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ABSTRACT

The quality of multimedia-based interaction is more the product of the way instruction is designed, and less the result of the system on which it is delivered. To fully exploit the capabilities of more powerful instructional technologies, designers must also reexamine the assumptions and expand the strategies employed in instructional design. Prescriptive, democratic and cybernetic learning environments have been identified for individualized instruction and have subsequently been adapted to interactive multimedia learning. Prescriptive environments specify learning objectives and the instructional system is used as a primary delivery medium. In most cases, it is the learner's role to receive and master the given content. Democratic environments emphasize the learner's role in defining what is learned, how it is learned, and the sequence in which it is learned; navigation, motivation and access supersede objectives and evaluation. In cybernetic environments, a complete system allows the learner to interact freely and naturally with the instruction in a process of mutual exchange. Control is negotiated but decisions are left in the hands of the learner. This paper applies five instructional design issues to each of these environments--control, practice, feedback, cooperation, and metacognition--and considers how each of these notions might be expressed in difference multimedia environments. (Contains 19 references.) (AEF)

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# Multimedia Design Principles for Constructing Prescriptive, Democratic and Cybernetic Learning Environments

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**Abstract:** This paper explores principles for designing interactive multimedia instruction based on a classification scheme for multimedia environments which includes prescriptive, democratic and cybernetic categories. If a multimedia developer first considers the nature of the desired learning environment, a continuum of instructional design decisions naturally obtain. This paper considers several design issues, including control, practice, feedback, cooperation, and metacognition, and provides examples of how they are expressed in different multimedia environments.

The quality of multimedia-based interaction is more the product of the way instruction is designed, and less the result of the system on which it is delivered. To fully exploit the capabilities of more powerful instructional technologies, designers must also reexamine the assumptions and expand the strategies we employ in instructional design . This paper abbreviates several ideas which due to space restrictions, cannot be elaborated fully here. For a more thorough treatment of this topic, I encourage you to contact me directly, and I will send you a complete paper.

## Three Learning Environments

At least three distinct learning environments have been identified for individualized instruction and subsequently adapted to interactive multimedia learning (Romiszowski, 1986; Schwier, 1993). These include prescriptive, democratic and cybernetic learning environments. Prescriptive environments specify learning objectives and the instructional system is used as a primary delivery medium. In most cases the boundaries of learning are externally imposed, and the learner's role is to receive and master the given content.. Democratic environments emphasize the learner's role in defining what is learned, how it is learned, and the sequence in which it is learned. Democratic learning resources emphasize navigation, motivation and access, and they down-play objectives and evaluation. Cybernetic environments emphasize a complete system in which the learner can interact freely and naturally with the instruction, which in turn responds dynamically with the learner. The cybernetic instructional environment, unlike instruction provided in prescriptive and democratic environments, actually expands beyond the initial design decisions made during its development. This expansion marks its difference from being merely a sophisticated prescriptive environment; the very substance of the learning landscape is changed by the nature of interactions during instruction, not just the path followed by an individual through existing material (whether prescribed or democratic).

This paper applies five instructional design issues to each of these environments— control, practice, feedback, cooperation, and metacognition. How might each of these notions be expressed in different multimedia environments?

## Instructional Design Principles for Prescriptive Environments

### Prescriptive Learner Control

In prescriptive environments learner control speaks to when learners might be empowered by being given more control over instruction and conversely when learners might be hampered by having such control. In other words, a prescriptive environment assumes the question, "should learners be given or denied control of learning?" In designing prescriptive multimedia environments, control is often expressed in the selection of content and sequence. Naive or uninformed learners require structure, interaction, and feedback to perform optimally (Carrier and Jonassen, 1988; Higginbotham-Wheat, 1990; Kinzie, Sullivan, and Berdel, 1990). Giving ill-prepared learners control over instruction may permit them to make poor decisions about which

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content is important and how much practice is required, which may in turn be reflected in decremented performance (Coldevin, Tovar, and Brauer, 1993)

**Example:** A pre-test is given at the beginning of a tutorial program. Those learners who score higher on the pre-test are informed of objectives they are expected to achieve, and placed in less restrictive versions of the tutorial. Those who score lower are placed in highly prescribed, remedial programs.

### Prescriptive Practice

Practice events in prescriptive instruction should require learners to use information; that is, practice during prescriptive instruction emphasizes acquisition of specified skills and knowledge. In prescriptive environments, practice should be imposed often during early stages of learning and less often as time with a particular topic progresses (Salisbury, Richards, & Klein, 1985). As facility and familiarity with the learning task increase, so should the difficulty of practice. In prescriptive multimedia environments, the difficulty level would be managed externally by giving the learners access to progressively more difficult tasks only as they are successful with previous material.

**Example:** Embed several relatively easy questions in the first sections of a program. When the learner demonstrates mastery of simple questions on a particular topic, give fewer, but progressively more difficult questions.

