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INFORMATION TECHNOLOGY TOOLS FOR CURRICULUM DEVELOPMENT

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Curriculum Development Aided by Technology

Before discussing specific information technology tools for curriculum development, it is useful to first examine the two main fields involved. This chapter therefore begins with a brief discussion of curriculum development as a complex task, and those aspects that lend themselves most naturally to being supported by technology. Thereafter, recent advances of IT in supporting complex tasks are addressed.

Curriculum Development: A Complex Endeavor

In this chapter, the term *curriculum* is used in accordance with Taba's (1962) broad definition: "a plan for learning." A well-considered plan specifies how learning will take place and considers its central rationale, the aims and objectives, content, organization, and evaluation of learning (Walker, 2003). Curricular concerns may be addressed at several levels: supra (society), macro (system), meso (school), micro (classroom), or nano (learner). Among other characteristics, a robustly designed curriculum will evidence consistency among curricular components and across curricular levels (McKenney et al., 2006). Depending on the level the curriculum addresses, different groups of people are involved in the process of creating this plan for learning. At the supra and macro level these are (among others) subject-matter experts, pedagogical content experts, and educational policy makers, whereas at meso, micro, and nano level, teachers, teacher teams, school leaders, and learners are commonly involved. As far as

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the design of lesson materials (micro level) is concerned, particularly educational publishers, subject-matter experts, pedagogical content experts, IT-experts, and teachers are engaged. When taking all factors and actors into consideration, curriculum development may be viewed as a complex task.

In the last 15 years, many computer-based tools have been developed to support designers during the complex endeavor of instructional and curriculum development, especially at the micro level (Gustafson and Reeves, 1990; van den Akker et al., 1999; van Merriënboer and Martens, 2002; Zhongmin and Merrill, 1991). These developments have been influenced by the growing possibilities of information technology and evolving insights in the potentials of computer-based tools in this domain. The following section provides an historical perspective on the field of IT tools that support the performance of complex tasks in general and of educational design tasks in particular.

IT Tools for Supporting Complex Tasks

Amidst an explosion of technological innovation, several types of IT tools emerged that also have been applied to the context of curriculum design. In this section, we distinguish three types of these IT tools: Electronic Performance Support Systems (EPSSs), Knowledge Management Systems (KMSs), and Repositories for Reuse. As depicted in Figure 1, an example will be given for each type of tool in the following section.

Electronic Performance Support Systems

The concept of EPSSs was born in the late 1980s and took a foothold in the early 1990s. An EPSS is a computer-based system that provides integrated support in the format of any or all of the following: job aids (including conceptual and procedural

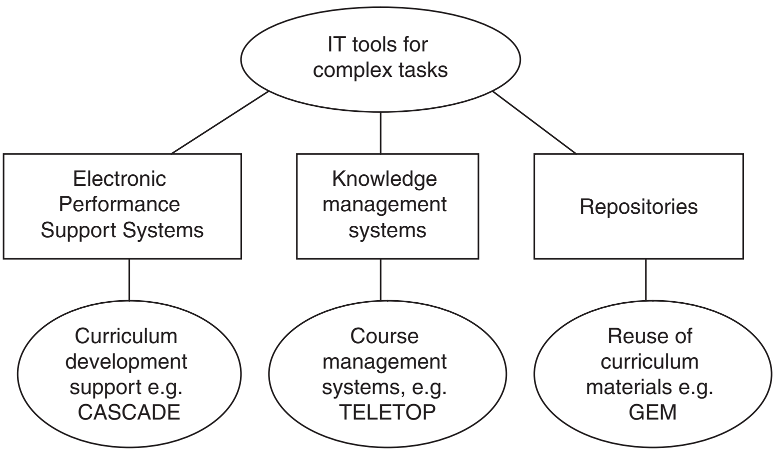

Fig. 1 ICT tool types used to support the complex task of curriculum development

information and advice), communication aids and learning opportunities (such as Computer-Based Training (CBT), in order to improve user performance.

