Design Computing Education Software Development
Integration of Scaffolding Strategies and Multiple Representations

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Design Computing is an interdisciplinary field that centres on the intersection of design, computer science and linguistics. This multidimensional face of the new paradigm of design computing necessitates a mutual understanding of computing and designs as a whole, which are usually, conceived as separated stages of computed-mediated design. Based on cognitive and computational approach, with the integration of scaffolding strategies and multiple representations, an interactive and real-time design computing learning system is constructed. By interactively manipulating the various attributes, codes, parameters and digital media contents in a distributed system, learners are gradually exposed to the mutual relationship of representational digital multimedia and the underlining programming syntax in a collaborative environment. The author attempted the use of game programming technology in the development of the above system to support design learning and research in understanding design activities. The aim is to identify the design process that if taught well would address the core goals of design education.

Keywords. *Collaborative Learning; Design Computing Education; Learner-centred Design; Scaffolding Strategies; Multiple Representation*

Design Science

The need for innovative designers has never been stronger. As society advances, design problems increase in complexity and the kinds of expertise and experience required to create effective solutions increase as well. Over the last decade efforts to support and enhance the practices of design professionals have evolved into a new paradigm, design science. Finger and Dixon (1983) have grouped the resulting research into six research areas: 1. discovering and describing design processes; 2. developing prescriptive models of design activity based on best practices found in industry; 3. creating computer models of design processes; 4. developing languages and representations to support design; 5. creating analytic tools to support design; 6. developing design practices for manufacturing and life cycles. These endeavors have introduced new tools supporting design and have helped practicing designers improve their processes. It is unclear, however, how designers learn the skills and knowledge to be productive and innovative (Newstetter, W. and et al., 2000).

Bring design knowing and learning together

Wales and Stager (1977) have tried to build on this work by advocating "guided design" as a pedagogical strategy. Guided design prescribes the processes that good design is to follow, providing a procedural roadmap for aspiring designers, providing a "scaffold" for their experience and efforts. However, preliminary empirical research by Atman and Bursic (1996) suggest that access to prescriptive design methods may not be as effective as a scaffolding device to learners of design as might be hoped. This seems to be because students failed to see the relevance of the tools and methods provided by the instructor. Over the last two decades in cognitive science and educational psychology, researchers failed to see connections between the proposed pedagogic strategies, the learning sciences, and studies of the skills and capabilities of expert designers. Gaining access to the cognitive processes, situational constructs and to the knowledge that comprises expert design activity poses a considerable methological challenge. How can we develop experimental or experiential constructs and organize data collection methods that will reveal how designers solve design problems (Newstetter, W. and et al., 2000)?

In this research, the author attempted the use of the following notions of computer-mediated collaborative learning, scaffolding strategies and multiple representations towards forging those links to bring design knowing and learning together and suggested the use of game programming technology in the development of a design computing education system to support design learning and research in understanding design activities. The aim is to identify the design process that if taught well would address the core goals of design education.

Computer-Mediated Collaborative Learning

Educational research had attempted to determine under what circumstances collaborative learning is more effective than learning alone, and more recently, numerous studies have focused on computer-mediated collaborative learning. In psychology, interest in collaborative learning is related to the emergence of new theories such as "share cognition" and "distributed cognition". These theories move away from the view traditionally held in cognitive science according to which human cognition is bound inside individual heads. The word "collaboration" is also used very frequently in computer science to describe the interactions among artificial agents (Dillenbourg, 1998).

Learner-centred design

The use of constructivist and social constructivist theories in learner-centred design (LCD) differs from the past efforts to design software tools for learning. Computer-aided instruction (CAI, based on behaviorist principles) and intelligent-tutoring system (ITS, based on information processing psychology) have attempted to package educational components that can train learners. Many CAI systems use a more information-transfer, passive model of learning. And ITS approaches can be less useful in loosely structured, wide-ranging work practices. While useful in more constrained fields like geometry and algebra, ITS tools can be difficult to implement for less constrained work activity. Quintana, C et al. (2001) suggested that the key is that learner-centred tools should scaffold active participation by the learner in new work practices of all kinds.

Multiple Representations

In learning declarative knowledge and problem solving skills, multiple representations such as verbal, graphical and mathematical representations, knowledge at different levels of abstraction (e. g. qualitative and quantitative, specific cases or general models) are involved (van Someren et al., 1998). Seel and Dörr (1994) have discussed the distinctive relationship of supplantation of mental images through graphics and the instructional effects on spatial visualization skills of adults. Boshuizen and Schiff (1998) have discussed the issues of problem solving with multiple representation by multiple and single agents. This

coordination of multiple representations is a topic that has not received as much attention in cognitive science as it deserves.

