PERGAMON

Computers & Education 34 (2000) 1–15

COMPUTERS & EDUCATION

www.elsevier.com/locate/compedu

A developmental model for distance learning using the Internet

Katia Passerini*, Mary J. Granger

Department of Management Science, School of Business and Public Management, The George Washington University, Washington, DC 20052, USA

Received 19 July 1999; accepted 27 September 1999

Abstract

The Internet opens a new generation of distance education (*fourth generation*), introducing sophisticated delivery tools and creating a paradigm shift with profound implications on the design of distance education courses. In order to accommodate this medium, novel curriculum design and learning models may be appropriate. In this paper, there are several instructional design models presented and a hybrid model is developed. This model integrates both constructivist and objectivist approaches to instructional design. When creating or redesigning courses for Internet distribution, content and media developers, faculty and researchers benefit from the identification of a developmental model taking into account both learning and design principles. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Computer-mediated communication; Distance education and telelearning; Navigation; Pedagogical issues; Teaching/learning strategies

1. Introduction

Distance education, also referred interchangeably as distance learning, is not a new instructional phenomenon. In over a century, it evolved from correspondence study, open universities, teleconferencing, networks and multimedia delivery to today's Web-based technologies. This evolution is characterized by new teaching approaches, including the adjustment of instructional materials supported by different delivery media. With the advent of

* Corresponding author. Tel.: +1-202-994-7375; fax: +1-202-994-4930.
E-mail addresses: pkatia@gwu.edu (K. Passerini), granger@gwu.edu (M.J. Granger).

0360-1315/00/$ - see front matter
PII: S0360-1315(99)00024-X

the Internet, a new generation of distance education emerged. Complementary to the other models, Internet-facilitated instruction allows for the implementation of synchronous and asynchronous interaction and opens a new series of learning opportunities for education. Increases in bandwidth technologies and worldwide access to interconnected networks enable the Internet and the World Wide Web to develop into a viable delivery system for distance education. To accommodate this growth, the models for the development of distance instruction need to expand. This paper reviews the historical transitions leading to a fourth generation of distance education and claims that traditional system approaches to education need to be reviewed to integrate strategies appropriate to the new tools. It proposes a developmental approach generated by the opportunities for student–instructor interaction and media delivery on the World Wide Web. It stresses the need for the identification of an integrated design model to support distance education initiatives.

2. Distance education: a system evolution

Distance education is over a century old. Initially, communication occurred through the printed media and the mail system, creating "correspondence education." Today, almost all forms of communication in distance education programs involve some level of electronic communication.

Moore & Kearsley (1996 p. 2) in fact define distance education as:

> "planned learning that normally occurs in a different place from teaching and as a result requires special techniques of course design, special instructional techniques, special methods of communication by electronic and other technology, as well as organizational and administrative arrangements."

This definition encompasses all the critical elements of a distance education system. The delivery medium (electronic or other technology) is only one component of a framework that includes the re-definition of instructional techniques, methods of communications and course design strategies. Organizational and administrative support is a key element of the implementation of distance education, highlighting the need for a concerted effort as a pre-requisite for successful distance education delivery.

This unified approach is applicable at all levels of distance education, be it an entire distance learning program (such as a University degree), a simple distance unit (selected courses in a program), or distance learning institutions (like the British Open University or Universities consortia). In each of these cases, the elements of Moore and Kearsley's definition carry different weights in the implementation model. For example, in a distance learning institutional implementation, administrative and organizational resources will have a heavier role than other elements such as individual course design techniques. In an individual delivery unit, instead, course design and management techniques will have a key role. Nevertheless, all the elements, adjusted for their relative weight, need to be considered in a successful developmental model.

2.1. From correspondence learning to Internet delivery

Moore & Kearsley (1996) identify three main evolutionary stages of distance education. *Correspondence learning* is part of the opening generation of distance programs (*first generation*), crossing the end of the 19th and beginning of the 20th century. In correspondence learning the major means of communication are printed materials, usually customized textbooks that contain lesson outlines and exercises. Students complete assignments based on the textbook instructions and "mail" the assignments to the instructor, who provides feedback via first class mail. Several universities inside and outside the United States employ correspondence learning. The United States Department of Agriculture (USDA) Graduate School awards complete degrees through correspondence studies.

The *second generation* of distance education started in the early 1970s. The British Open University was granted the status of a degree-granting program in 1969 (Moore & Kearsley, 1996). The aim of open-universities is reaching off-campus students, delivering instruction through radio, television, recorded audio-tapes and correspondence tutoring. Several universities, particularly in developing countries, still use educational radio as the main instructional delivery tool. Educational radio and television (teleconferencing) were implemented with distance learning before the official recognition of the British Open University. Public broadcasting educational services had been experimented in the United States as early as the 1940s (i.e. Johns Hopkins and Columbia broadcasting systems). Audio-conferencing (conducting a class using the telephone) is also part of the second generation of distance education programs. Audio conferencing is used today to conduct distance courses by the University of the South Pacific (Fiji) using public telephone lines to connect students wishing to attend courses from neighboring countries in the South Pacific Islands.

