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Fostering Pedagogical Soundness of Multimedia Learning Materials (1)

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The design and development of multimedia learning materials remains an emerging field. In terms of fostering sound pedagogy, beliefs about how these materials should be presented and what they can and should be able to do continue to evolve. This paper presents a set of 10 principles that reflect current beliefs about the processes and contexts of optimal learning in general and within multimedia environments more specifically. They are intended to serve as guidelines for generalists who are responsible for overseeing the creation and implementation of pedagogically sound multimedia products. The first two principles focus on general challenges that developers face in creating these materials; the next six, highlight specific qualities that characterize effective products; the last two principles examine issues tha arise when a product makes its way into a classroom setting.

L'élaboration de matériel didactique multimédia demeure un domaine relativement nouveau. Dans la perspective d'une saine pédagogie, la réflexion se poursuit quant à ce que de tels documents devraient comporter et quant à ce qu'ils devraient pouvoir faire. Ce document expose un ensemble de 10 principes reflétant les idées actuelles quant aux processus d'apprentissage optimal dans un cadre général et dans le cadre plus précis des environnements multimédias. Ces principes pourraient servir de cadre d'orientation aux généralistes responsables de la création et de la réalisation de produits pédagogiques multimédias. Les deux premiers principes portent sur les grands défis que doivent relever les créateurs de tels documents. Les six principes suivants soulignent les qualités propres aux produits efficaces. Enfin, les deux derniers principes portent sur les questions qui se posent lorsque de tels produits arrivent en classe.

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(2) We use the terms "multimedia learning materials", "learning materials", or "product(s)" inter-changeably to refer to interactive CD-ROMS, CD-ROMs with internet links, and fully online computer-mediated environments.

Today's technology provides exciting possibilities for creating rich computer-mediated learning environments. At the same time, beliefs about how multimedia learning materials should be designed and about what they can and should be able to do in an educational context continue to evolve as new knowledge in the form of research findings, learning theory, technological innovations and applications, actual product development, and user feedback combine in unforeseen ways to inform those beliefs.

In this paper, we present 10 principles that reflect current beliefs about the processes and contexts of optimal learning in general and optimal learning within multimedia environments more specifically. These principles are intended to serve as reflective guideposts for those generalists who have been entrusted with overseeing, participating in, and consulting on the creation of pedagogically-sound multimedia learning materials*.

Before presenting the principles it is helpful to keep in mind a few caveats. First, it became evident during our review of current educational literature that much of what is known about best practices for creating multimedia learning environments has been derived from professionals' written reflections and special "pilot projects" or "laboratory-type" studies using multimedia, rather than from research focusing on a broad range of more typical learner contexts. Also, inconsistent findings, the complexity of the issues, and the rapid technological changes within the field, highlight the overall challenge facing developers. Finally, developers and educators need to keep in mind that attentive development of multimedia learning materials is only one of many factors that shape learning experiences and outcomes. The learning impact of a given product can only begin to be understood and appreciated in terms of the local context in which it is used. Hardware and software accessibility; teacher and learner attitudes, knowledge, and experience; classroom, school, and home subcultures; and the specific ways that users "work with" the product are just some of the many contextual factors that influence learning, but that are beyond the reach of the multimedia development team.

The ten principles discussed in this paper were derived from a review and synthesis of the current (primarily 1994-1998) scholarly and professional educational literature relating to multimedia as a learning tool. Multiple searches of the ERIC database, electronic journals, currenr issues of selected journals, and our university's online catalogue were completed. A preliminary list of search terms evolved from several broadly defined early searches in the area of educational technology. These initial terms were regularly revised in subsequent searches as we read and reviewed articles and books generated from the searches. At its

most comprehensive and inclusive phase, we used the following terms to guide our searching: Computers, Computer Assisted Instruction, Computer Oriented Programs, Computer Software, Computer Software Reviews, Computer uses in Education, Curriculum Design, Education, Educational Media, Educational Technology, Hypermedia, Instructional Materials, Internet, Multimedia Instruction, Technology, and Technology Education. (Computer Mediated Communication was later added to this list following advice from an anonymous reviewer.) These descriptors were combined with Instructional Effectiveness or Evaluation Criteria. Searches were also done of key authors who were identified from our preliminary analysis of initial search results. The web sites of the Council of Ministers, all Canadian Ministries of Education, Canadian Teachers Federation, Canadian Heritage and its agencies, as well as special web sites (e.g., SchoolNet, TACT, MarcoPolo, MaMaMedia, Inspiration software) were also examined.

