ACTIVITIES AND MODELS: IMPLICATIONS FOR THE SYSTEMS DEVELOPMENT LIFE CYCLE

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ABSTRACT

All software must pass through the four phases of the system development life cycle (SDLC) in one way or the other (i.e., waterfall method, prototyping method, etc.), and instructional multimedia software is no different. However, since the requirements of information systems and the requirements of instructional multimedia systems differ so dramatically, the nature of the analysis, design, development, and maintenance activities associated with each differs greatly as well. As computing professionals in small college/university environments (which often provide little to no technological support for the instructional process beyond the furnishing of hardware) and with the increasing importance of software in the teaching/learning process, it is likely that many of us will be called upon in the future to address the issues associated with the development of instructional multimedia systems. Using a review of the instructional multimedia software development literature as the foundation, this paper describes: 1) the types of activities that should take place during the design phase of the SDLC when creating instructional multimedia applications, and 2) the general characteristics, processes, and flows of nine multimedia instructional design models, including tutorials, drills, practice programs, simulations, instructional games, didactic presentations, explorations, structured observations, and simulated personal interactions.

INTRODUCTION

All software must pass through the four phases of the system development life cycle (SDLC) in one way or the other (i.e., waterfall method, prototyping method, etc.), and instructional multimedia software is no different. However, since the requirements of information systems and the requirements of instructional multimedia systems differ so dramatically, the nature of the analysis, design, development, and maintenance activities
associated with each differs greatly as well. As computing professionals in small college/university environments (which often provide little to no technological support for the instructional process beyond the furnishing of hardware) and with the increasing importance of software in the teaching/learning process, it is likely that many of us will be called upon in the future to address the issues associated with the development of instructional multimedia systems.

Like the traditional SDLC, the analysis phase of the instructional SDLC is broken down into two subphases: the preliminary analysis and the detailed analysis. The preliminary analysis consists of analyzing the client’s request for assistance, summarizing his or her findings in a preliminary report, and conducting a client sign-off meeting. The detailed analysis consists of identifying and stating the objectives of the instructional application, gathering information on the intended audience of the application, performing a concept (or task) analysis, identifying the restrictions that must be considered when determining the feasibility of designing, developing, and implementing the application, performing a costs/benefits analysis, preparing and delivering a feasibility report, and conducting a client sign-off meeting. The analysis phase of the instructional SDLC has been described in detail and published elsewhere (Beasley, 1998a).

**DESIGN ACTIVITIES**

System design transforms the logical requirements of an instructional multimedia application into a physical instructional design specification. This instructional design specification is then converted into a working instructional multimedia application during the implementation phase of the SDLC. The purpose of the design phase is to identify and document the best means of achieving the desired instructional result, and during this phase all instructional design materials should undergo a continuous process of formative evaluation (McDaniel & Liu, 1996; Reid & Mitchell, 1991). The analyst should periodically submit the instructional design materials to others (e.g., colleagues, subject matter experts, learners) for constructive feedback in order to ensure that the materials are consistent with the objectives of the intended instruction and that they are of acceptable quality. When these critiques are returned, the analyst should carefully evaluate them and make any necessary changes to the instructional design. This constant evaluation, even at the expense of time and cost, reflects the practice of successful multimedia developers (McDaniel & Liu, 1996).

The first activity of the design phase is to review, refine, and sequence the instructional objectives developed during the analysis phase of the SDLC. Reviewing the previously identified instructional objectives at this point is important especially if a significant amount of time has elapsed since the completion of the analysis phase, or if a different analyst has been assigned to the project and the analyst needs to be brought up to speed on the instructional objectives of the application. The second task within this activity is to refine the instructional objectives. The analyst should take care to ensure that all of the instructional objectives for the application are stated in simple, yet specific and precise terms that the learner can easily understand. Although the instructional objectives should be succinct, the analyst should make sure they are not too terse or lean. Otherwise, they may not be useful. After the instructional objectives have been reviewed and refined,
they should be sequenced logically by identifying those objectives that build upon others. The analyst should also identify those objectives that can be combined and focused on concurrently.

The second activity of the design phase is to determine the individual lesson modules the instructional application should contain as well as identify their logical sequence. The first task of this activity is to group together or separate out the instructional objectives into discrete lesson modules. In general, a one-to-one relationship between instructional objectives and lesson modules is ideal. If it is determined that a number of lesson modules will be needed to satisfy a single instructional objective, then the objective may be too general. The analyst should probably break this objective into a set of more specific objectives so that a one-to-one relationship exists. As a general rule, lesson modules should be kept to a maximum of between 15 and 20 minutes in length due to the limitations of human vigilance at mental tasks (Jay, 1983). In addition, the greater the demand on the learner's mental resources during the instruction, the more time is needed between modules to keep learner performance at a satisfactory level. The second task within this activity is to group the lesson modules of the application sequentially. The sequence of these modules will normally correspond to the sequence of the instructional objectives developed earlier. However, the analyst should make certain that the lesson modules that rely on prerequisite knowledge or skills are presented after the prerequisite modules.

