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Supporting collaborative design activity in a multi-user digital design ecology

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ABSTRACT

Across a broad range of design professions, there has been extensive research on design practices and considerable progress in creating new computer-based systems that support design work. Our research is focused on educational/instructional design for students' learning. In this sub-field, progress has been more limited. In particular, neither research nor systems development have paid much attention to the fact that design is becoming a more collaborative endeavor. This paper reports the latest research outcomes from R&D in the Educational Design Studio (EDS), a facility developed iteratively over four years to support and understand collaborative, real-time, co-present design work. The EDS serves to (i) enhance our scientific understanding of design processes and design cognition and (ii) provide insights into how designers' work can be improved through appropriate technological support. In the study presented here, we introduced a complex, multi-user, digital design tool into the existing ecology of tools and resources available in the EDS. We analysed the activity of four pairs of 'teacher-designers' during a design task. We identified different behaviors - in reconfiguring the task, the working methods and toolset usage. Our data provide new insights about the affordances of different digital and analogue design surfaces used in the Studio.

1. Introduction and background

There has been extensive research and development work (R&D) over the last few decades, studying and creating better support for practitioners in many design fields. The focus has shifted, steadily but slowly, from individual designers to collaborative design teams, within which complementary skills are brought together (Koutsabasis, Vosinakis, Malisova, & Paparounas, 2012; McComb, Cagan, & Kotovsky, 2015). The work reported in this paper contributes to a more specialised line of R&D within educational technology, aimed at creating and testing better tools and methods for the design and production of learning resources. The sub-field of design to which we are contributing is variously described in the literature as instructional design, educational design, learning design, design for learning or teaching-as-design (Conole, 2013; Dalziel, 2015; Laurillard, 2012; McAndrew, Goodyear, & Dalziel, 2006). More specifically, we are contributing to R&D which, over the years, has included work on authoring languages and authoring systems (Barker, 1987), performance support for instructional design (Tennyson & Barron, 1995), the language of instruction (Eckel, 1993), intelligent instructional design aids (Pirolli & Russell, 1990), courseware engineering (Goodyear, 1995), educational modelling languages (Koper &

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Tattersall, 2005), design patterns (Dimitriadis, Goodyear, & Retalis, 2009), and visual languages for education (Botturi & Stubbs, 2008). Pirolli (1991), Goodyear (1997), van Merriënboer and Martens (2002) and Paquette (2013) provide reviews and a sense of the trajectory of this sub-field.

Conceptions of the nature of learning, the range of instructional approaches used, the tools and other resources available to learners, and the complexity of design problems have not stood still. Indeed, the problem space for educational design is now *much* more extensive and heterogeneous (Conole, 2013; Gibbons, 2013; Goodyear & Dimitriadis, 2013). A good deal of the early work in this field concentrated on meeting the needs of ‘solo’ designers, such as subject-matter experts who had little or no pedagogical training. However, as in other design fields, collaborative design practice has become increasingly common, as the demand for richer, more complex learning experiences has increased at all educational levels. A distinctive feature of our collective approach is that we aim to study and improve the work of design teams, rather than solo designers, designing for complex learning situations, such as those involved in collaborative, open-ended, inquiry-based forms of learning (Lu, Lajoie, & Wiseman, 2010; Strijbos, Kirschner, & Martens, 2004). Support for collaborative educational design is still far from common, but some interesting examples are beginning to appear, such as *LdShake* (e.g. Hernández-Leo, Moreno, Chacón, & Blat, 2014) and *SyncrLD* (Derntl, Nicolaescu, Terkik, & Klamma, 2013).

We built an Educational Design Studio (EDS) to carry out research on collaborative educational design. The design sessions studied in the EDS usually involve small ($2 \leq n \leq 6$) teams consisting of university or school teachers, educational designers and/or educational technologists. The design sessions studied in the EDS typically last between one and four hours, and are usually one part of an extended design process that lasts for several weeks. The EDS has evolved through several cycles of development (Thompson, Ashe, Carvalho, Goodyear, Kelly, & Parisio, 2013; Wardak, 2014), each of which has typically involved: brainstorming and use of mock-ups by members of our research team; implementation of new tools and methods; user testing, and in-depth analysis of rich, multi-channel audio and video recordings of design teams in action. From this work, we have learned that it is essential to understand each new tool as just one part of a complex digital and material ecology of tools and resources which collectively constitute the EDS. We are also better able to depict the complex, evolving, interdependencies between tools, working methods and divisions of labour in the collaborative activity of design teams.