Earlier work in this area demonstrated a clear orientation toward "proof of concept" thinking, as evidenced by the literature that populated journals at that time (for an overview of EPSS-related literature from 1989 to 1995, please refer to Hudzina et al., 1996). Emphasis was given to defining the innovative concept of EPSS, to demonstrating its potential feasibility, and to verifying the likelihood of its usefulness (cf. Gery, 1995) as well as to discussing ways of exploring the potential further (Stevens and Stevens, 1995). The widely accepted goal of EPSS is to provide whatever is necessary to generate performance and learning *at the moment of need*. An EPSS can be distinguished from other types of interactive resources by the degree to which it integrates *information, tools and methodology* for the user. It should be noted that, while high quality performance support is likely to contain learning opportunities, experts lament the misconception that CBT – by itself – constitutes performance support; they call for CBT utilities to be more easily integrated in larger systems (Dickelman, 2003a). In other words, consensus has not been reached on the ideal balance of support elements in systems, with many variations being offered in literature (e.g., Collis and Verwijs, 1995; McKenney, 2008; Nieveen and van den Akker, 1999; Raybould, 1990; Stevens and Stevens, 1995). Whereas earlier research and development efforts seemed more inspired by the idea of exploring what electronic *systems* could offer, a trend rapidly emerged in which *user performance* became central, with the supporting systems on the periphery (Rosenberg, 1995; Winslow and Bramer, 1994); hence the concept of Performance-Centered Design (PCD) was born. This gave rise to articulation of fundamental forms of support (Gery, 1995; Marion, 2002), and attributes and behaviors of performance-centered systems (Gery, 1997; McGraw, 1997) as well as methodologies for conducting PCD (Raybould, 2000) and guidelines for designing tools to support specific learning-behaviors (Gery, 2002). At the same time, advances in the field of human performance technology (HPT), with its emphasis on systematically bridging the gap between what is and what should be in human performance, have provided useful concepts and tools for conceptualizing performance problems (e.g., see Wilmoth et al., 2002, for an overview of HPT models).

A variety of EPSSs have been developed to support designers during the complex endeavor of curriculum development. These tools tend to be created for instructional designers, preservice teachers, inservice teachers, teacher educators, and educational consultants. Tools in this classification assist in the design and development tasks that might also be described as *desk work*. These tasks include planning needs analysis (but not the actual data collection), drafting and designing curriculum materials, creating formative evaluation instruments, and analyzing work flows. Task-specific tools within this classification include those designed to aid in personal course or lesson planning (Gervedink Nijhuis and Collis, 2005; Wild, 2000), creating teacher guides for use by others (McKenney, 2005), and formative evaluation (Nieveen and van den Akker, 1999). Outputs from systems within this classification may be conceptual (e.g., formulating an approach for conducting a context analysis) or concrete (e.g., an interview scheme to be used with headmasters during context analysis).

For comprehensive accounts of tools for instructional and curriculum design, please refer to Nieveen and Gustafson (1999), van Merriënboer and Martens (2002), or Spector and Ohrazda (2003). Studies have demonstrated that support tools can aid both design experts (de Croock et al., 2002; Merrill and Thompson, 1999; Rowley, 2005; Spector, 1999) and nondesign experts, such as teachers and subject-matter experts (McKenney et al., 2002; Mooij, 2002). In Section 2.1 an example of an EPSS for curriculum developers will be more fully described.

Knowledge Management Systems

A KMS is a system for managing knowledge within an organization. A KMS may support the creation, capture, storage, and/or dissemination of knowledge and/or expertise. Although realizing their potential is often difficult (cf. Rosenberg, 2002), KMSs support the performance of complex tasks by offering aids for communication, coordination, collaboration, and control (Spector, 2002).