The third activity of the design phase is to identify the multimedia instructional design models appropriate for satisfying the objectives of the instructional application. The details of these models are discuss in the next section of this article. For larger applications, a combination of these instructional designs may be required to cover all four phases of the instructional process. These phases consist of: 1) presenting new information or modeling new skills, 2) guiding the learner through the initial acquisition of that new information or those new skills, 3) providing practice with the new information or skills, and 4) assessing the learner's acquired knowledge or skill-level.

The fourth activity of the design phase is to identify those strategies that are appropriate for assessing the learner's knowledge of the subject matter to be studied. During this activity, the analyst should determine if recognition tests (e.g., true-false, multiple-choice), recall tests (e.g., fill-in-the-blank, short-answer, essay), problem-solving tests, demonstration/performance tests, or some other form of tests are most appropriate for the subject matter. The important thing to remember is that the analyst should make sure that the assessment strategies selected accurately measure the learner's progress toward the instructional objectives developed earlier.

The fifth activity of the design phase is to determine the types of media that will be needed to make the instructional multimedia application a reality. During this activity, the analyst should study the stated instructional objectives of the application, the proposed lesson modules, the chosen instructional design models, and the selected assessment strategies to determine the types of media that will be required for the instruction. It is important to understand that the analyst is not locating the resources to be incorporated into the instruction at this point—that is reserved for implementation. He or she is simply
determining what kind of media would be appropriate at which points during the instruction.

The sixth activity of the design phase is to develop a storyboard of the proposed multimedia application. A storyboard represents the sequence of screens that will be present in the application along with a written description of the dialogue that will take place with the learner. The storyboard provides a clear representation of the structure and functionality of the application before costly implementation occurs.

The seventh activity of the design phase is to compile the materials gathered and/or created during the first six activities of the design phase, summarize the design recommendations, and deliver the detailed instructional design specification to the client.

The eighth and final activity of the design phase is to conduct a client sign-off meeting. During this meeting, any misunderstandings with regard to the objectives of the instruction, the sequencing and scope of the application's lesson modules, the instructional design models chosen, the assessment strategies to be used, the media types to be incorporated into the application, and/or the storyboard can be cleared up. The analyst should be careful to incorporate into the design specification any client comments, making any revisions to the document as necessary. Once these specifications are agreed upon as accurate by the client, the analyst should obtain a written sign-off from the client indicating that he or she concurs with the proposed design of the instructional multimedia application and that the next phase of the SDLC—implementation—can commence. Figure 1 summarizes the instructional software development process literature as it applies to the design phase of the SDLC.

<table>
<thead>
<tr>
<th>Design Activities</th>
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<tbody>
<tr>
<td>Objective Review, Refinement, and Sequencing</td>
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<tr>
<td>Bergman, et al. (1990)</td>
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<td>Paulhusser, et al. (1996)</td>
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<td>Henderson, et al. (1993)</td>
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<td>Wissniewski, et al. (1994)</td>
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<td>Meadlin (1995)</td>
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<td>McFadila, et al. (1996)</td>
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<td>Siler (1994)</td>
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<td>Voss, et al. (1995)</td>
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Figure 1. The instructional software development process literature as it applies to the design phase of the SDLC.

DESIGN MODELS

Traditionally, several computer-based instructional design models have been recommended to guide the development of computer-based learning environments (Alessi & Trollip, 1991). These models include tutorials, drills, practice applications, simulations, and instructional games. Several other computer-based instructional design models have been suggested as well (Falk & Carlson, 1992). These models include didactic
presentations, explorations, structured observations, and simulated personal interactions. Each of these instructional designs has proven effective in a number of content areas, has distinct instructional characteristics, and covers different phases of the instructional process (i.e., present, guide, practice, assess).

Tutorials are most appropriate for teaching factual information. They can be used to teach about events that have occurred in the past, or they can be used to teach about things that are generally accepted as true today. Tutorials are also appropriate for teaching rules, such as the rules of the family tree or the rules of mathematical addition. Tutorials can also be used to teach principles and guidelines, such as accounting principles and guidelines for good computer program documentation. Finally, tutorials are suitable for teaching problem-solving strategies, such as algebraic word problem representation or interpersonal conflict resolution.

Drills are most appropriate for teaching paired-associates or information about connected or related things, such as the states and their associated capitol cities, multiplication tables (e.g., 9 x 9 = 81), and English/foreign language vocabulary pairs. Poncelet and Proctor (1993) provide some specific guidelines for constructing drills based on cognitive learning theory research.

Practice applications are most appropriate for providing practice with problem-solving skills and other process-oriented tasks. Whereas a drill might be used to help a learner memorize associated pairs (e.g., 9 x 9 = 81), a practice program might be used to provide practice in the development of mathematical equations using the addition, subtraction, multiplication, and division operators to come up with a given number. Practice applications are also useful for providing practice with process-oriented tasks, such as business transactions. For example, a practice application might be used to provide an employee with practice filling out a customer credit application. Again, see Poncelet and Proctor (1993) for a list of guidelines. Figure 2 describes the general processes and flows associated with tutorials, drills, and practice applications.
Simulations are most appropriate in situations in which having the learner perform a given task in the real world would be too dangerous, too costly, or too time-consuming. Thus, simulations are used to help the learner build a useful mental model of a part of the real world and to provide the opportunity to test that mental model safely and efficiently. For example, a flight instructor might wish to demonstrate the ramifications of different reactions to an emergency landing situation. Since an improper response to an emergency situation in a real airplane could prove fatal, a simulation could be developed and utilized.