The *third generation*, early 1980s, benefited from satellite technologies and the emergence of communication networks facilitating the delivery of analog and digital content to computer workstations. These technologies also enable new forms of real time interaction with two-way videoconferencing, or one-way video and two-way audio communication. During this generation, CD-ROM products for multimedia self-paced learning were introduced. Additionally, computer networks link instructors and students, enabling electronic communication exchanges based on course material, students learn by reviewing videotapes, audio-tapes, textbooks or multimedia CD-ROMs. Bulletin boards made their first appearance for group interaction at a distance, offering central repositories for class communication.

While Moore & Kearsley (1996) present communication networks and computer-based multimedia as part of the third generation of distance education programs, current developments of telecommunication technologies, most notably the advent of the Internet, have shifted distance education to a completely new instructional approach. Because of the exponentially increased abilities of distant student-to-students interaction, rarely enjoyed by previous implementations, the Internet opens a new generation of distance education (*fourth generation*). Internet technology empowers the joint exploration of the delivery mechanisms of previous generations, adding stronger collaborative learning elements. There is a substantial shift from an instructor-led approach, in which the instructor, the videotape producer, or the multimedia developer exclusively created the content of instruction, to a real learner-centered approach. The interaction and collaboration opportunities, opened by communication

technologies to students geographically distant, facilitate the transition to a richer learning environment. Asynchronous and synchronous interactions on the network are the main instructional components of the virtual classroom, and the instructional materials (lesson notes) are only the background material, from which class "discussion" originates.

3. The Internet, a paradigm shift for distance education

With the diffusion of Internet technology, distance education is moving from being a "distant" to a "closer" experience than a traditional classroom. Although physical distance is still present, the real learning "space" among students is closer. Interaction may take place more actively than in a traditional classroom, especially when traditional instruction is conducted in large classrooms and is not conducive to frequent exchanges of ideas. Furthermore, it is only with the use of the Internet, and the World Wide Web, that distance education moves away from an objectivist approach to education to a constructivist environment.

Although claiming a student-centered approach since its inception, the dynamics of the earlier generations of distance education did not enable shifting away from instructor-led learning. The empowerment of the learner consisted primarily on the learner's decision on "when" to study content provided by textbooks, radio/television broadcasts or "information-bounded" computer software. In a networked environment providing access to several channels of communication (student-content, student-to-student, student-to-instructor, but also student-to-other-hypermedia content, and student-to-other-instructors), learning is a product of the interactions in the virtual classroom, and not a product of self-paced mastery of instructional material. Asynchronous discussions, moderated and summarized by the instructor, become the "live" textbook where students learn from each other.

Rather than being an obstacle to interaction, "distance" becomes the seed of interactions among participants with diverse backgrounds and experiences, and facilitates the realization of other learning models born within the constructivist approach, such as socio-cultural learning. Classrooms become boundary-less both geographically (with students taking degrees from anywhere in the globe) and content-wise (with contextual access to supporting readings from any hyper-linkable site). The instructor may provide hyper-linking to external resources, or the students can decide to explore content beyond what is presented in the virtual classroom. They may follow a free-navigational path starting from the class web-site and returning to it through alternate paths.

3.1. The implications for the design distance education courses

This paradigm shift has profound implications in the way distance education courses are designed. These implications affect the choice of instructional development models traditionally used to map instructional objectives to course delivery strategies, and the choice of the type and length of information delivered through the interconnected networks. This paper describes how traditional instructional design models (Dick and Carey, Jerrold Kemp, and others) need to be integrated with developmental approaches taking into consideration new characteristics.

These characteristics include: the variety of needs and learning strengths of the students in the virtual classrooms, the inclusion of supplemental information/content resources, the elaboration of most appropriate content (with a variety of media) and the communication strategies (from discussion areas, bulletin boards, chat-rooms, workgroups, whiteboards, and others).

4. Design models and their characteristics

Redesigning a traditional course for Internet based delivery is a complex process that requires thorough planning and an implementation procedure. Knowledge of learning theories and instructional implications is a pre-requisite for successful realization of the learning objectives with the most appropriate tools and delivery components. There are several instructional design models faculty can rely upon: from rapid development to systematic implementation. In this paper, we review briefly several instructional design models, and formulate a hybrid model. This model encompasses both constructivist and objectivist approaches to instructional design.

Among the development alternatives available, Dick and Carey's (1990) step-by-step design model consists of a series of events in which the designer establishes the learning objectives and creates the instructional strategy to accomplish the objectives. Assessment tools measure learning goals compared with the instructional goals. A feedback loop in the form of formative and summative evaluations provides the control mechanism to revise instruction. In this model (Fig. 1), there is little room for individualized instruction. The up-front determination of objectives stipulates that the learner will follow the set of objectives established by the instructor/designer.

