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Cognitive Processes in Spreadsheet Comprehension

Bruno Emond (BRUNO_EMOND@UQAH.UQUEBEC.CA)
Département des Sciences de l'Éducation
Université du Québec à Hull
Case Postale 1250, Succursale B.
Hull (Québec) Canada. J8X 3X7

This research focuses on developing cognitive models of representations and processes of learners in a computer mediated communication environment. The purpose of the research is to enhance traditional and network working environments with intelligent help, tutors and performance support systems. The current research activities are centered on developing cognitive models of basic software applications found in computer-supported cooperative work environments such as spreadsheets.

Spreadsheets programs are certainly one of the most widely end user applications used in organizations. Although the usability and power of spreadsheets have made it a success story, there are still some usability issues regarding the ease of understanding and learning an analytical model implemented in a spreadsheet. Given the important role spreadsheets play for communication and cooperation in organizations (Nardi & Miller, 1991), and the growth of groupware integrating spreadsheets functionalities, it appears essential to develop a cognitive model of representation and processes for software design and evaluation and for design and evaluation of learning material using spreadsheet functionalities.

The current stage of this research is focused on building a cognitive model of how spreadsheet representational tools determine the construction of mental models of some knowledge domain. This is an important issue for designing learning material using spreadsheets given that it is well known that they impose an opacity between the presentation layer in the form of tabular data and the underlying functional layer that supports computation (Isakowitz, Schocken, & Lucas, 1995; Hendry, & Green, 1994; Saariluoma, & Sajaniem, 1991; Reitman Olson, & Nilsen, 1987-1988). The model should be able to explain spreadsheet expertise in terms of A) skills required for extracting mental representations of the functional layer through exploration of the presentation layer, B) skills required for implementing spreadsheet models that renders as explicit as possible the functional layer, and C) skills required to pass freely from the mathematical representation of a problem to its specific spreadsheet implementation (which likely have different computational properties such as the estimation of continuous functions by a series of iterations).

The empirical data on spreadsheet exploration shows that exploration of the functional layer is determined strongly by the presentation layer (Saariluoma, & Sajaniem, 1991). Recent innovations on spreadsheet programs such as Excel 5.0 have made possible the representation of functional dependencies at the presentation layer using graphical objects (pointing arrows). A pilot experiment has been conducted to examine the extend to which these tools were facilitating extraction of the functional layer by spreadsheet exploration. Preliminary results show that novice users are highly bound to the presentation layer in their exploration and that few exploration moves are based on the functional structure withstanding their familiarity with graphical arrows and the fact the spreadsheets contained text labels. These empirical results suggest the need for supervisory guidance during spreadsheet exploration by novices for the purpose of learning economics or accounting concepts.

A model of novice spreadsheet comprehension and exploration is currently under development using ACT-R (Anderson, 1993). The model includes declarative memory elements for the presentation, functional, and binding units (linking presentation to functional units). A set of production rules controls the creation of binding units and the selection of the next cell to select. This model is providing a cognitive foundation for spreadsheet design principles, and could be used to supervise and guide learners in learning economics or accounting concepts implemented in spreadsheet applications.

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