Overall, approximately 150 major articles, manuscripts, and books were consulted (a full bibliography is available from the authors). A preliminary draft of the principles was vetted with a panel of 10 experts that included classroom teachers, Canadian government and non-governmental representatives, and academic researchers. The current text incorporates comments from the panel of experts.

Prior to presenting the principles, we provide a brief overview of the philosophical context within which the principles rest. Our intent in making this context explicit is to share with the reader our own assumptions and central beliefs about the philosophical underpinnings of the principles.

Philosophical Context for Understanding the Principles

At its most essential level, an eclectic combination of behaviourism, systems theory, information-processing, constructivism, and critical pedagogy provide the main philosophical backdrop for thinking about how best to foster pedagogical soundness within multimedia learning materials,

Historically, since the 1960's, behaviourism, or behavioural learning theory, has provided the philosophical underpinnings of the vast majority of educational software. Drill-and-practice products, as well as true-and-false, matching, and sentence completion assessment strategies are typically associated with this orientation.

Like behaviourism, systems theory or the systems approach to instructional design has also had a significant impact on educational software. To the extent that multimedia designers rely on a systems

approach, they focus on taking all possible contingencies into account, and planning for them. Software products that include effective interaction between the user and the program, various feedback mechanisms, and performance-based objectives are congruent with a systems design model (Simonson & Thompson, 1994).

Although many learning materials still rely on behaviourism or systems theory in whole or in part, more recent conceptualizations of how learning occurs are introducing alternative ways to think about teaching and learning, and about educational multimedia development in particular. Information processing, with its roots in cognitive science, focuses on how the mind processes information during learning. The relationship of short-term memory to long-term memory, metacognition (thinking about one's thinking processes, self-monitoring, self-evaluation), and problem solving strategies are some examples of concepts related to this perspective (Rieber, 1994). One concrete implementation of the information processing perspective would be multimedia learning materials that incorporate helpful ways for learners to organize isolated bits of presented information and turn them into personally meaningful knowledge, for example, through access to a computerized journal or concept-mapping tool.

Constructivism adds another important dimension to our current beliefs about how individuals learn. A constructivist orientation treats learning as an interactive process whereby learners are actively involved in constructing meaning (Jonassen, 1991). Constructivists approach learning as a social, cultural and interpersonal process that is influenced as much by social and situational factors as it is by cognitive ones (Shuell, 1996). Developers of learning materials who treat learners as active participants who bring their own history, perspectives, and social context to the learning experience, and who believe that individuals learn best when they feel a sense of ownership, control, and authenticity when using multimedia learning materials, are incorporating a constructivist perspective, Today's technologies make it much easier to operationalize this learning philosophy. Although microworld environments are particularly known for this orientation, many new applications incorporate some aspects of constructivism within their design.

Critical pedagogy (Nichols & Allen-Brown, 1996) also plays a role in the development of pedagogically-sound multimedia learning materials, by highlighting several important issues. First, this perspective emphasizes that information is never value neutral; and it encourages socially responsible critical thinking by encouraging learners to reflect on the processes and implications of knowledge production. Second, this perspective reveals that the development and use of new technologies

carry with them consequences that may result in unintended and undesirable outcomes. It asks us to consider possible negative implications of the proliferation of multimedia learning materials --for example, the persistent and high cost to schools and families that comes with multimedia access as well as the widening gap between the technological haves and have-trots. Third, the perspective reminds us of common pitfalls such as cultural biases, marginalization of less powerful groups, stereotypical portrayals of people, gender, places, activities, and so on, It highlights the importance of fostering inclusive learning environments that are accessible, equitable, and responsive to all learners.

The Principles

The following 10 principles fall into three main types. The first two principles deal with more global issues; they consider the "general challenges" facing developers today who hope to create pedagogically sound multimedia materials. Principles 3 through 8 highlight specific qualities that characterize effective products. The final two principles focus specifically on important issues that arise when a product hopes to make its way into the formal school setting.