Instructional games are, in some ways, like simulations. Whereas simulations are used to simulate some real-world phenomenon, instructional games may or may not simulate reality. Many instructional games also resemble drills or practice programs in that they are many times used to provide learners with motivating practice in some content area. Regardless of the subject area, instructional games usually possess clearly defined competitive goals, such as scoring the most points, making the most money, or popping the most balloons. They also contain rules, such as the actions that will be allowed during the game and the actions that will not be allowed. Instructional games are most motivational when they contain these five basic ingredients: competition, challenge, fantasy, safety, and entertainment (Malone, 1984; Park & Reeves, 1991). Figure 3 describes the general processes and flows associated with simulations and instructional games.

Didactic presentations are appropriate for delivering factual information, teaching rules and principles, and demonstrating problem-solving strategies. These systems often take the form of a well-organized outline that is used to guide an instructor through a lecture or presentation. In this situation, the instructor utilizes a computer and some kind of projection device to display the outline for viewing by the audience. Other media, such as audio, still images, animations, and video can also be incorporated into the presentation.
for added impact. The instructor must elaborate on the content presented by the computer and provide relevant examples and analogies. See Beasley (1998b) and Beasley and Wade (1998) for specific guidelines on this instructional approach.

Explorations are most appropriate for delivering factual information. These types of systems, which rely heavily on hypertext linking capabilities, allow an instructor or learner to explore an information-rich environment based on personal relevance, interest or experience level, curiosity fulfillment, information needs, or task demands. A world wide web-based lesson or an online multimedia encyclopedia would both be examples of exploratory environments. Figure 4 describes the general processes and flows associated with didactic presentations and explorations.

Structured observations provide instructors and learners with set guidelines for viewing video segments via computer. They are appropriate for teaching factual information and rules. For example, a sociology instructor might wish to show video segments of two different cultures celebrating the same religious holiday. After showing the segments, the instructor might then compare and contrast each segment by pointing

Figure 3. General processes and flows associated with simulations and instructional games.

Figure 4. General processes and flows associated with didactic presentations and explorations.
Simulated personal interactions, like simulations, are most appropriate in situations in which having the learner perform in the real world would be too dangerous, too costly, too time-consuming, or would otherwise be impractical. The key difference between traditional simulations and simulated personal interactions is that the former are used mostly to simulate physical or procedural processes, while the latter are used to simulate human-to-human interaction. For example, a counseling instructor might wish to demonstrate predictable reactions to various verbal phrases used by a counselor during a counseling session. Using a simulated personal interaction application, he or she could demonstrate reactions to phrases that tend to be threatening to family members and thus evoke anger among them. The instructor could then demonstrate reactions to wordings that are less threatening to the family members and then compare and contrast the two. Figure 5 describes the general processes and flows associated with structured observations and simulated personal interactions.

Figure 6 illustrates the various computer-based instructional design models discussed here as well as the phases of the instructional process they typically cover.
SUMMARY

System design transforms the logical requirements of an instructional multimedia application into a physical instructional design specification. This instructional design specification is then converted into a working instructional multimedia application during the implementation phase of the SDLC. The purpose of the design phase is to identify and document the best means of achieving the desired instructional result. The first activity of the design phase is to review, refine, and sequence the instructional objectives developed during the analysis phase of the SDLC. The second activity is to determine the individual lesson modules the instructional application should contain as well as identify their logical sequence. The third activity is to identify the multimedia instructional design models (i.e., tutorials, drills, practice applications, simulations, instructional games, didactic presentations, explorations, structured observations, and/or simulated personal interactions) appropriate for satisfying the objectives of the instructional application. The fourth activity is to identify those strategies that are appropriate for assessing the learner's knowledge of the subject matter to be studied. The fifth activity is to determine the types of media that will be needed to make the instructional multimedia application a reality. The sixth activity is to develop a storyboard of the proposed multimedia application. The seventh activity is to compile the materials gathered and/or created during the first six activities of the design phase, summarize the design recommendations, and deliver the detailed instructional design specification to the client. The eighth and final activity of the design phase is to conduct a client sign-off meeting.

<table>
<thead>
<tr>
<th>Instructional Design Model</th>
<th>Phase 1 Present</th>
<th>Phase 2 Guide</th>
<th>Phase 3 Practice</th>
<th>Phase 4 Assess</th>
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<tbody>
<tr>
<td>Tutorials</td>
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<td>Simulations</td>
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<td>Structured Observations</td>
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<tr>
<td>Simulated Personal Interactions</td>
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<td>✓</td>
</tr>
</tbody>
</table>

Figure 6. Computer-based instructional design models and their respective instructional phases.

REFERENCES


Association for the Development of Computer-Based Instructional Systems (pp. 383-393). St. Louis, MO: ADCIS.


