Open access • Journal Article • DOI:10.1007/BF02504980

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Institutions: Open University

Published on: 01 Dec 2002 - Educational Technology Research and Development (Kluwer Academic Publishers)

Topics: Instructional design, Instructional simulation, Collaborative learning and Educational technology

Computer-Based Tools for Instructional Design: An Introduction to the Special Issue

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Modern instructional theories are characterized by their focus on rich, multidisciplinary and often collaborative learning tasks that are somehow representative for authentic, real life tasks. This new view on learning heavily increases the complexity of the design process and the resulting instructional systems. It is argued that computer-based instructional design (ID) tools may help to deal with this growing complexity. A framework to distinguish different kinds of ID tools is presented. This framework is then used to introduce the contributions to this special issue.

☐ Computer-based tools for instructional design (ID) help designers or teachers to perform one or more of the various activities that can be organized according to the ADDIE model, that is the analysis, design, development or production, implementation and evaluation of instructional systems (Gustafson & Branch, 1997). The history of computer-based ID tools is closely linked to the history of computer-based instruction. After it has been decided to use the computer as the primary instructional medium, or to develop computer-based instruction, it is an evident step to use the computer not only for the delivery but also for the production of the instruction. Consequently, research and development work in the field of ID tools has been dominated, and still is dominated, by *authoring tools* for the development or production of computer-based instruction. Many of those systems are commercially available (e.g., ToolBook, Macromedia Director, Authorware, etc.) and dedicated systems for authoring Web-based instruction, which is currently the most popular form of computer-based instruction, are rapidly appearing on the market.

But until now, there has been less interest in computer-based ID tools that support the analysis and design activities that are undertaken *before* a final medium selection is made and the instruction, which may be *not* computer-based, is actually produced. In addition, there has also been little interest in computer-based ID tools that support the implementation and evaluation activities that are undertaken *after* the instruction has been developed. The aim of this special issue is precisely to discuss characteristics of computer-based ID tools that do *not*

ETR&D, Vol. 50, No. 4, 2002, pp. 5–9 ISSN 1042–1629

focus on the development phase or on the production of computer-based instruction, to provide a variety of examples of such systems, and to discuss current trends and important directions for future research. In the next section it is argued that this kind of computer-based ID tool will become more and more important in the near future. Then the different contributions to the special issue are placed into a common framework and briefly introduced.

THE GROWING IMPORTANCE OF COMPUTER-BASED ID TOOLS

We think that the kind of ID tools discussed in this special issue will greatly gain in importance in the near future. First of all, this is related to a new view on learning that is often actively stimulated by governmental and labor organizations (Simons, van der Linden, & Duffy, 2000). The term *new learning* is used to refer to a broad array of instructional approaches that are all characterized by their focus on rich, multidisciplinary and often collaborative learning tasks (called cases, projects, problems, etc.) that are somehow representative for authentic, real-life tasks. The tasks should ensure active learning and integrate multiple learning objectives in a meaningful way. In addition, collaborative learning tasks offer the opportunity for negotiation between students and take advantage of the fact that multiple perspectives on reality exist, which may enrich the learning experience. From a task-analytical point of view, new learning thus asks for more powerful techniques that can deal with real-life tasks and, especially, complex sets of integrated learning objectives. And from a design point of view it should be clear that the design of practice and in particular the design of meaningful whole tasks, is given precedence over the—traditional—design of to-be-presented information. Both changes contribute to an increased complexity of the design process and the resulting instructional systems.

Other changes may be less central but are still of utmost importance to the nature of the design process. First, the multidisciplinary character of learning tasks indicates that ID is no longer aimed at stand-alone "one-teacher" courses, but often needs to rely on the expertise of more teachers and must fit into the (re)design of a whole curriculum within an educational organization. A comprehensive contextual analysis is needed to clarify the context and identify all stakeholders involved. Second, traditional target group analysis must be refined in order to cope with personalized and individualized forms of instruction, which are needed to develop truly learner-centered instructional systems. Third, the focus on self-directed learning and the desire to make students responsible for their own learning processes requires a thorough analysis of higher-order skills such as self-regulation and self-assessment, and also confronts the designer with the difficult task to intertwine the ID for these higher-order skills with the basic design for domain-related first-order skills. And to conclude, the increased use of information and communication technology (ICT) in instructional systems has its own new problems and design challenges (e.g., Tabbers, Martens, & van Merriënboer, in press). It requires a balanced approach to finding an optimal medium mix, instead of simply selecting one primary medium.