An example of this model is the use of one-way instructional television or videotaped courses. The video producers and the content expert take the exclusive role of developing a finite instructional product, scripting each instructional moment. Although evaluations are conducted and feedback and revisions are incorporated into the model, in the case of video production, the ability to make revisions is limited by the rigidity of the media. Video production and video editing are costly endeavors and even minor changes require extensive staff and hardware involvement. This, in turn, calls for tight instructor control of the course content and development.

Another framework, Kemp et al. (1994) design model (Fig. 2), takes a more flexible approach to design by identifying several development phases, without any particular order within the system. This model presupposes the continuous evaluation of each design and redesign stage (in the form of formative evaluations) during the development. Learner characteristics are taken into account and influence the selection of the instructional objectives and the teaching strategies. Although this design model increases the interaction with learners and individualizes instruction based on the feedback from the learner characteristics, its approach remains within the realms of an objectivist paradigm.

The Jerrold Kemp design model is particularly suitable, for example, to two-way audio communication in distance learning courses. The audio-conferencing sessions are scheduled and adjusted to learners' needs, shaped by their interests and developed from the audio discussion.

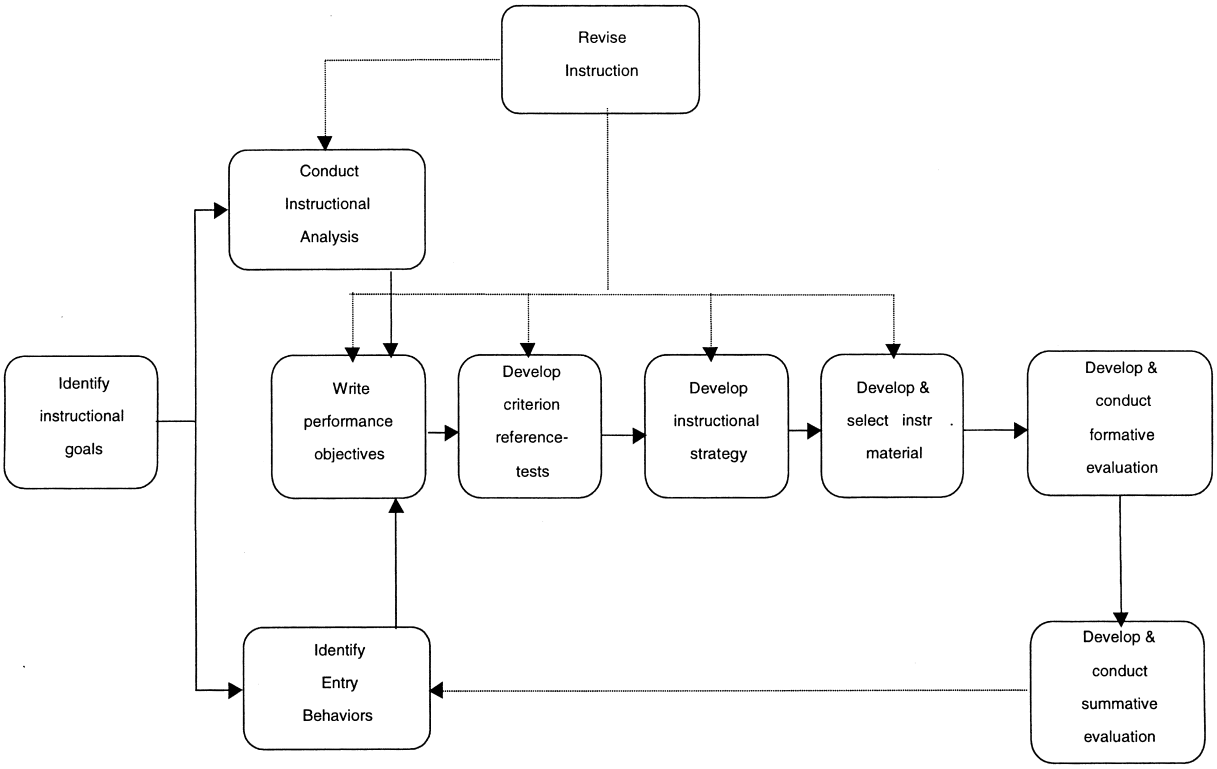

Fig. 1. Dick and Carey design model.

The level of instructor control is present in the definition of teaching activities and domain, pre-testing strategies and learning evaluation. The content of the audio-interaction is shaped by the outcomes of the synchronous interaction. Although this model allows for a higher level of learner control than the Dick and Carey's, the instructor is still the originator and moderator of communication, and the most common form of interaction only flows from instructor-to-students.