I) Effective learning materials strive to incorporate technological potential in pedagogically meaningful ways.

As noted earlier, today's technology provides exciting possibilities for creating rich learning environments. Audio, static graphics, text, video, and animation, along with authoring tools, can be combined in imaginative ways to yield innovative and inspiring products that provide meaningful and interdisciplinary learning environments, For example, some products allow learners to investigate ideas, theories, and concepts in the context of real-life problems. What's more, the nonlinear, nonsequential hypertext environments provide the potential to link personal "findings" within and across domains. Other products allow learners to manipulate real data; examine copies of original manuscripts; listen to, create, and revise a range of visual images and sound effects or recordings; or take on the roles of imaginary or real characters who are involved in complex problem solving.

At the same time many multimedia learning materials fall far short in terms of pedagogical value. For example, in a review of 750 software programs marketed for young children, Haugland and Wright (1997)

report that only about 20 percent met children's developmental needs. There are, of course, many reasons why any given product may prove to be pedagogically weak. One major reason is the "technocentric" trap, wherein the primary motivation for including a functionality in a product is simply because the technology makes it possible to do so. Another major reason is the misguided belief that these materials are simply re-purposed books, what critics of this approach have described as "coffee table books 10,000 pages long" (Druin & Solomon, 1996, p. 81). That said, there are some success stories--the edutainment CD-ROM of David Macaulay's *The way things work* is considered one such case (Druin & Solomon, 1996).

Another important reason why multimedia learning materials may not realize their full potential as learning tools is that the developer may not be aware that current instructional practice relies much less on drill-and-practice, rote memorization, and factual recall approaches than in the past. These types of methodological approaches may be helpful as introductions to simple, well-structured knowledge domains (for example, learning the multiplication tables). At the same time, they are much less effective in helping learners authentically apply that knowledge or in helping them solve real-life problems that typically involve using more ill-structured and complex knowledge domains (Jacobson & Spiro, 1994).

The overall challenge, then, is to build multimedia learning environments that complement other valued and more entrenched learning environments by discovering and drawing on their unique pedagogical strengths. The remaining principles are intended to assist in that challenge.

2) Effective learning materials strive to be intrinsically motivating to learners.

An important distinctron to be made here is the difference between extrinsic and intrinsic motivation during learning experiences. The former provides "rewards" for good responses (e.g., a smiley face, ribbon, hand clap, drum roll), whereas the latter taps into the excitement of learning; for example, it builds on a learner's willingness and desire to learn (Jacques, Preece, Carey, 1995). Extrinsic motivation, for example, could be a game that is fun to play but the "learning" that takes place is seen as something to be endured or tolerated. The incorporation of graphics and sound are often seen as opportunities to enhance motivation; but when their primary purpose is to amuse and entertain, they can quickly become ineffective extrinsic motivators. Once the novelty of glossy and glittery

presentations fades, the experience can quickly become flat and tiresome, and even disruptive, if little is offered in the way of purposeful and meaningful learning encounters.

Most writers agree that fostering intrinsic motivation should be the aim of multimedia developers. Current American Psychological Association (APA) guidelines (1997) highlight the essential role of intrinsic motivation for learning. It is enhanced in those situations that the learner perceives as personally relevant, interesting, meaningful, and challenging. It is also enhanced when learners have opportunities for choice and control in how and what they learn, and when the reasons for learning are rooted in the learning situation itself. It incorporates challenge, curiosity, and fantasy (Rieber, 1994). It gains and keeps learner attention and interest. It blurs fun and learning and helps develop a "research spirit" (Gregoire, Bracewell, & Laferriere, 1996).