The main goal of this paper is to share results from the latest iteration of the EDS. This iteration involves the following new elements: i) high-level conceptual design tasks that encourage rapid consideration of alternative design options by a small team of designers; and ii) a set of personal and shared multitouch surface devices. The most significant new element is a prototype multitouch design table running software that we have produced to support rapid conceptual design through the provision of design patterns and other scaffolds for design work.

The remainder of the paper is structured as follows: in the next subsections (1.1 and 1.2), we provide a summary of recent R&D relevant to the EDS: focusing on computer-based support for design and collaboration respectively. Section 2 explains the rationale for, and development of, the EDS and summarises the main lessons learned from earlier iterations of studying design activity in the EDS. Section 3 presents our new empirical material, analysing the incorporation of a multi-user digital design table into the existing ecology of tools of the Studio. We summarise data describing the distribution of activity of the teacher-designer participants and share the outcomes of closer examination of specific fragments of activity. The paper ends with section 4 which presents insights and more general implications for the support of collaborative educational design, as well as suggestions for future research in this area.

1.1. Computer-based support for (educational) design

Most areas of design practice outside education rely upon a range of tools and methods in the conduct of their work. In design fields in which computer-aided analysis of the performance of designed components is possible, the use of CAD (computer-aided design) systems quickly became the norm (Li, Lu, Fuh, & Wong, 2005; Mitchell, 1977). In architecture and product design, CAD systems are often linked to computer-aided manufacturing systems (CAD-CAM) so that design complexity and construction complexity can be managed together. In these more established design professions, formal notation systems and visual languages have also been developed and adopted, enabling partial or complete designs to be stored, shared and re-used.

While there has been some exploratory R&D along these lines in education (see e.g. Botturi & Stubbs, 2008; Koper & Tattersall, 2005), the use of formal notation systems and visual languages is still rare in educational practice. A thin stream of empirical studies of the work of experienced (and novice) instructional designers, and of teachers engaged in specially-formulated design tasks, attests to the fact that designing for other people's learning is suffused with “wicked problems” which rapidly overpower the unaided design abilities of many education professionals (Ertmer et al., 2008; Huizinga, Handelzalts, Nieveen, & Voogt, 2013; Kirschner, Carr, van Merriënboer, & Sloep, 2002; Rowland, 1992; Tessmer & Wedman, 1995).

A number of tools supporting the *analysis phase* of design have been proposed in the literature. Most of them are provided as document-based templates or descriptions of pedagogical ideas that can be completed or read with a computer or on pieces of printed paper. For example, the *Persona Card* and *Similarly, Factors and Concerns* templates can guide designers' reflections around intentional, social and material factors that describe the design context, situating the perspective of the learners in the centre of the design (Mor & Mogilevsky, 2013). *Course Features* (Cross, Galley, Brasher, & Weller, 2012) also supports the analysis phase, offering teachers a list of elements to help them decide which ones may be useful to consider in their designs. Design patterns can also support pedagogical decisions; they provide structured descriptions of sound pedagogical ideas that serve specific educational situations (Goodyear & Retalis, 2010b).

The articulation of design ideas as overviews of courses and activities is also supported by a range of software tools. For instance, *Course Map* (Cross et al., 2012) supports table-based textual outlines of courses. *CompendiumLD* (Brasher et al., 2008) provides a visual interface to represent maps of learning outcomes, sequences of activities and information about task times. Other design tools scaffold teachers in the authoring of detailed plans for learning activities, ready to be used in practice. One example is *LDSE* (Laurillard et al., 2013) which embeds knowledge of pedagogical research to guide teachers in planning. *Web Collage* (Villasclaras-Fernández, Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2013) supports the design of learning tasks based on collaborative learning flow and assessment patterns that are provided to teachers as visual templates. *OpenGLM* (Derntl, Neumann, & Oberhuemer, 2011) implements a more general visual representation (like a concept map) that allows the expression of diverse pedagogies.

Most computer-based educational design tools, such as those mentioned above, are desktop or Web-based editors that support a *single user*. They function in ways that limit their value to design