Each of the models highlights very important aspects of course design but lacks the cognitive flexibility that the delivery of hypermedia instruction allows. Hypermedia environments enable the designer to focus only on the definition of the learning domains and to move away from the identification of every instructional activity. Decisions on navigation and access remain in the hands of the learner. Spiro, Feltovich, Jacobson & Coulson (1991) presents a model of a crisscrossed landscape establishing educational goals without constraining the users to the identified boundaries. In this hypermedia design model, a level of guidance is provided to the learner with contextual navigation clues, and orientation within themes. However, the learner is encouraged to freely access the learning domain. A representation of the hypermedia design model (Fig. 3) is suggested by McManus (1996).

In this model, the instructor defines the learning domain and a series of cases leading to several learning paths within the same domain. Parallel to the instructor-determined boundaries, a corresponding path stimulates learner-controlled navigation. Both paths lead to

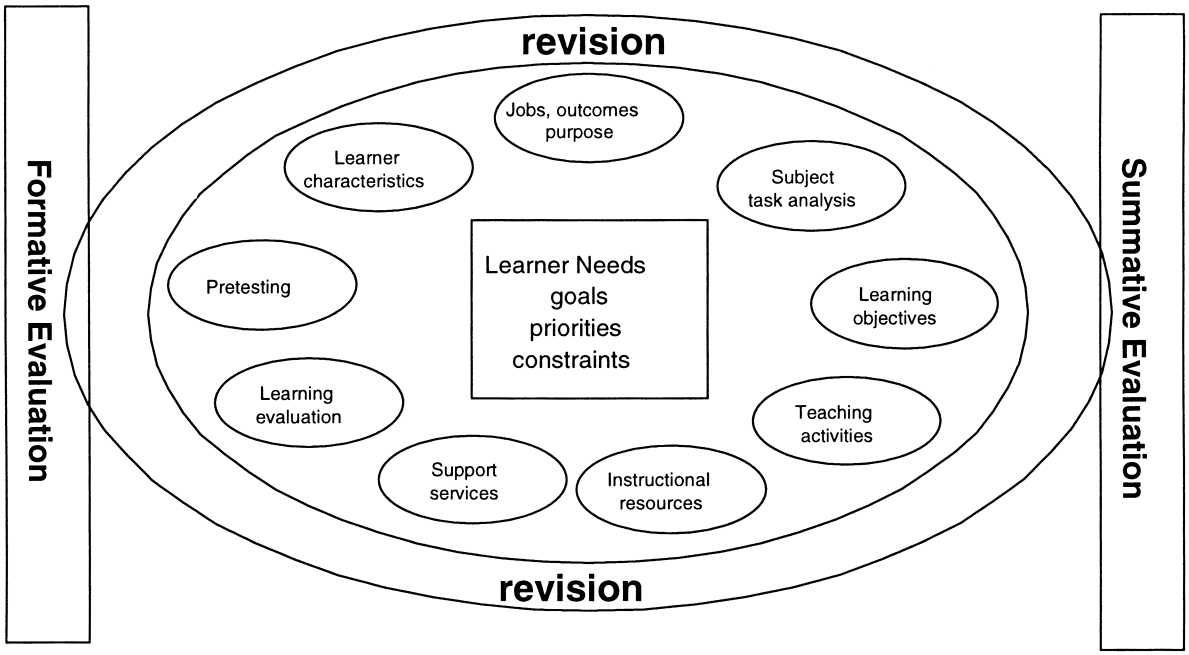

Fig. 2. Jerrold Kemp design model.

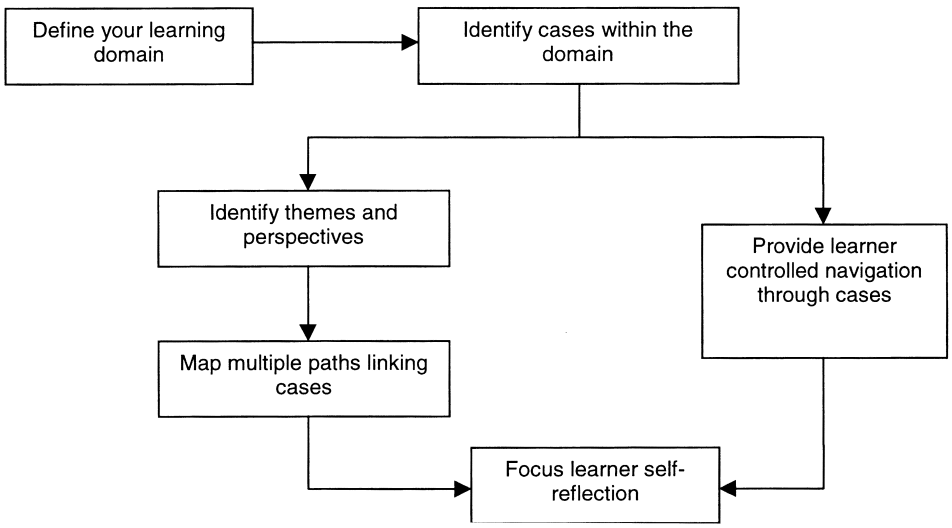

Fig. 3. McManus (1996).

the final objective of providing feedback and review questions to facilitate learner self-reflection and control of the path followed for arriving at the self-reflection/assessment of learning area is not relevant.