Because intrinsic motivation is believed to be essential for sustained learning, choices around what content gets included and about how and what prose, graphics, authoring tools, games, simulations, microworlds, and the like are presented need to be carefully considered. It has often been said, for example, that quality storytelling need not rely heavily on fancy visuals for engaging learners. In another vein, when developers forget that the main purpose of charts and graphs is to provide the learner with helpful data, and add too much decoration (sometimes referred to as "chartjunk") (Rieber, 1994), confusion--and hence reduced motivation, can follow. This in part is one main reason why developers are always encouraged to carefully consider, and include, various media as *the product develops* rather than to add them at later stages of development,

Engagement or effort is also considered to be an important dimension of motivation to learn (e.g., APA, 1997; Gregoire et al., 1996; Jacques et al., 1995). Acquiring complex knowledge requires considerable energy, effort and persistence on the part of the learner. Products that are learner-

that place high value on the quality of the ideas, that encourage thoughtful and challenging interactions, that allow the learner to choose the types of media they like for their learning activity, and that include opportunities for regular evaluation would appear to offer the most potential for promoting the active and sustained involvement of learners, Active and sustained involvement is also likely fostered when a product presents material in a functional way which allows for easy yet sophisticated navigation; when a product incorporates aesthetic choices and/or learner options which take into account currently valued age, gender, class, race, and cultural preferences; and when its authoring tools help learners transform information gleaned from the product into personally meaningful knowledge.

3) Effective learning materials link to prior knowledge

Learning is believed to be enhanced when the learner is able to meaningfully link new information to prior knowledge and experience (APA, 1997; McFarland, 1995; Shuell, 1996). Shuell, for example, highlights the central role of prior knowledge in determining what and how much is learned.

There are various ways that multimedia learning materials can foster links to prior knowledge. Well thought out linking capabilities such as pop-up and jump links or notetaking, outlining, and concept-mapping tools (Schroeder & Kenny, 1995), can facilitate personalized knowledge-building by helping learners transform data and information through rehearsing, extending, revising, and integrating their existing and emerging understandings. One online example of this type of learner support can be found in the MaMaMedia online environment, where learners are invited to build "sandwiches" (hierarchical grouping of information) and create "villages" (clustered grouping of information) (Tapscott, 1998).

Often, too, learners use multimedia learning materials for carrying out a quick, strategic search for information related to a particular issue or sub-issue, rather than for browsing, exploring, or immersing themselves in the content. Electronic reference materials such as electronic encyclopedias are often used for this purpose, although many other products containing a content-rich infobase can serve similar needs. It is essential, however, that multimedia learning materials rely on "smart" and user-friendly search engines that incorporate Boolean (and, or, not) and proximity operators, if learner expectations are to be met. Search engines that yield meaningful results and allow for adjustment of search strategies as new knowledge arises can also help learners build on past and evolving understandings. A review of the 1996 edition of *Compton's interactive encyclopedia,* for example, illustrates the frustration that arises when a product relies on a poor search engine (Jacso, 1996).

Given that hypermedia allows for personal exploration along a range of "paths", learners can also build knowledge through more unanticipated, incidental, learning (Rieber, 1994). Jump links that allow learners to pursue an unanticipated line of interest as well as tidbits of knowledge tucked behind "minor" icons are ways of fostering this discovery aspect of knowledge-building. For example, the Canadian Heritage Terra Nova product *Making history: Louis Riel the North-West Rebellion of 1885* provides a good example of effective use of the latter strategy. Also, a well constructed multimedia environment allows learners to construct their

own personal linkages between and among different kinds of information that they encounter (Wiburg, 1995).

4) Effective learning materials support developmentally appropriate learning experiences.

Learning is also believed to be most effective when educators take into account the cognitive, social, and emotional development of a learner (APA, 1997). Shade (1996) uses the term "low entry, high ceiling" to describe multimedia learning materials that allow for more or less complexity and that can be used by learners at various developmental levels. In a similar vein, current Manitoba guidelines (Manitoba Education and Training, 1998) highlight the value of multimedia learning materials that allow accessibility by a range of learners and provide "room to grow." Other writers also highlight the value of multimedia learning materials that allow varied points of entry and option paths for learners with more or less sophisticated levels of experience and knowledge (e.g., Gregoire, et al., 1996).

Consideration of this principle might suggest a range of interfaces (from simple to more complex), reduced or expanded menu items, less or more complex parameters (coupled with optional progressive help), opportunities to change a presentation sequence, editable instructions, and program alterations that take effect based on learner response. At the same time, the use of non-hierarchical terms to present these options helps to avoid undermining learner self-esteem.