Design Computing Education System

Design computing is an interdisciplinary field that centers on the intersection of design, computer science, and linguistics. These multidimensional faces of this new paradigm necessitate a mutual understanding of computing and design as a whole, which are usually conceived as separated stages of computer-mediated design, i. e., Computer application and computing considered as the production force and design considered as the product for presentation. As design educators we use computers as educational tools in simulating cognitive processes, explicating knowledge structures and even gathering their content as potentially useful material for the designer. In this research, interactions among artificial agents and human being in design computing learning are considered.

Agent and Prototype Development

An interactive and real-time design computing learning system agent model (Fig. 1) is constructed. By interactively manipulating the various attributes, codes, parameters and digital media contents in a distributed system, learners are gradually exposed to the mutual relationship of representational digital multimedia and the underlining programming syntax. The system combined the interactive coding verification capacity of visual software development utility such as Visual Studio and interactive multimedia manipulability of authoring utility such as Flash, with the introduction of 3D real-time simulation capacity for collaborative design computer learning in a dis-

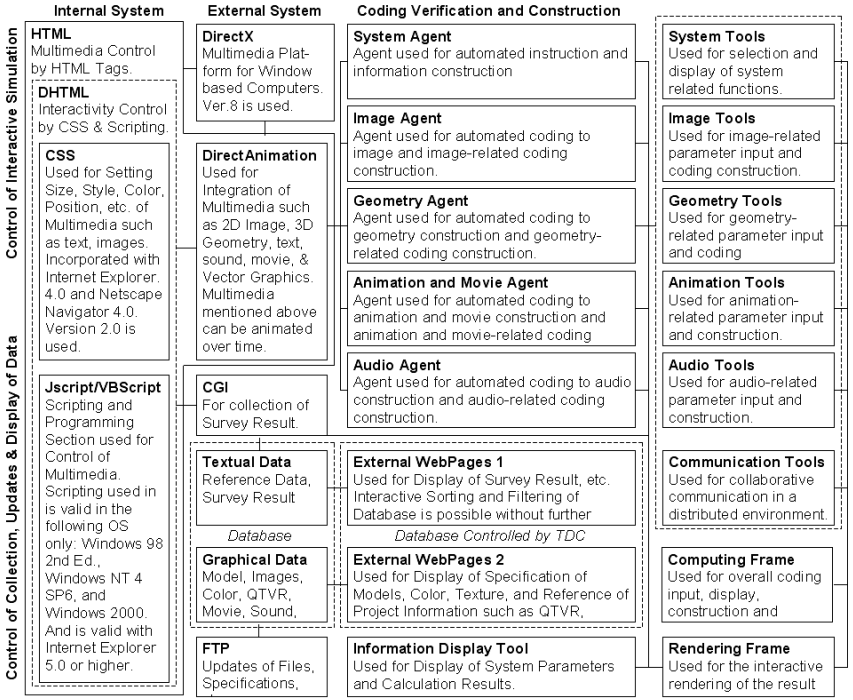

Figure 1. Agent Model

tributed environment.

Based on the use of JavaScript, VBScript and DirectX Scripting in combination with the DirectX multimedia platform in a web-based distributed environment, the prototype of the above agent model is constructed. Learners can interactively predict and evaluate the combined effect of digital multiple representations of multimedia contents (qualitative, semiotic and semantic) and programming codes (quantitative, mathematical presentation, syntax) real-time in a distributed environment. The aim is to expose the underlining mutual relationship of design and computing which are either intentionally hidden or simplified by coding automation functionalities of authoring software. Learners learn from their tentative trials on the combination of scripting and multimedia. The result of the design and coding can be discussed in a distributed environment. Researchers can use the design process history collected to discover and describe design processes, which may be later translated to prescriptive models of design activity, computer model of design process. The system is considered both a learning and research tool in the stream of design computing education.

Conclusion

The goal of this research is to demonstrate the importance of multiple representations and scaffolding strategies in design computing education software development. This research is premised on the belief that stimulative design computing learning and teaching based on a learner-centered design approach can lead to significant improvements in the effectiveness of design courses and to the future capabilities of practicing designers. This research is under progress.

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