5. Towards a preferred model

Technology-supported instruction has been traditionally more suitable to step-by-step development processes (similar to the system development life cycle (SDLC) methodologies that guide software development). More recently, researchers started arguing that the use of the Internet for the delivery of instruction has revolutionized the objectivist/behaviorist approach, thus, allowing more room for student's self-determination and, therefore, control of learning (McManus, 1996). Asynchronous delivery of course material on the WWW presupposes that the students and the instructor do not necessarily interact in real-time. Although the instructor sets specific deadlines, students are responsible for organizing themselves within the deadline and have access to the materials and lectures at their own pace and control.

Given the impact of the Internet and the possibilities that it opens for instructional design, the authors propose a development framework that takes into account the constructivist paradigm, within the framework of a behaviorist step-by-step development process. This framework is highlighted in its general components (Fig. 4) and then detailed in the following Sections.

5.1. A hybrid design model

Ideally, an Internet distance education course design model follows a developmental model that presents hybrid characteristics of the objectivist and constructivist learning paradigm. Adding instructional strategies that allow open navigation and learning objective re-adjustments — based on students' learning choices — to the structured waterfall systems development life-cycle model (Fig. 4) appears to be a viable composite strategy. This composite can be obtained in two different ways: adjusting the course content to account for user characteristics and needs, or encouraging students contributions to course objectives through the inclusion of other learning themes and topics and its sharing with the class. These objectives can be accomplished through the extensive use of shared files areas, discussions areas, and chat areas.

This development model consists of five main phases:

1. Analysis
2. Design
3. Development
4. Evaluation
5. Delivery

These phases are divided into tasks and implemented sequentially (in a step-by-step modality).