While KMSs have been used in education, tools more tailored to the job of planning instruction or teaching most often fulfill these functions: Course Management Systems (CMSs). Common forms of (teacher) support in CMSs include administration tools (e.g., grading tools, assignment tracking, testing); course delivery tools (e.g., discussions, messages, shared work space); and content development tools (e.g., templates for course design, content reuse, instructional design aids). For comparison of CMS products most commonly used by K-12 schools and in higher education, visit http://www.edutools.info. For an early overview of Web-based course support, see the special issue of the *International Journal of Educational Telecommunication*, 5(4), 1999, which examines relevant technical, pedagogical, and institutional issues. Section 2.2 elaborates on an example of a CMS. Instructional Knowledge Management Systems (IKMSs) bear resemblance to CMSs, but also offer additional functionalities, such as the management of paper-based documents and knowledge management across multiple courses (e.g., across subjects and disciplines); for additional information on IKMSs and their core features, please refer to Edmonds and Pusch (2002).

Repositories of Resources for Reuse

The advance of flexible access to digital information supported by World Wide Web browsers in the early 1990s also rang in an era of digital libraries and digital repositories. These are "organized collections of information resources and associated tools for creating, archiving, sharing, searching, and using information that can be accessed electronically" (Reeves, 2005, p. 527). In educational settings, digital libraries particularly focus on the reuse of digital teaching and learning materials (see, for example, the *Journal of Interactive Media in Education*'s special issue in 2003). The term *reusable resources* pertains to the teacher perspective as well as the learner perspective. Several national and international repositories have been established to collect and share digital resources. For example, the Dutch EduRep

(Educational Repositories) initiative (http://edurep.kennisnet.nl) offers a central listing of (digital) learning material that is available through the Internet. Its databases include the collections of materials offered by publishers, educational institutions, and socio-cultural organizations; most participating organizations are active in the K-12 sector. Searches in EduRep yield information about the various resources and links to either (a) download the resource itself or (b) request it from the provider (e.g., in the case of paper-based resources).

Commonly referred to as learning objects (also knowledge objects or sharable content objects), reusable resources from the learner perspective are frequently incorporated into tools that assist with curriculum implementation. Strijker and Collis (2007a) describe differences in curriculum contexts and also the requirements for different approaches for the use of learning objects. Learning objects vary, due to differences in size, granularity, shape, and intended usage, but the following definition by Sosteric and Hesemeier (2002) may be useful, "A learning object is a digital file (image, movie, etc.) intended to be used for pedagogical purposes, which includes either internally or via association, suggestions on the appropriate context within which to utilize the object." Wiley's (2000) taxonomy distinguishes five types of learning objects and their various characteristics; this same chapter also emphasizes the need for instructional use to be well-specified. Others, such as Harvey (2005), go on to stress the need to apply instructional design principles to the learning object development process. In fact, he warns that, "If such principles are not heeded, learning repositories will gain a reputation for amateurish content, rather than credibility as worthwhile educational resources."

From a technical perspective, much of the discussion concerning the reuse of learning objects centers on the need for standardized Learning Object Metadata (LOM) to facilitate interoperability between systems. The Learning Technology Standards Committee (http://ieeeltsc.org/) authored the LOM standard to make this possible. The LOM is based on categories such as lifecycle, technical, educational, rights, relation, annotation, and classification. Within these categories metadata elements such as title, language, keyword, author, version, intended user role, context, age range, and typical learning time can be found. This LOM standard is also incorporated in the Sharable Content Object Reference Model (SCORM), which is a set of specifications for composing Web-based learning objects (diNitto et al., 2006).

However, sustainability and interoperability are fundamentally determined by issues from the human perspective. In terms of design, three factors bear particular mention: (1) technical expertise (skills within a particular team); (2) commercial interests (remember that IBM's technology was once so proprietary that not even another system's keyboard could be used!); and (3) planning ahead (having both the perspective and the time to tackle things with reuse in mind). Perhaps even more importantly, reusable materials must be a shared goal, as Spector (2002) argues, "… the key to successful reuse is not a particular tagging scheme or a particular technology – the key to successful reuse is in getting people with relevant interests, expertise and motivation to collaborate in ways that obviously extend and enhance what they might accomplish individually." Also, Parrish (2004, p. 65) takes a critical look at the proposed benefits of learning objects, and aptly points out that "solutions lie in more effective instructional practice … not simply access to more content."