### Prescriptive Feedback

In prescriptive environments, feedback will often take the form of error detection and correction. Because instructional learning outcomes are explicit, it is possible (and probably desirable) to funnel the feedback about learner performance toward the intended outcome. Feedback acts to correct errors, and the effect is more powerful if the learner feels confident that the incorrect response is correct, yet in verbal information tasks, correct response feedback is better than no feedback. Instruction utilizing response certitude estimates is less efficient, probably due to the time taken by the learner to make estimates, but efficiency is seldom a major consideration in interactive multimedia instruction. Feedback effects also tend to be stronger when no other instructional text is present, thus increasing the feedback's informational effect.

**Example:** Have learners declare their level of confidence at key points during instruction, and then tailor feedback to acknowledge the professed level of confidence.

### Prescriptive Cooperative Learning Strategies

In prescriptive environments, learners use cooperative learning strategies to collectively address externally defined tasks. The goal is to bring a broad range of skills and collective energy to bear on a complex task. One strategy is to emphasize interdependence and accountability: The performance of each member of a cooperative group must contribute to the group's achievement, and the reward structure must account for this. Another strategy is promotive interaction, where an individual's effort to bolster the efforts of other group members is promoted through heterogeneous grouping. Yet another issue is training for collaboration. Learners can be trained to use interactive strategies effectively, and training should be both content-specific and content-independent (Hooper, 1992).

**Example:** Multimedia materials may include an independent module for developing global collaborative skills, and providing specific strategies to be used within the program by the group.

### Prescriptive Metacognitive Strategies

In prescriptive environments, metacognitive skills are used by the learner to notice when something is not clearly understood and take appropriate remedial action. They may also include selecting from among various memory strategies, including "metamemory" skills with different memory strategies and an awareness of



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how to choose which is appropriate for a given task; and "metacomprehension" skills which include being able to detect when one fails to comprehend something and is able to take appropriate remedial action.

**Example:** Encourage learners to watch for difficulties, and think about ways to find answers to their problems.

## Instructional Design Principles for Democratic Environments

### Democratic Control

From a democratic perspective, learner control is assumed. It is central assumption in a democratic environment that learners construct multiple—and equally valuable—realities from their unique interactions with instruction. If the learner is to be given control over significant decisions, it is incumbent that they also be given the skills necessary to exercise the control. Multimedia designers cannot assume that learners are able to assume control without learning *how* to take control and make productive decisions. Several applicable design principles can be extracted from the literature. Learners who are generally high achievers or who are knowledgeable about an area of study can benefit from a high degree of learner control (Hannafin and Colamaio, 1987). Giving the learner control may increase motivation to learn, but it does not necessarily increase achievement and may increase time spent learning (Santiago and Okey, 1990).

**Example:** Offer learners control of a program. Let them select topics and sequence, but provide advice when appropriate about the possible consequences of their choices.

### Democratic Practice

In democratic environments, practice may include use and review of specific content or skills, but also includes practice with strategies for learning, not just practice with specific content or skills. Learners can benefit from memory and organizational strategies to make information more meaningful. Practice events in democratic multimedia environments should encourage learners to use information and discover and derive new relationships in information. Democratic multimedia instruction should be designed to include opportunities for learners to acquire strategies for using the instruction optimally. Instructional cues can be used productively, even with passive learners, to promote exposure to elaborations, and consequently increase time-on-task and achievement (Lee and Lehman, 1993). Practice in democratic and cybernetic environments should be varied and available to the learner at any time, and in several forms to satisfy self-determined needs.

**Example:** Include "strategy" modules within a program to apply newly learned content to novel situations, or provide on-line advisement to learners reminding them to practice using new content.

### Democratic Feedback

In democratic multimedia environments, feedback will often take the form of advisement; that is, informing learners about the consequences of choices and patterns of choices, or providing recommendations about productive avenues of study. Because learners are defining specific learning outcomes in democratic environments, feedback will attempt to help learners articulate their own goals and help them follow productive paths through the learning system. Learners maintain or change their own cognitive operations based on how new information about their performance matches their expectations about performance (Mory, 1992). Delayed feedback may be more effective for higher cognitive tasks than immediate feedback. It is possible that delaying feedback allows additional time for reflection, and this in turn may facilitate learning challenging material.

**Example:** Include an on-screen "advise" button for the learner. When selected, it provides the learner with a visual map of their choices and paths (audit trail) and highlights preferred alternatives for the learner with explanations.





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## Democratic Cooperative Learning Strategies

In a democratic environment, cooperative learning strategies place emphasis on teamwork and shared responsibility for decision-making. Some appropriate strategies include training for collaboration. Learners can be trained to use interactive strategies effectively, and training should be both content-specific and content-independent (Hooper, 1992). Multimedia materials may need to include an independent module for developing global collaborative skills. Debriefing sessions following group processes should also be included to allow group members to reflect on effective and ineffective strategies they used.