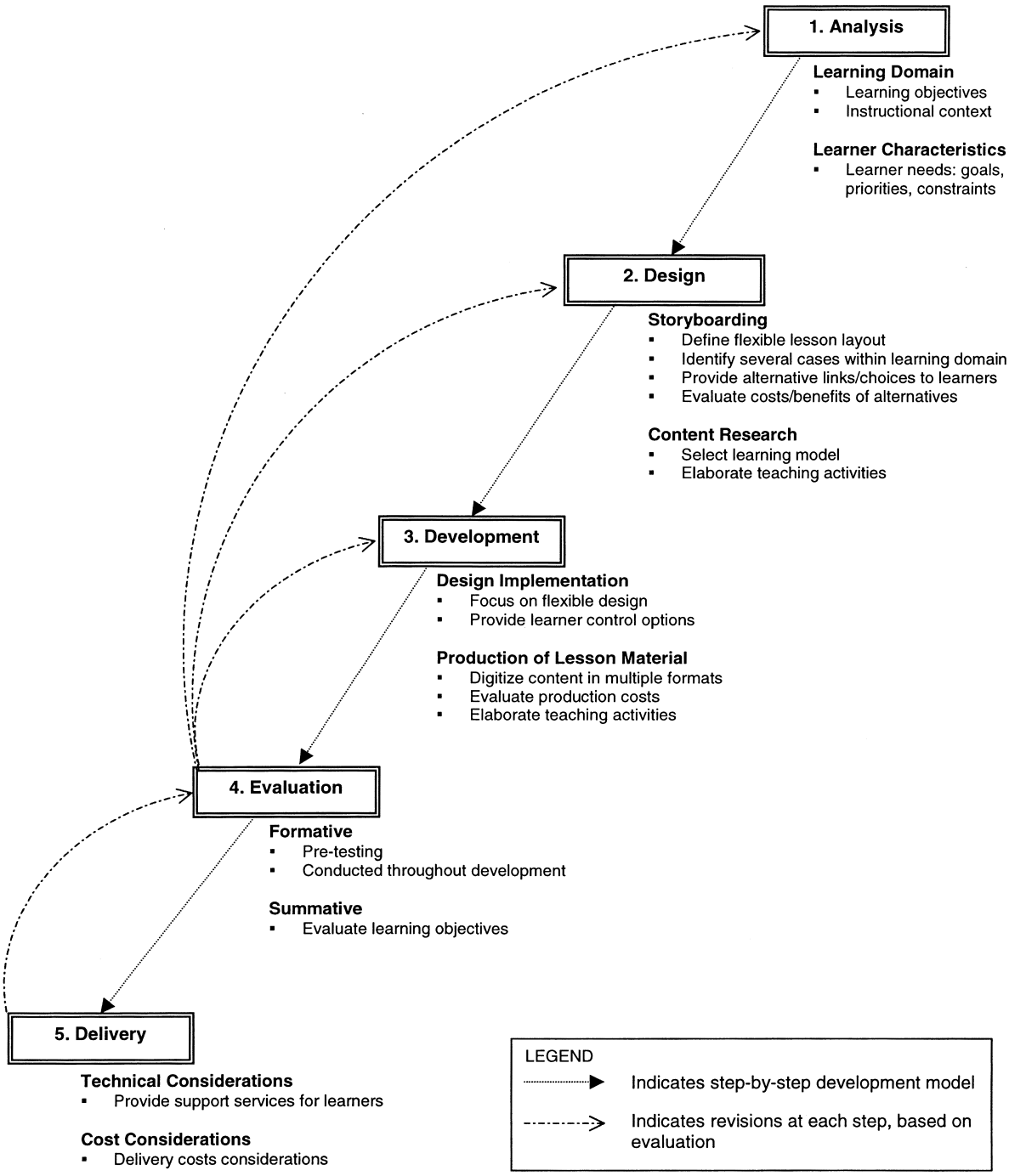

Fig. 4. Hybrid development model.

Additionally, they are constantly revised based on the feedback loop generated by formative evaluation throughout the entire development process.

5.1.1. Analysis

In the *analysis phase*, the instructor needs to focus on content development based not only on learning objectives, but also on an analysis of the targeted populations. Learners' cognitive, social, physical and personal characteristics need to be identified. Because the course will be delivered at a distance, focusing on several of the variables shown in Fig. 5 (Reeves & Brackett, 1998) will improve understanding of course content. The feedback gathered through the analysis of users' characteristics will enable choosing effective delivery strategies and appropriate technologies. Although it may not be possible, or feasible, to gather information on all the variables, knowledge of past students' characteristics can guide the implementation of the course and the design of group assignments, as well as the types and amount of audiovisual material to be used in the asynchronous lectures.

For example, if the user population has limited mastery of technology and displays anxiety with the instructional tool, the content delivery can be adjusted to support inexperienced users. Text becomes the principal delivery tool. The installation of computer plug-ins to access audio and video content will be problematic for this user population. However, if intended users report difficulties in reading material on the screen, the layout of text on the Web can be re-arranged to accommodate visual difficulties. For example, text could be made available for printing in a single-packaged file, rather than being distributed on several linked Web pages. The greater the opportunities to accommodate these needs, the greater the satisfaction and the motivation of the targeted audience.

On the basis of the needs assessment and the evaluation of the user populations (through observations, interviews, questionnaires, focus groups, or documentation review), preliminary content and objectives of the course can be specified, including evaluation procedures and delivery mechanisms.

5.1.2. Design

The preferred strategy for developing instructional content needs to be outlined in the *design*

Cognitive Characteristics	Personality Characteristics	Social characteristics	Physical characteristics
➢ general aptitudes towards technology ➢ functional literacy (e.g., reading level) ➢ visual literacy (e.g., ability to perceive graphics) ➢ computer literacy ➢ learning styles ➢ prior content knowledge	➢ motivation to learn in computer mediated environments ➢ motivation to learn ➢ interests ➢ attitudes toward content ➢ attitudes toward learning ➢ attitudes toward technology ➢ self-esteem ➢ anxiety ➢ beliefs ➢ locus of control (instructor/personal)	➢ attitudes toward collaboration ➢ tendencies to cooperate or compete ➢ relationships with peers ➢ socioeconomic status ➢ attitudes toward authority ➢ career ➢ educational level	➢ visual abilities ➢ auditory abilities ➢ tactile abilities ➢ fatigue ➢ age ➢ sex

Adapted from: Reeves T. & Brackett F. (1998).

Fig. 5. Learner characteristics.

phase. The most demanding tasks in this phase are the identification of the learning model for instruction and the implementation of strategies transferring this model into asynchronous learning environments. This presupposes a clear understanding of learning models and instructional interaction that need to guide the specification of the lesson plan.

If the stated objective is fostering cooperative or collaborative learning, the role of the lecturer will need to be minimal and most of the class content will be based on the students instructional interactions in threaded discussion areas and other group-based assignments. In this case, the instructor will be a participant to the asynchronous discussion but neither a moderator nor a leader. If, instead, the instructor is following an objectivist approach *à la* (Gagné, 1985), the implications for instructional designs are that learning needs to be objectives-based and is built upon mastery of prior skills. In this context, the instructor plans every moment of the instruction, with lectures sequentially building on prior knowledge.

Once the instructional model is determined, a *storyboarding* technique is an appropriate hypermedia design tool. Storyboarding consists of flowcharting/drawing all the elements and links that will be included in the course format. In an Internet environment, a "storyboard" should guarantee flexibility in lesson layout (i.e. provision of multiple study material and hyperlinks). It should specify the elements (media clips, hyperlinks, and content) integrated in a distance course on the Internet, but should allow navigation beyond these elements. A storyboard for Internet-based courses will be concerned with the appropriate design guidelines that advance the delivery of specific course content. Of particular importance in the storyboarding phase is, in fact, the respect of the factors that influence cognition, such as the coherence of the course web deployment and the cognitive load imposed for course site navigation. The objective of the designer is to increase *coherence* and to reduce *cognitive load*, factors that are inversely related to cognition (Szabo & Kanuka, 1999). The hypermedia designer may apply a set of principles (Fig. 6) when designing for comprehension (Thuring, Hannemann & Haake, 1995). These principles guide learner orientation and navigation (therefore, reducing cognitive load) and increase local coherence (with respect of current location) and global coherence (current location with respect to overall content). The correct use of these principles will guarantee the creation of effective distance learning materials.