When striving to create a developmentally appropriate product, it is also helpful to keep in mind that human intelligence is now conceived of as a range of multiple intelligences, for example, spatial, verbal-linguistic, logical-mathematical, bodily kinesthetic, musical, interpersonal, and intrapersonal intelligence (Gardner, 1993). Therefore, a learner's capabilities will often vary from one type of context to another. A product that is responsive to these differences builds in customizing flexibility, thereby encouraging learners to take fuller advantage of their specific intellectual strengths and yet providing them with electronic coaching and support when strengthening their weaknesses.

Performance assessment functions help learners *create* learning experiences that are appropriate to their own developmental level. Pedagogically sound practice or self-assessment exercises encourage reflection on and reconsideration of errors, misconceptions, or stereotypic reasoning through clear feedback that links to related content, optional

assistance, alternative problem representations, easier and similar follow up problems, and/or personal record-keeping.

5) Effective learning materials support learner control and choice.

Supporting learner control and choice is believed to be important for a range of reasons. For example, it allows individuals to work at their own comfort level, it fosters ownership of the activities, it recognizes individual needs and preferences, it encourages independent use of a product, and it fosters self-monitoring and self-evaluation. Learner control and choice within a product can take many different shapes. Products that provide intuitive interfaces enhance learner control by limiting the need for extensive outside help. Navigational flexibility permits learners to easily follow different paths through the content, to access different forms of knowledge, and to limit or expand the level of environmental complexity they wish to experience. In a similar vein, optional electronic coaching (for example, by activating a *helpful* help button or pop-up links), optional bimodal discourse (for example, by activating simultaneous written and oral discourse), optional cueing (for example, by activating a process highlighter to clarify a particular aspect of an explanatory animation), and an optional index with a user-friendly and helpful search engine for easy and strategic access to the overall infobase, help learners tailor their environment to suit their own needs and preferences. Problem-solving simulations that include the necessary content for developing solutions within or with the product enhance a learner's sense of control by acknowledging the "do-ability" of a task. At the same time, products that permit learners to input their own personal or local resources (e.g.. photographs, drawings, original local documents), tap into the "real" lives of learners.

Products incorporating user-friendly tools that allow individuals to easily plan, organize, create, keep track of, represent, erase, interrupt-and-later-resume, copy, save, and print their "work', support learner control by assisting with specific sub-tasks that foster personal knowledge-building. Tools that allow learners to refine and revise their work by means of friendly editing features recognize the importance of allowing that knowledge to be re-presented.

Finally, learner control and choice can be enhanced by providing an easily-accessible learner guide. This guide could present and explain a range of interesting on-computer and off-computer learning activities. In addition to fostering independent and creative use of the product itself, suggestions for off-computer activities can extend the value of the product

by encouraging other ways of interacting with the world (for example, activities that rely on kinesthetics, on non-virtual experimentation, or on face-to-face relationships with other members of the community),

6) Effective learning materials support inter-dependent learning.

Learning communities, where learners and teachers can interact and collaborate with others within and beyond the classroom to generate, revise, and evaluate knowledge, are also believed to be powerful vehicles for fostering individual learning (e.g., APA, 1997; Shuell, 1996).

Multimedia learning materials can offer opportunities for learners to form learning communities through various project-based initiatives. For example, Scardamalia and Bereiter (1996) have developed a multimedia collaborative learning environment that brings together diverse groups of participants. A key feature of this learning environment is a community database constructed by learners. As much as possible, this database is open to all participants, although sections can be designated as private. Learners can visit the database, comment on its contents, create links to other media, develop visuals that synthesize their emerging conceptual understandings, initiate special purpose discussions, as well as search content or comments within or across databases. Through these activities, learners are encouraged to develop working relationships; to critique each others' work; to create, use, and revise knowledge; and to consider ideas from multiple perspectives.

Multimedia learning materials can also offer collaborative learning opportunities by connecting participants to authentic activities outside the classroom (Dyrli & Kinnaman, 1995) through links with official educational partners and recognized web sites. These links to high quality sources can provide learners with access to helpful archived or up-to-date information, to "recognized experts" with specialized knowledge in particular fields, and to other "emerging experts" (or co-learners) who are examining similar issues. For example, a product might include links to primary databases of a national agency or consortium for use in personal projects and/or provide access to the working worlds of scientists, historians, mathematicians, curators and the like. Canada's SchoolNet consortium is one example that supports this type of inter-dependent learning.

