A model for designing Computer-Supported Cognitive Tools

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Abstract

We present here a model for designing computer-supported cognitive tools. This model uses Popper's theory of knowledge, which is suitable for the design of knowledge-oriented tools. Three levels are successively considered in the design of such tools: the material world 1, the artefactual world 3, and the cognitive world 2. This three-level model can be used either beforehand for designing new cognitive tools or a posteriori for analyzing them.

Introduction

A cognitive tool, either material or immaterial, is aimed at facilitating actions by amplifying or restructuring cognitive processes [1]. Cognitive tools are commonly non-electronic (e.g., multiplication tables), although research pays recent attention to computer-supported tools (e.g., word processing, LOGO, CSCL, etc.). There is a large literature about cognitive tools and the way they affect human cognition during teaching or learning [2]; but little is known about the way to build new ones. We present here guidelines serving this purpose.

The main goal of such tools is to manage knowledge per se. Thus a theory accounting for knowledge and its relations to human beings is needed. We use here Popper's theory of knowledge [3], which can be detailed as follows. The entire human experience can be categorized into three worlds. The first one, called "world 1" is the physical world (i.e., the world of matter and energy, including all living and inert forms). The second is the world of conscious experiences, called "world 2" (i.e., our perceptual experiences as well as our intentions). The third is the world of "objective knowledge" or "world 3", the objective content of scientific, theoretical, or cultural thoughts. This framework, as researchers pointed out [4], provides a useful way to think about the relations between knowledge content taught and learner experience.

Presentation of the Model

The common purpose of computer-supported cognitive tools is to simulate or assist some cognitive processes involved during teaching or learning a given domain. We claim that Popper's theory can be adequate for our goal of characterizing cognitive tools, because computer-supported cognitive tools in instructional contexts are functionally a blending of three kinds of objects: material objects on which human action can be performed (e.g., a computer), theoretical (e.g., the course content, cultural procedures used in action), as well as cognitive objects (e.g., learning, comprehension, knowledge construction). Let us detail these levels.

The first one is the world 1 level, and represents the material grounding of cognitive tools (see Figure 1 below). The most common object encountered in such tools at this level is the paper sheet, but some more complex material extensions are encountered as well (e.g., microworlds, school environment). The second is the world 3 level. Once the material background is chosen, artefactual schemes or cultural recipes supported by this material are necessary, because the sole background would be insufficient to provide adequate assistance for teaching or learning. Specific immaterial cognitive artefacts, like checklists, tables, grids, content to be taught, etc., have to be determined. The third level is about world 2. Once specified, the very goal of artefacts has to be in accordance with cognitive processes (i.e., amplifying or restructuring them). The specific role of artefacts is not only to represent objects pertaining to world 1 (material) or world 3 (cultural), but also to implement or help some events of the human world 2 (in our case, events about learning and teaching). A large list of instructional events can be drawn, including course planning, student assessment, classroom management, etc.

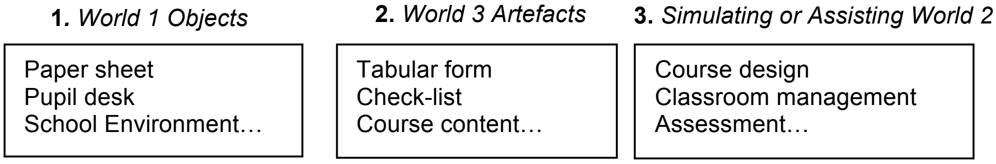

Figure 1. A Model for Constructing Computer-Supported Cognitive Tools.

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An Application of the Model

This three-level model can either be used beforehand for the design of new cognitive tools or a posteriori for analyzing them. First, it is being used in an instructional design university course at master level. Second, we worked out our model by analyzing two systems we implemented (see Table 1 below): *Look Cum* [5], a system for observing and capturing on the fly instructional moves in classrooms and *Apex* [6], a distance-learning system that automatically assesses the semantic content of student course summaries. Both systems rely on Latent Semantic Analysis [7], a statistical method accounting for semantic relations between words or actions.
We plan to design a more comprehensive framework using this model in order to teach it in instructional design courses.

Table 1. Two Examples Instantiating the Model.

Level/System	*Look Cum*	*Apex*
World 1 Level	Classroom map (students' location)	Paper sheet for writing out texts
World 3 Level	Keyboard shortcuts representing the main instructional events	Outline of the course to be summarized
World 2 Level	Automatic detection of patterns in observed classroom events	Automatic assessment of the semantic content of texts by Latent Semantic Analysis

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References

[1] Pea, R. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed cognitions* (pp. 47-87). Cambridge: Cambridge University Press.

[2] Jonassen, D. H., & Carr, C. S. (2000). Mindtools : Affording multiple knowledge representations for learning. In S. P. Lajoie (Ed.), *Computers as Cognitive Tools* (T. 2, pp. 165-196). Mahwah: Erlbaum.

[3] Popper, K. (1979). *Objective Knowledge*. Oxford: Oxford University Press.

[4] Bereiter, C., & Scardamalia, M. (1996). Rethinking learning. In D. Olson & N. Torrance (Eds.), *The Handbook of Education and Human Development* (pp. 485-513). Oxford: Blackwell.

[5] Allègre, E., & Dessus, P. (2003). Un système d'observation et d'analyse en direct de séances d'enseignement [An Observation System for Analysing Instructional Sequences]. In J. M. C. Bastien (Ed.), *Actes des Deuxièmes Journées d'étude en Psychologie Ergonomique (EPIQUE 2003)* (pp. 85-90). Roquencourt: INRIA.

[6] Lemaire, B., & Dessus, P. (2001). A system to assess the semantic content of student essays. *Journal of Educational Computing Research, 24*(3), 305-320.

[7] Landauer, T. K., & Dumais, S. T. (1997). A solution to Plato's problem : the Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review, 104*, 211-240.

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