Large-scale learning object repository initiatives have been undertaken by universities (e.g., Merlot (Malloy and Hanley, 2001; MERLOT, 2007) and MIT (MIT, 2007)) as well as organizations such as the European Union (Ariadne (ARIADNE, 2007)). In Section 2.3 an example of a repository for reuse of resources in K-12 education will be described more extensively.

Three Cases of IT Support for Curriculum Development

This section discusses examples of the three types of IT support tools discussed in the previous section. Each tool is described based on four system characteristics: (a) user profiles; (b) design processes supported; (c) results generated; (d) support formats offered. The *user profiles* for tools for curriculum development vary in terms of the educational design expertise of the user group, the scope of the intended user group, and the computer experience. While some tools are designed for large audiences (commercial production), many are also custom made for smaller ones. Tools further differ in terms of the part(s) of the *design process* for which the support is offered (analysis, design, construction, implementation, evaluation). *Tool results*, or outputs, vary depending on the target group (e.g., learner-based, teacher-based); form (paper-based, computer-based, www-based); and extensiveness of the task being supported (site specific, generic). Finally, while the accents in different tools shift to meet user needs, most tools include some *support form(s)* of advice, tools, learning opportunities, and communication aids.

Example of an EPSS: CASCADE-SEA

CASCADE-SEA stands for Computer ASsisted Curriculum Analysis, Design and Evaluation for Science Education in Africa. It is the name of a computer program that helps resource teachers create exemplary teacher guides.

User Profile

CASCADE-SEA assists facilitator teachers, working at regional teacher resource centers, in making teacher guides that can then be used by other teachers (usually colleagues in the same region). The CASCADE-SEA system has been used by facilitator teachers in Namibia, Tanzania, Zimbabwe, and South Africa in conjunction with broader curriculum development initiatives. In addition, the following other groups have been using the system in recent years: preservice teachers in Zimbabwe (in curriculum methods courses) and professional curriculum developers from the Tanzanian Institute of Education as well as course designers within the Faculty of Education at Eduardo Mondlane University on Mozambique.

Fig. 2 Main menu within CASCADE-SEA

Design Process Supported

As the main menu (Figure 2) illustrates, CASCADE-SEA guides its users through the following key phases in the cyclic process of curriculum development:

- Rationale (Why am I making materials? What do I want to achieve with them?)
- Analysis (What kinds of materials do we need? What are the problem areas?)
- Design (How can I best structure these materials? What kinds of tips do I include?)
- Evaluation (Do they work as I had hoped? How can they be improved?)

Results

Different outputs are produced in each area of the program. These are summarized in Table 1.

Support Formats

CASCADE-SEA was designed to provide four main types of support: advice, tools, learning opportunities, and communication aids. Six illustrations of each type are provided in Table 2.

Table 1 Main outputs from CASCADE-SEA system

Area	Conceptual results	Concrete: Printable, electronic outputs
Rationale	Articulation of aims	Rationale profile
	Clarification of context	Design tips
		Implementation recommendations
		Templates
Analysis and evaluation	Generation of questions	Analysis/evaluation plan
	Selection of methods to answer questions	Analysis/evaluation plan checklist
		Analysis/evaluation instruments (interview schemes, questionnaires, document analysis checklists, etc.)
		Guidelines for working with respondent groups (headmasters, teachers, learners, classes)
		Suggestions on (re)shaping materials
Design	Setting goals	Table of contents
	Choosing assessment	Individual lesson plans
	Clustering and sequencing content	Lesson plan checklist
	Shaping layout	