Multimedia learning materials can also encourage collaborative learning in learner dyads, small groups, or larger class groups. For example, the CD-ROM *Le Maitre des* produced by Club Pomme in

France, has been successfully used by teams of learners as well as by individual learners (Cousineau, 1998).

7) Effective learning materials promote critical literacy skills.

One of the strengths of multimedia learning materials is the fact that they allow learners access to a wide range of information. For example, a concept, an issue, a process, an event, a biography, and so on, can be presented in many different ways. Developers need to keep in mind, however, that the choices that they make around content and presentation are never value neutral. They need to recognize that all knowledge is socially constructed, and that what counts as legitimate knowledge within the learning environment will be shaped in part by their choices. Certain information will inevitably be omitted or stressed; and examples may emphasize or ignore different social, gender, or cultural perspectives.

The responsibility for fostering critical literacy is neither easy nor straightforward. It is not simply a case of assuring that appropriate numbers of different groups are represented, that groups are not stereotyped, or that language is non-sexist, although these issues are of course important. Products that adopt visible story lines, for example, may openly value some "perspectives" over other equally legitimate ones, Bigelow's (1996) review of the popular CD-ROM historical simulation *Oregon Trail* ZZ, illustrates this challenge. He points out that while attention has been given to multicultural and gender-fair characteristics in terms of who is included in the simulation, it is the experiences of white male settlers that are highlighted. He urges teachers and learners to develop critical computer literacy skills so that they can challenge these kinds of implicit and explicit cultural biases.

A number of review frameworks have highlighted the importance of considering how products represent different social, gender, and/or cultural perspectives (e.g., Manitoba Education and Training, 1998; McFarland, 1995; Swan & Meskill, 1997-98). This consideration might take the form of encouraging the learner to explore, express, and/or examine multiple interpretations of events. It could mean that there are a range of meaningful responses to a problem (Druin & Solomon, 1996; Honebein, Duffy, & 1993). It might refer to the representation of different perspectives in order to encourage the learner to see an issue from the point of view of various stakeholders and to examine how different social groups might frame a "problem" or "solution" (Morgan, 1995). In a similar vein, it might provide a range of discourses, allowing learners to explore whose voice gets heard and whose gets ignored in the

material they create as well as in the information that they access and examine. It can also mean the opportunity for the learner to co-create interpretations with other learners, to place these interpretations in the "public domain", and to critically evaluate the kinds of information presented and generated.

8) Effective learning materials support equitable learning environments.

In terms of equitable learning environments, a number of software evaluation frameworks have highlighted the importance of ensuring that multimedia products reflect linguistic, social and cultural diversity. For example, the Nova Scotia guidelines for evaluating software present an extensive list of points to consider when assessing potential bias in software (Nova Scotia Department of Education and Culture, 1998). According to these guidelines, visual and textual content needs to be examined to determine to what extent gender, age, race, culture, ethnicity, and class issues are taken into account. Shade (1996) and Haugland and Wright (1997) support these recommendations for equity and also include attention to diverse family structures and ability.

For Canadian learners, additional attention also needs to be placed on representing and respecting Canada's multicultural makeup as well as its French- and English-speaking communities. This seems particularly important given the proliferation of products developed in the U.S. For example, humour, music, popular and cultural images and icons, as well as language and historical perspectives, often vary across cultural groups, In some cases, these differences may warrant the development of a separate and distinct product rather than a more straightforward translation of a product into the other official language. Also, products that hope to make their way into English- and French-Second-Language classrooms, need to take into account the special needs of these groups. For example, optional support could take the form of word pronunciation, simplified definitions, grammatical exercises, structured role-plays or simulations, and the like.