In the design phase, strategies for multiple delivery formats are pieced together. These strategies are informed on the collected data on learner population and present alternative paths for diverse learners. The final number of alternative paths and media is also based on benefit/cost considerations. The unit costs (development time and resources) of utilizing

- P1: Use typed link labels
- P2: Indicate equivalencies between information units
- P3: Preserve the context of information units
- P4: Use higher order information units
- P5: Visualize the structure of the documents
- P6: Include cues into the visualization of structure which shows the reader's current position, the way that led to this position and navigational options for moving on
- P7: Provide a set of complementary navigation facilities which cover aspects of direction and distance
- P8: Use a stable screen layout with windows of fixed position and default size

Fig. 6. Hypermedia for cognition design principles.

additional media and designing flexible layouts may hinder implementation and need to be factored in the project budget.

5.1.3. Development

Once the storyboard is in place with a layout supporting cognition, the *development phase* generates the lesson plans and lesson materials based on the hypermedia design phase specifications. During this phase, the media used for instruction are developed and digitized. They are then integrated and synchronized in the software applications chosen for production (HTML editors, web-courseware applications, or other web-authoring software). These applications will be chosen based on the level of technical expertise of the developers as well as their "ease of use" for the learners. For example, a popular web-courseware application may be chosen by developers/instructors because it is relatively easily to program, but it may have a poorer graphical user interface and a higher level of navigational difficulty than other applications. A careful evaluation of the technical expertise required on the part of the learners should be conducted, and weighted against the developmental needs of the producers.

A distance education course delivered entirely on the Internet requires modifying traditional media. If audiocassettes or videotape-based distance courses consisted of 2-h length cassette tapes, which replicated the instructional approach in the traditional classroom, imitating this model on an Internet-based course is technically challenging, and may be counterproductive for learning. Video and audio content must be shortened and reduced to the identification of key examples. Digitized clips will consequently be shorter and easily accessible using streaming technologies. These clips will be integrated with text descriptions and visual images offering hyperlinks to other content. Offering a variety of opportunities for interaction is crucial for keeping the students actively engaged. By offering multiple messages, learner choice is promoted, and class interaction is shaped around learners' preferred media/content (students choose to comment on a specific video clip, rather than a lecture slide or an audio file). Models that were applicable in the classroom or in educational television are not applicable in the highly interactive environments of the Internet and the World Wide Web.

5.1.4. Evaluation

The *evaluation phase* includes product review during and after production (formative and summative evaluation). The formative evaluation is an ongoing feedback processes undertaken during production and should occur at every phase of course development. The purpose of this type of evaluation is to improve the instruction before the final version is implemented. Formative evaluations can be done in a variety of ways: questionnaires, user focus groups, or interviews. Summative evaluation occurs after the final version of instruction is implemented. This type of evaluation is designed to assess the overall effectiveness of the instructional layout. Both the formative and the summative evaluations can be elaborated to obtain feedback on a variety of criteria. Reeves (1993) identifies several evaluation variables using a Likert-scale. Some hypermedia evaluation variables include:

- *Navigation*: This is a critical variable because users need user-friendly orientation clues in an interactive program. It summarizes the user perceived ability to move through the contents of an interactive program in an intentional manner.

- *Screen design*: Dimension of interactive programs including dimensions related to text, icons, graphics, color, and other visual aspects of interactive programs.
- *Information presentation*: It is concerned with whether the information contained in the knowledge space of an interactive program is presented in an understandable form. An elegantly designed user interface for an interactive program is useless if the information it is intended to present is incomprehensible to the user.
- *Media integration*: It is the combination of different media to produce an effective final product. It defines the extent to which the various media (text, graphics, audio, video, etc.) work together to form one cohesive program.
- *Overall functionality*: It is the perceived utility of the program. The overall functionality must be judged in relation to the specific intended use that the designer wanted to achieve.

Evaluations should focus both on the design of instructions (effective design, respect to instructional design principles) and on the matching of learning objectives with instructional strategies. In this respect, students' feedback on the asynchronous and synchronous communication experience is a key factor. These evaluations should be conducted throughout the course (with formative evaluations). They can also be based on other evaluation models, such as illuminative evaluations. Illuminative evaluations disclose important factors and issues emerging in a particular learning situation, factors which might have been overlooked by the instructor.