Table 2 Illustrations of support types offered within CASCADE-SEA

		Examples from the CASCADE-SEA program
Advice	Tailor-made	Reminders of choices made previously
		Consistency checks (illogical options are disabled)
		Heuristics
	Generic tips	Reference and further reading lists provided for sub-tasks
		Examples given in explanations
		Sample/draft text preformatted in text-entry boxes
Tools	Internal	Templates provided for all instrument types
		Automatic-save/archive/copy
		Generates (draft) plans
	External	Drawing and concept-mapping software
		Links to relevant Websites
		Additional resources available through online database
Learning opportunities	Implicit	Visual appearance suggests a method for doing (sub)tasks

(continued)

Table 2 (continued)

		Examples from the CASCADE-SEA program
		Previews consequences of user actions
		System monitors and responds to user choices
	Explicit	Explanations
		Tutorials
		Illustrations
Communication aids	Written	Shared database
		Website discussion forum
		E-mail links
	Verbal	Checklists for use in design team discussions
		Examples to stimulate dialogue
		Instructions for interacting with respondents

For Further reading on the Cascade system, please refer to the following sources: McKenney, 2008; McKenney et al., 2002; McKenney, 2005

Example of a KMS (CMS): TeleTop

TeleTop is a Web-based course design and delivery environment. It was originally designed to support university faculty in planning and managing their courses, as well as using telematics applications in their teaching.

User Profile

Since the initial development of TeleTop, the tool has been revised and expanded. Nowadays, TeleTop is also used on a large scale in Dutch secondary education as well as adult and vocational education, higher education, and corporate and government organizations.

Design Process Supported

TeleTop is an online CMS, whose functionalities include options to postcourse information (about, e.g., learning goals, assessment, teachers); create and submit assessments (e.g., assignments, quizzes); post e-sources and learning objects (e.g., presentations, multimedia files, simulations); and communication aids (e.g., online discussions, shared workspaces).

Results

The use of TeleTop results in a Web-based course environment. Figure 3 offers an example of one of the resources (leermiddelen) about gravity. The site is in Dutch to support students and teachers in there native language; translations in the text are given in parentheses and refer to this figure.

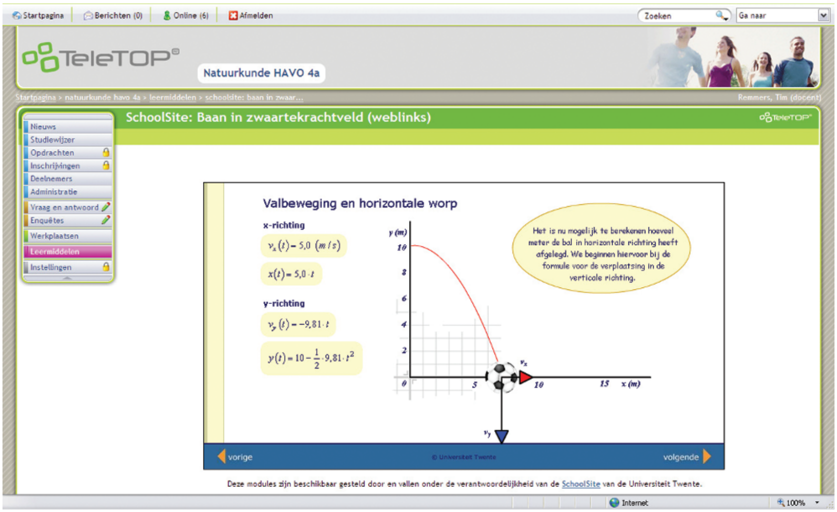

Fig. 3 Resources within a Science TeleTop course environment

Support Formats

The Teletop system is database driven. Support within the TeleTop system is offered in several ways, including the following.