A number of writers (e.g., Comber, Colley, Hargreaves, & Dorn, 1997; Crawford, 1998; Larsen, 1995; Prickett, Higgins, & Boone, 1994; Tapscott, 1998) have highlighted the issue of accessibility to equitable learning environments for diverse learners. Multimedia developers should consider that many learners won't have top-of-the-line hardware and that options should be considered about how to make the experience accessible and motivating to more disadvantaged groups. Also, in terms of sensitivity, despite growing evidence that the differences between male

and female learners regarding accessibility to computers, use of computers, and confidence levels may be narrowing, it is important that products assure gender-fair environments that respect the special needs and interests of both groups (Goodnow, 1998; Hodes, 1995-96; Tapscott, 1998; Yates, 1997). A similar point can be made with regard to fostering multicultural and antiracist environments. Regarding learners with special challenges, customizing options, clear and consistent interfaces, and structured guidance are a few examples of how a product can support their learning. The province of Newfoundland maintains a particularly good web site regarding technology issues for special needs populations (Newfoundland and Labrador Department of Education, 1996).

Good learning environments permit learners to "see themselves" in authentic ways. One simple example of how developers can take a proactive stance regarding the issues that have been highlighted above is the cautious use of clip-art images. Some writers (Binns & Branch, 1995; Buck, 1995) have pointed out that while visual images represent powerful aids to the learning process, many visuals--especially clip-art images--are culturally biased. In a similar vein, products that allow learners to select personal features (for example, by selecting the gender and ethnicity of a given character) help learners see themselves within the experience. Multimedia products that are sensitive to cultural, gender, and special needs factors offer great potential for promoting equitable learning opportunities for all learners. The challenge for developers is to strive to turn that potential into actual product design.

9) Effective learning materials intended to support formal schooling take into account regional and local needs and requirements.

Multimedia learning materials may link explicitly, implicitly, or not at all to a provincial, territorial, or state school curriculum (Squires & McDougall, 1994). If the goal of a product is to explicitly link to a particular aspect of a curriculum, close collaboration with knowledgeable curriculum experts is essential. For example, Saskatchewan's SchoolNet Grassroots Program has developed evaluation criteria which stress the point that projects funded by them must "directly correlate to one or more Saskatchewan Curriculum guides" (Saskatchewan Education, 1997).

Of course, developers who hope to see their products used within classrooms and resource centres as supplementary learning materials would be wise to carefully take into account the curriculum and teaching needs of those potential users. For example, edutainment products that stress education more so than entertainment as well as

general education reference products, if appropriately developed, certainly have the potential to complement and supplement school-based teaching and learning. Surprisingly, however, it appears that many developers neglect to develop their product with formal schooling needs in mind (Druin & Solomon, 1996).

It *is* helpful to keep in mind, for example, that education scholars (e.g., Haugland & Wright, 1997; Shade, 1996; Squires & McDougall, 1994; Swan & Meskill, 1997-98), along with ministries of education (e.g., Manitoba Education and Training, 1998; Nova Scotia Department of Education and Culture, 1998) are currently developing, and regularly revising, guidelines for evaluating the pedagogical quality of multimedia learning materials in an effort to foster informed purchase choices. Keeping abreast of current and emerging standards of quality seems essential if a given product hopes to receive formal endorsement. In a similar vein, it is also helpful to keep in mind how important it is to develop (and market) a product that responds to the needs of today's teachers, who "now buy many of their own resources for their classes and take them with them when they transfer to another school" (Thayer, 1998).

10) Effective learning materials provide comprehensive pedagogical support to educators.

Despite some of the rhetoric suggesting that most schools and classrooms are integrating multimedia learning materials into regular class activities, many experienced teachers probably remain multimedia novices. This seeming disadvantage presents special "professional development" opportunities for savvy product developers, however. For example, products could include explanatory videos and/or written documents that help teachers learn how to navigate within an environment and how to build their own knowledge through guided practice with a product's authoring tools. A more comprehensive approach could be to develop, within the product, a set of pilot-tested, pre-packaged workshop modules that "lead teachers" could use to assist colleagues in developing confidence and competence with the product.

A well-developed and *easily accessible* (e.g., optional print versions) educator's guide could provide tangible help in integrating the materials into the curriculum. Such a guide could include such ready-made resources as electronic slides and overheads; pictures, posters, or maps related to the topic; student handouts; lists of up-to-date resources (for example, bibliographies and descriptions of commercially available audiotapes or videotapes, URLs, atlases, biographies, children's books);

and creative examples of ways to use the product across curricular areas and for specific problem-solving and knowledge-building activities. Providing field-tested time estimates for carrying out common tasks can provide support by helping teachers plan for and cope with the tight time constraints that are an inherent part of classroom life.

