaction style is widespread (see Table 1).

A prototypical example may be JClic (XTec, 2016), which allows for different types of educational activities, such as puzzles, associations, text activities, and crosswords. Activities are grouped in projects. Its interface is based on a menu, and it has four main tabs: "Project" for defining general features; "Media Library," where the teacher must provide all the multimedia contents such as images, audio, or video; "Activities," where the teacher selects the next activity to be created or updates previously defined ones; and "Sequences," where the order to accomplish the activities is specified. A different set of options is displayed, depending on the type of activity selected. Hot Potatoes is another project with a similar approach (Half-Baked Software Inc. and University of Victoria Humanities Computing and Media Center, 2013). It requires previous knowledge related to web design or the use of image manipulation programs if teachers want to include images of different sizes (e.g., GIMP, Photoshop, or Paint).

Smart Notebook (SMART, 2013) uses an alternative approach where activities are designed by dragging and dropping visual elements or by directly painting on the screen. However, the activity creation is not consistent across different types of activities, since each type must be selected in a menu and different options appear in each element to configure the corresponding activity. In the same line of dragging and dropping, the Mouse Mischief add-on (Moraveji et al., 2008) harnesses the potential of the PowerPoint interaction paradigm to turn it into a simple but powerful authoring tool. However, it has a small variety of activities.

Authoring exercise functionality can also be found embedded in tools allowing teachers to create course-based learning environments, where activities are designed to be executed as part of a course. A fair representative of this class of tools is Microsoft LCDS (Microsoft Learning, 2013), which helps teachers in creating learning environments that will be executed as computer-based training applications by specifying their own pedagogical principles. Other projects that focus on authoring courses are Xerte