– Template tool: Offering seven course models and support for selecting the most relevant.
– Menu-design tool: Offering different additional functionalities to choose within the course models.
– Roster-design (Studiewijzer) tool: A scheduling framework and possibilities to offer and retrieve assignments.
– A course tutor: Offering recommendations for flexibility, technology and pedagogy.
– A Learning Content Management System: Offering reuse (zoeken) possibilities and connections to digital repositories.

The connection to the digital repositories is made through a search (zoeken) option in the right top of Figure 2. This search option provides direct access to educational repositories and makes it possible to select resources from educational repositories directly. Based on the copyrights copies or links to the course material are provided. Table 3 provides examples of support given in the form of advice, tools, learning opportunities, and communication aids.

Example of Repositories for Reuse: GEM

The U.S. Department of Education's National Library of Education launched the Gateway to Educational Materials (GEMs) project in 1996 to help educators find lesson plans and teacher guides on the Internet (see http://www.thegateway.org).

Table 3 Examples of support offered within TeleTop

	Examples from the TeleTop environment
Advice	Videos with expert comments
	Consistency checks (illogical options are disabled)
	Guidelines for selecting functionalities
Tools	Templates provided for seven course structures
	Reuse previous course through copy/edit function
	Selection from educational repositories (Zoeken)
	Tracking, tracing, and reporting (Administratie)
	Menu designer
Learning opportunities	Explanations
	Simulations
	Tutorials
	Videos
Communication aids	Group work and shared workspaces (Werkplaatsen)
	Question and answer (Vraag en antwoord)
	Questionnaires (Enquetes)
	Online and offline messaging (left top icons)
	E-mail links (Deelnemers)
	Threaded discussions

Further reading on the TeleTop system: Strijker and Collis, 2005, 2007b; Collis and Moonen, 2001

GEM is a consortium of government agencies, educational institutions, nonprofit and commercial organizations offering access to over 40,000 records from over 600 consortium member collections; see Figure 4.

User Profile

GEM was initially designed to help practicing K-12 teachers locate materials and tools for use in their classrooms. While that remains the case, additional user groups now include administrators, preservice teachers and their educators, parents, and the general public.

Design Process Supported

The GEM resources primarily aid in the planning and organization of learning and instruction. Many resources also offer artifacts to use in the classroom with learners. Some items contain tools or tips for assessment. Although in the minority, there are also classes of resources meant to help leaders and managers as well as the establishment of collaborative partnerships (e.g., between businesses and schools).

Results

GEM searches yield access to various types of teaching and learning resources, predominantly lesson and activity plans and instructional units. Additional types of

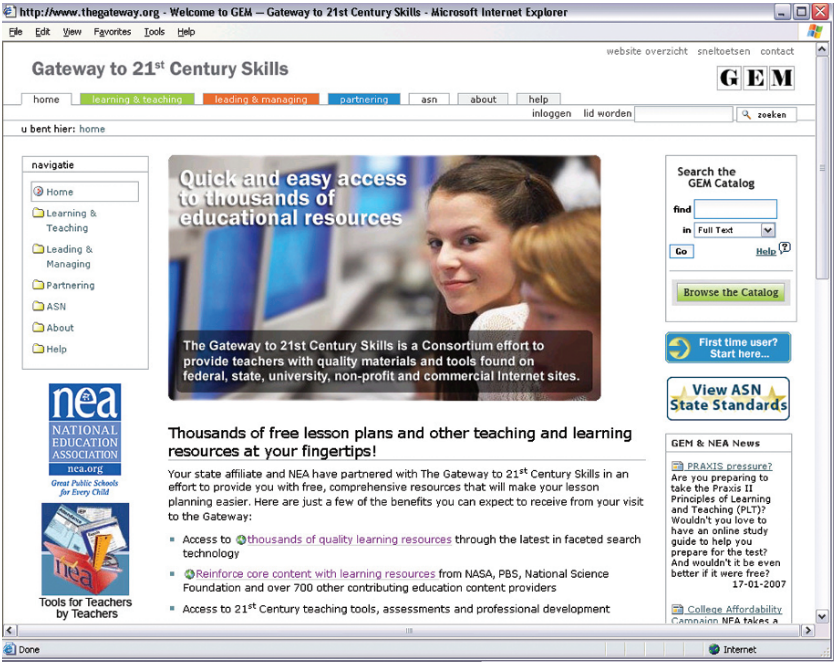

Fig. 4 Screen shot from the homepage of the GEM Website

resources include images, digital and paper-based tools, data sets, and references. For a comprehensive description of results, please refer to the aforementioned Website.