5.1.5. Delivery

The *delivery phase* refers to the actual delivery of the instruction, whether classroom-based, laboratory, or computer-based. In the context of Internet delivery, the assessment of the effective and efficient delivery of instruction on the Internet is implied. This phase must promote the students' understanding of material, support the students' mastery of objectives, and ensure the students' transfer of knowledge from the instructional setting to their work environment.

Cost considerations and technical considerations will also influence the delivery mechanisms of the instructional material. Since the Internet is the means of instruction, the type of instructional materials and interaction strategies will affect delivery, technical performance and costs associated with the course. If the course is fostering collaborative learning through the use of communication technologies, such as live broadcasting on the network, the server capabilities need to be sophisticated. Dedicated video servers need to be used to stream live feeds from the instructor. This suggests high hardware costs, which need to be budgeted in addition to the developmental and production costs. A high quality delivery of streaming audio and video on the Internet poses technical challenges. Frequent interruptions, long downloading wait time, and poor media quality are not conducive to instruction and lower interest and attention (Nielsen, 1996). Students' understanding of material will be affected by poorly delivered digital content. Providing technical assistance and individualized tutoring addressing individual problems and concerns are necessary elements for success. This implies that the course taught by a lead professor needs to be supported by other content and technical experts providing individualized support. Course development and management tasks required in a

distance education course are more-resource intensive than traditional courses. These maintenance costs need to be factored into the project budget and cannot be overlooked.

6. Summary

The growing use of Internet technologies for distance education opens new educational possibilities that move well beyond the provision of more sophisticated delivery tools. The communication and instruction possibilities made feasible by the interconnected network foster exchanges among students and instructors, and among students in the classroom. The open navigation opportunities increase learner control of the instructional experiences. These elements render the Internet a unique tool for distance education, one that allows a real shift from an instructor-centered learning paradigm to a real student-centered learning domain. With students' access to a variety of resources, the need arises to render a more flexible course design process taking into account learner exigencies, and shaping the instructional elements. This paper reviewed traditional instructional design models and compared them to instructional delivery strategies in Internet instruction, identifying a hybrid design model that merged step-by-step and objectivist methodologies with flexible design and constructivist strategies. This integrated model maintains the procedural elements beneficial to complex design processes, but enables opportunities for revisions throughout development and delivery of instruction. When creating or redesigning courses for Internet distribution, content and media developers, faculty and researchers benefit from the identification of a developmental model taking into account both learning and design variables.

References

Dick, W., & Carey, L. (1990). *The systematic design of instruction*. New York: Harper Collins.

Gagné, R. (1985). *The conditions of learning and theory of instruction*. New York: Holt, Rinchart & Winston.

Kemp, J. et al. (1994). *Designing effective instruction*. New York: Merrill.

McManus, T. F. (1996). Delivering instruction on the world wide web: hypermedia design model. Available: (http://www.svsu.edu/~mcmanus/papers/wbi.html#cognitive) [October, 1999].

Moore, M. G., & Kearsley, G. (1996). *Distance education: a systems view*. Belmont, CA: Wadsworth.

Nielsen, J. (1996). (On-line) Interface design for Sun's world wide web site. Available: (http://sun-on-net/uidesign/) [April, 1999].

Reeves, T. C. (1993). Evaluating interactive multimedia. In D. M. Gayesky, *Multimedia for learning: development, application, evaluation*. Englewood Cliffs, NJ: Educational Technology.

Reeves, T. C., & Brackett, F. (1998). User characteristics checklist. Available: (http://mime1.marc.gatech.edu/mm_tools/ucc.html) [April, 1999].

Spiro, R. J., Feltovich, P. J., Jacobson, M. J., & Coulson, R. L. (1991). Cognitive flexibility, constructivism, and hypertext random access instruction for advanced knowledge acquisition in Ill-structured domains. In T. Duffy, & D. Jonassen, *Constructivism and the technology of instruction*. Hillsdale, NJ: Lawrence Erlbaum.

Szabo, M., & Kanuka, H. (1999). Effects of violating screen design principles of balance, unity, and focus on recall learning, study time, and completion rates. *Journal of Educational Multimedia and Hypermedia*, *8*(1), 23–42.

Thuring, M., Hannemann, J., & Haake, J. M. (1995). Hypermedia and cognition: designing for comprehension. *Communication of the ACM*, *33*(8), 57–66.

Katia Passerini specializes in multimedia and distance learning at the George Washington University, where she is completing a Ph.D. in information systems and working as an instructional design specialist. She worked as a consultant in information-technology and knowledge management projects at the World Bank, and as a multimedia specialist at the Library of Congress. She published in selected European journals, particularly in the areas of curriculum development and comparative educational systems.

Mary J. Granger is an associate Professor of Management Science in the School of Business and Public Management at George Washington University. Her research interests include Information Systems curriculum development, ethical and professional issues in the curriculum, computer-aided software engineering and database design. She has published previously in Journal of Information Systems Education, The Journal of Education in MIS and the SIGCSE Bulletin.