Thus, new learning has important effects on the design of instructional systems and in general increases the complexity of design processes. Several measures may be taken to effectively deal with this. For instance, most researchers agree that the simple, linear version of the ADDIE model is not useful to conduct complex design enterprises. Rapid prototyping approaches (Tripp & Bichelmeyer, 1990) or highly flexible, "zigzag" design approaches seem to be more apt for the design of new learning environments. Furthermore, ID is becoming more and more a collaborative task. On the one hand, design teams are needed that consist of instructional designers, content experts, and teachers, who provide multidisciplinary input,and often graphical artists, and programmers. On the other hand, a much larger group of stakeholders (e.g., educational managers, field experts, branch representatives, etc.) needs to be involved in order to take care of organizational constraints and consequences (Kessels, 1999). All these changes to the design process require at least a good information management, making sure that intermediate and final design products are clearly linked to each other, stored in well-organized databases, easily accessible and changeable for all parties involved, and so forth. It is our firm conviction that computer-based ID tools may help to do so.

A SAMPLE OF COMPUTER-BASED ID TOOLS

An increasing number of researchers believe that computer-based ID tools can play an important role in resolving some of the problems and difficulties that occur in ID (cf., Reiser, 2001; van den Akker, Branch, Gustafson, Nieveen, & Plomp, 1999). Recent review articles of computer-based ID tools (Nieveen & Gustafson, 1999; Wang, 2001) describe a broad range of ID tools, including so-called "preauthoring systems" that support needs assessment (e.g., Advisor P.I.) or the whole analysis and design process (e.g., Advanced Instructional Design Advisor or AIDA, Designer's Edge, Langevin Instructional DesignWare), systems for the selection of methods and media (e.g., Training Delivery Assessment Model, Automated Media Selection Model), and systems for supporting the implementation and evaluation of instructional systems (e.g., CASCADE-EVAL). The ID tools do not differ only with regard to the specific analysis and design activities that they support, but also on a large number of other dimensions. Nieveen and Gustafson (1999) provided a useful conceptual framework to compare ID tools, with the five dimensions: (a) development process and theory, (b) intended output, (c) purpose and evidence, (d) intended users, and (e) task support.

The dimension *development process and theory* pertains to the phase or phases in the design process that are supported by the tool (A, D, D, I, E or combinations). The underlying theory, if any, can be a broad paradigm (e.g., social-constructivism, behaviorism, cognitivism) or a highly specific ID model (e.g., the instructional events of Gagné for AIDA, van Merriënboer's 4C/ID-model, 1997, for the ID tools described by de Croock et al. in this issue). The dimension *intended output* pertains to the desired results of the activities that are supported, for instance, a concept tree of lesson contents, a training blueprint, a lesson plan, an evaluation plan, or a particular medium choice. The dimension *purpose and evidence* pertains to the main purpose of the tool, such as speeding up the design process, increasing the cost effectiveness, or improving the quality of to-be-designed products. Evidence reflects the data that are available to support the claimed benefits in terms of validity, practicality and effectiveness. The dimension *intended users* refers to the function or role of the users (e.g., professional designers, teachers, learners, school management, etc.) as well as specific characteristics that are necessary to effectively work with the ID tool, such as computer experience, design experience, and so forth.

Of particular interest for our current purpose is the fifth dimension, namely *task support.* ID tools can be seen as a special type of electronic performance support system (EPSS; Bastiaens & Martens, 2000; Gery, 1991), that is, interactive computer-based tools that provide on-the-job, just-in-time support to facilitate task performance or product development. They can be designed to give four basic types of support: (a) *library and information* support, by providing useful resources and databases, (b) *standardization* support, by providing rules, regulations and directions for performing specific tasks, (c) full or partial *task automation,* by providing automated tools, expert systems and wizards, and (d) *instruction,* by providing users just-in-time learning materials that may help to perform their tasks. Many means of support may be distinguished for each of the basic types, including checklists, cue cards, glossaries and dictionaries, diagrams, examples, intelligent agents and wizards, frequently asked questions, how-to procedures, references, templates, tutorials, and much more. An important issue concerns the extent to which the tool can be adapted to users' needs: its adaptability and customizability.