Support Formats

Trends and tips, with relevant links, are offered on GEM's three themes (teaching and learning, leading and managing, and partnering). The dominant theme is the teaching and learning strand, but for all strands, users can search and browse by subject, type, level, keywords, mediators, or beneficiaries. Help is offered for effective browsing and searching.

Further reading on GEM: Small et al. (1999); Sutton (2003).

Future Directions

The concept of performance support for curriculum development is relatively young. The variety of tools developed implies that the concept's potential has been widely recognized. Advocates of performance support systems cite a variety of potential advantages, the most common of which include improved task performance, transfer of knowledge and skills, organizational learning, and cost-saving.

Naturally however, there are obstacles to realizing all the benefits. When it comes to curriculum development tools, evidence of sustained use is rare. On one hand this could be caused by the fact that this kind of follow-up research is hardly carried out. On the other hand, potential hindrances to EPSS implementation in regular design practices constitute no small hurdles. From the technical perspective, logistics and infrastructure can present huge challenges (e.g., the inertia of legacy systems and the need for network administrators to install non-Web-based environments) and new technologies can be unstable. Even more significant are barriers from the human perspective, which commonly include unfavorable organizational or political climate, philosophical differences (e.g., "a computer shouldn't be able to do my job for me"), and personal resistance (time-consuming, intimidating, confusing). Oftentimes, educational designers are not even aware of relevant, available tools. EPSS design is often a risky business, as it usually requires high investment and yields difficult-to-measure results. Insufficient needs analysis is a common pitfall among EPSS designers, who sometimes base their products on user perceived needs, rather than real ones. Perhaps this is due in part to the fact that, with a few recent exceptions, participatory development of EPSSs has been scarce. Reeves and Raven (2002) offer a useful framework for assessing the feasibility of designing an EPSS.

But what is on the research and development horizon?

Over a decade ago, Gery (1995, p. 48) said, "Few [EPSSs] are guided by a set of integrated and fully articulated design principles. Many innovations are the result of team creativity and iterative design employing rapid prototyping coupled with ongoing usability and performance testing." Since then, steps have been made to strengthen development processes for EPSSs in general (Carliner, 2002; Dickelman, 2003b), but far less so when it comes to designing performance support specifically within the field of education. If progress is to be made toward a much-needed increase in quality and types of performance support tools for K-12 and higher education, then it would seem fitting to consider design principles for this genre of tools. Such principles should be distilled from well-documented, high-quality research and development endeavors.

In terms of future research, it would seem that systematically evaluating the degree to which these tools actually can yield the potential benefits (effectiveness) should be high on the agenda. In fact, Gustafson (2002, p. 65) takes this notion a step further, "Probably the single most important area needing further attention is systematically evaluating the effectiveness and appeal of the education and training that result from using [instructional design] tools."

With regard to the future, the growth of information technology for curriculum development is almost surely to be steered by technological innovation. For example, we could see more integrated use of intelligent technologies (e.g., agents, search engines, filtering) and generic tracking and tracing utilities (cf. Quesenbery, 2002). This can lead, for example, to a more sophisticated personalization of support and learning through portal technology (cf. Strijker and Fisser, 2008). Perhaps systems will be linked to mobile phones that can be used to collect data: pupil location, time of events, and even utterances while performing a new learning task. In all cases, additional examples of system design, flanked by design research during prototyping as well as implementation, are needed to extract insights and advance the field.

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