Educator guides can also help teachers envisage themselves less as "content experts",explainers" and "initiators" (the educator as "sage on the stage") and more as co-creators (Squires & McDougall, 1994) who encourage learners through argumentation; debate; provocative, open-ended, and critical questioning; collaborative use of concept-mapping tools; demonstrations of effective search strategies; tolerance of effective, yet partial solutions to complex problems, and the like (the educator as life-long learner and "guide-on-the-side"). A product could also support a web site to provide learner- and classroom-tested ideas and supportive materials to educators. The web site for *Inspiration* (a concept-mapping tool), for example, includes many examples of success stories and actual project outcomes from learners and educators who have used the product. In a similar vein, partnerships or strategic alliances, along the lines of Canada's long established SchoolNet initiative, the more recent TACT initiative (TeleApprentissage Communautaire et Transformatif/ Technology for Advanced Collaborative Teaching), or the recently launched American initiative MarcoPolo (Woodall, 1998) could provide ongoing support to educators using a range of multimedia materials.

In terms of learner-learner dynamics, educator guides can also offer suggestions about how the product might be used individually or independently by learners, by learners working in dyads or small groups, and as large-group teaching and learning tools. Even simple suggestions adopted from popular co-operative learning approaches such as three, then ask me" (where students are asked to seek three other sources of help before turning to the teacher) fosters independent and co-operative problem solving and also recognizes the leadership potential of other learners, many of whom may have greater experience within multimedia environments than their teachers. In a similar vein, simply pointing out the advantages of "managing by walking around" can help educators monitor progress, encourage co-operative problem-solving, spot emergent problems, and discourage indiscriminate "channel hopping" across programs (Ragsdale, 1997).

Available technology also makes possible secure performance assessment functions for use by teachers. For example, pre-tests and special recorded exercises can help them customize a product according to the special needs of an individual learner or group of learners and can help identify specific areas where additional support is required. At the same

time, teachers need to be able to override these diagnostics if they so choose. Also, record-keeping components such as journals, concept maps, portfolios, or placement tests need to be easy to set up and operate, and need to be able to accept any number of learners or groups of learners. Finally, products that chart learner progress and then develop meaningful reports for learners, the instructor, and parents can provide an ongoing and long-term perspective on learner progress (Prokopanko, 1998).

Conclusion

The principles presented above offer exciting challenges and possibilities for those embarking on a multimedia initiative that aims to incorporate pedagogical value. It is doubtful, however, that those challenges and possibilities can be realized without the ongoing participation of a range of experts and stakeholders. Increasingly, the use of interdisciplinary design teams (Druin Solomon, 1996) and formative evaluation and responsive design processes are considered essential for ensuring quality product development. When team membership includes representation from content and discipline experts, teachers and other educational practitioners, educational scholars, and learners themselves, as well as from instructional and technical design experts, the possibility of producing a multimedia product which ensures optimum learning is enhanced. For example, content experts can help assure meaningful, accurate, comprehensive, and up-to-date content; educational scholars can help assure pedagogically sound and socially responsible strategies for working with the content; teachers and other practitioners can help assure user receptivity as well as sensitivity to classroom constraints; learners can help developers see strengths and weaknesses "through the eyes" of those who interact most with the product; and instructional and technical design experts can help teams make technologically realistic choices and also assure that the product rests on sound design principles,

The principles that have been developed within this paper are intended to serve as guidelines for generalists in their role as overseers of, participants within, and consultants for multimedia product development teams. Of course, it should be kept in mind that there is no such thing as a "perfect" product; any given initiative will have pedagogical limitations. Depending on a range of factors (for example, financial and human resources, agreed-upon purpose and scope of the project), some initiatives may build in pedagogical quality through more extensive attention to some principles more so than to others. That said, our research leads us to believe that all of the principles need to be considered during product

development, Even the most basic designs and simplest products can be enriched in a pedagogical sense through thoughtful and judicious choices.

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