Table 1 uses the five dimensions to briefly summarize the ID tools that will be discussed in this special issue. The contributions are ordered according to the level of the educational sector they are directed to, ranging from kindergarten to industrial training. The first contribution, by

Table 1 ☐ Characteristics of the instructional design tools that are discussed in this special issue in a conceptual framework (based on Nieveen & Gustafson, 1999).

Digital Planning Board (Mooij)	*CASCADE (McKenney et al.)*	*Knowledge management tools (Spector)*	*ADAPT^{IT} (De Croock et al.)*
1. Development process and theory			
Supports instructional management and implementation. Social constructivist approach.	Supports formative evaluation, but also development and implementation (MUCH, SEA and IMEI). Pragmatic Approach.	Support *collaborative* design and development activities; tools may also be used as instructional management system. Framework is CSCW.	Supports analysis and design (Core) as well as evaluation (Eval). Based on 4C/ID* methodology.
2. Intended Output			
Advise learners re: learning activities. Information on learner progress for teachers and parents.	Evaluation plans, (multimedia) lesson plans	Can be any computer-based design product.	A detailed training blueprint (Core); suggestions for improving the blueprint (Eval).
3. Purpose and evidence			
Individualize and optimize instruction. First positive evaluation results are available.	Improve evaluation and design process and quality of instructional materials. Evaluation results available (except for IMEI).	Facilitate cooperation in (distributed) design teams and improve reuse of materials. Preliminary evaluation results available.	More efficient task performance; higher quality of training programs. Some preliminary results for usability of ID tools (prototypes) available.
4. Intended Users			
Learners, teachers, school management.	Professional designers, (resource) teachers in developing countries.	Professional designers, content matter experts and teachers in various organizations.	Professional designers, but usually with background in learning domain—not in ID.
5. Task support			
Standardization and task automation. Is used by different target groups.	Information, standardization and task automation. Different systems for different users exist.	Information sharing through communication aids, networked.	Information, standardization, and task automation. May be customized for particular target group.

Note: ADAPT^{IT} = Advanced Design Approach for Personalized Training—Interactive Tools. CASCADE = Computer ASsisted Curriculum Analysis, Design and Evaluation. CSCW = computer-supported collaborative work; ID = instructional design; IMEI = Innovation in Mathematics Education in Indonesia; MUCH = MUltimedia curriculum design in CHina; SEA = Science Education in Africa.

Ton Mooij, "Designing a Digital Instructional Management System to Optimize Early Education," describes the Digital Planning Board—an ID tool that may help to implement personalized and learner-centered instruction in kindergarten and primary school. The second contribution, by Susan McKenney, Nienke Nieveen, and Jan van den Akker, "Computer Support for Curriculum Developers: CASCADE," describes a family of ID tools that helps professional designers and secondary school teachers in developing countries to design and evaluate their instructional materials. The third contribution, by Michael Spector, "Knowledge Management Tools for Instructional Design," describes the role that knowledge management tools can fulfill for the distributed planning, implementation, and management of instructional systems in higher education. The fourth contribution, by Marcel de Croock, Fred Paas, Henrik Schlanbusch, and Jeroen van Merriënboer, "ADAPT^{IT}: ID Tools for Training Design and Evaluation," describes tools for the analysis and design (CORE) as well as the evaluation (EVAL) of industrial training programs for complex skills.

The final article, by Kent Gustafson, provides a critical discussion and comparison of the contributions. In particular, three questions will be answered:

1. If and how the systemic, nonlinear character of the design process is taken into account by the different ID tools.
2. If and how collaboration between designers, content experts and possibly other team members is facilitated by the tools.
3. If and how the context for use of the tools with all its relevant stakeholders has been taken into consideration.

Other questions that will be posed pertain to the state of the art of the presented ID tools and their flexibility:

- Do they make good use of smart expert systems and current wizard and intelligent agent technology?
- Are they sufficiently task specific to empower their users?
- Can they be easily customized to another target group or context?

Answering these questions in the discussion about the ID tools presented will eventually lead to a description of important themes for future research. □

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