> **Example:** Have learners input the number of users for materials, and provide alternative designs. Each member of a team is given specific problems to solve or activities to complete during the program, and the program monitors individual, as well as group, progress toward completion of the instruction.

## Democratic Metacognitive Strategies

In democratic multimedia learning environments, the issue becomes one of not leaving the learner adrift in a sea of content without the tools to be successful, and increasing the metacognitive demands placed on the learner (Park and Hannafin, 1993)."Self regulation" is an individual's ability to make fine adjustments to errors detected when the instruction provides no feedback. "Schema training" has to do with getting the learner to generate personally relevant structures for understanding material, and becoming less dependent on structures provided by the instruction. "Transfer" is the ability of the learner to apply a strategy to an unfamiliar and dissimilar learning task. Metacognitive strategies can promote learning and can be generalized across learning situations, but they must be learned and practiced. In any instruction, but particularly in democratic and cybernetic multimedia environments, metacognitive strategies can be learned which will help the learner make more productive decisions (Osman and Hannafin, 1992).

> **Example:** One method of developing such strategies is learner advisement about metacognitive strategies. Learners can be given reminders about ways to approach materials (e.g. "Have you thought about trying this approach? It worked for you the last time you tried it."). The focus with such strategies should be on providing metacognitive prompts and promoting self-generated strategies, while weaning the learner from prompts as quickly as possible.

# Instructional Design Principles for Cybernetic Environments

## Cybernetic Control

Control is negotiated in cybernetic multimedia environments, and is the product of mutual exchange. The learner may be advised about difficulty levels and productive choices, but decisions will be left in the hands of the learner. Decisions result in consequences to which the learner must respond. Learner control with advisement seems to be superior to unstructured learner control for enhancing achievement and curiosity, promoting time-on-task, and stimulating self-challenge (Arnone and Grabowski, 1991; Mattoon, Klein, and Thurman, 1991; Milheim and Azbell, 1988; Santiago and Okey, 1990). Further, the amount of control available to a learner at any particular time in a program should not necessarily be fixed. Courseware should be adaptive. It should be able to alter instruction dynamically, based on learner idiosyncrasies (Carrier and Jonassen, 1988).

> **Example:** Learners enter a fully simulated landscape of the human body and navigate by pointing in the direction they want to move. Navigation options for making choices increase as the learner navigates successfully.

## Cybernetic Practice

The purpose of practice in a cybernetic environment subsumes using information, applying information, and testing new skills and information, but all are done in a simulated and saturated environment. Practice



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approximates practicing in a real environment, and the growth in a learner's ability to perform new skills is commensurate with actual skill levels.

**Example:** A surgeon practices hip replacement surgery in a virtual surgery theater. Learner acquires new skills and practices using them in a full simulation, and is given more challenging situations as skills increase.

### Cybernetic Feedback

In cybernetic environments, feedback can be characterized as mutual and negotiated. Learners set directions and make choices, and the learning system "learns" from patterns which emerge how to respond to the learner or provide new challenges. Feedback will often provide a "metacognitive viewpoint" for the learner, responding naturally and logically to learner actions, identifying intentions, and establishing levels of challenge for the learner.

**Example:** The system identifies a pattern of responses, say a tendency for the learner to respond to oral challenges in French, rather than English. The system provides feedback in French, and monitors whether the learner performs more successfully. If the learner falters, the system switches back to English, and informs the learner of the decisions made.

### Cybernetic Cooperative Learning Strategies

In cybernetic environments emphasis may be placed on collaborative problem solving or competition within a stimulus-rich environment. Learners may "join forces" to address problems presented in a simulated environment, and the system will have a wider array of input from which to "learn." In a competitive cybernetic environment, learners may be pitted against one another in a simulation.

**Example:** Two participants are given the task of designing the dining areas in a restaurant to obtain optimum seating arrangements. Both are placed in a virtual restaurant, and asked to move tables. One is to concentrate on maximizing workflow for employees, the other is concerned with seating as many diners as possible. As they make decisions, the system develops rules for optimizing seating designs.

### Cybernetic Metacognitive Strategies

In cybernetic environments, systems "tune" themselves to the metacognitive strategies employed by learners, adjust to them, and advise the learner of trends which emerge. This assumes that programs are sufficiently sophisticated to extrapolate meaningful trends from patterns of learner responses, a type of cybernetic metacognition not readily available. Osman and Hannafin (1992) warn against designs in which the training in metacognitive strategies require more energy than the content to be learned. The lesson: beware metacognitive overhead costs.

**Example:** In a virtual restaurant environment, learners are given the ambiguous task of designing dining areas. As learners impose designs on seating arrangements, the system monitors decisions made, and extrapolates the metacognitive strategies employed (e.g. one learner is designing for maximum seating possible, while another is attempting to create an aesthetic and intimate atmosphere).

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