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ABSTRACT

In designing materials for use in a contructivist learning environment, instructional designers still have a role in selecting the situations that may provide a stimulus for knowledge construction and providing features that support students and teachers in using these materials. This paper describes the process of designing a series of case-based interactive videodiscs to be used within a constructivist learning environment. The cases present two elementary teachers and their students as they progress through science lessons based on the conceptual change model of science teaching. Dual audio tracks allow the viewers to hear either the classroom events or the teacher's reflections on the classroom events. Assumptions about teaching and learning that guided the design, and implications of these beliefs for the instructional materials are discussed; generalizations are derived about the differences between the process described and procedures recommended by traditional instructional design models. (Contains 18 references.) (AEF)

Title:

A "Layers of Negotiation" Model for Designing Constructivist Learning Materials

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A "Layers of Negotiation Model" for Designing Constructivist Learning Materials

Many authors have questioned whether traditional instructional design models are suitable for designing constructivist learning materials (see, for example, the May and September 1991 issues of Educational Technology). Although Winn (1991) questions whether "traditional procedures and assumptions of instructional design" can be applied to designing materials for constructivist learning environments, he admits that "... while instructional design by constructivists may seem to be a contradiction in terms, there is still a lot of designing to do." (p. 39). In designing materials for use in a constructivist learning environment, instructional designers still have a role in selecting the situations that may provide a stimulus for knowledge construction and providing features that support students and teachers in using these materials (Young, 1993). However, Winn (1991) indicates that designing materials for constructivist learning environments "requires a change in the assumptions about how people learn and about how instructional decisions are made "(p. 38). These discussions imply that the processes of instructional design, not just the products, must be revised to accommodate constructivist ideas about learning.

The purpose of this paper is to discuss the process of designing a series of case-based interactive videodiscs to be used within a constructivist learning environment. The cases present two elementary teachers and their students as they progress through science lessons based on the conceptual change model of science teaching (Cosgrove & Osborne, 1985). The two hours of videodisc footage were condensed from approximately 60 hours of videotape documenting actual classroom events occurring during 2 weeks of science instruction in two classrooms. The three cased include a 1-week lesson on levers (5th grade), a 1-week lesson on inclined planes (5th grade), and a 2-week lesson on seeds and eggs (1st grade). The discs illustrate a variety of on-location classroom events: student investigations, small group interactions, student record keeping, large group discussions, and demonstrations. Dual audio tracks allow the viewers to hear either the classroom events or the teacher's reflections on the classroom events. This set of video-based cases provide a context for preservice elementary science teachers to engage in reflective thinking. Using these materials, students have the opportunity to seek answers to questions that evolve from their interactions with the materials, explore the stages in conceptual change science teaching, and gain experience with reflection on teaching.

As we designed these materials, we were guided by a set of constructivist assumptions about learners and learning. These assumptions had implications for the learning materials and, we believed, for the instructional design process. We assumed that traditional instructional design models would not provide adequate guidance in designing these materials; instead, we sought to design our materials guided by our assumptions about teaching and learning, and once the materials had been developed, to reflect back over the design process and compare our procedures with those prescribed by traditional models. This paper documents that process: we outline the assumptions about teaching and learning that guided our design efforts, we discuss the implications of these beliefs for the instructional materials, we describe our design process, and finally, we derive some generalizations about the differences between our process and the procedures recommended by traditional instructional design models that may be of use to other designers.

Assumptions about learners and learning

We assume that learners come to an instructional setting with a wide variety of background experiences that have shaped their understandings, beliefs, and values. Thus, the meaning that a learner derives from an instructional experience may not be the same as another learner's; an individual's experience is mediated through a unique filter of understanding, beliefs and values (Freyberg & Osborne, 1985). Learners may focus on different inputs or all may attend to the same data. Similarly, there is no guarantee that an instructional intervention will "work" for every student; student's ideas could be uninfluenced or influenced in unanticipated ways by the intervention, depending on the learner's action on the experience (Gilbert, Osborne, & Fenshem, 1982).

We believe that learning is a process of sense-making, of assimilating new information within existing knowledge structures, and adjusting prior understandings to accommodate new information. In order to facilitate the assimilation and accommodation of new experiences, we believe that disequilibrium is essential. Learners must be dissatisfied with their existing knowledge and beliefs in order for learning to take place (Posner, Strike, Hewson, & Gertzog, 1982).

In addition, we believe that learning is a social enterprise. Learners can become dissatisfied with their existing knowledge when they compare their ideas with ideas of others, both experts and peers (Solomon, 1989). Thus, through this sharing of knowledge, learners may find new ideas that are intelligible, plausible, and useful alternatives. Through social interactions, as well as through action on objects, learners make sense of the world.

Implications for learning materials

Grounded in our beliefs about the nature of learners and learning, are implications for the learning materials. We recognize that learners may come to the instructional setting with varied background knowledge, beliefs, and attitudes; therefore the materials must be capable of supporting a variety of learners possessing a variety of perspectives as they attempt to create meaning from the instructional materials. Similarly, meaning is not inherent in instructional material; instead meaning is created by learners as they interact with the materials, with the teacher, and with other learners.

From her synthesis of recommendations from numerous researchers "attempting to articulate constructivist theory", Driscoll (1994, p. 365) identifies five conditions that should be incorporated within constructivist learning environments. She suggests that constructivist learning environments should:

1. Provide complex learning environments that incorporate authentic activity.
2. Provide for social negotiation as an integral part of learning to allow insights to emerge through the group process that may not come about otherwise.
3. Juxtapose instructional content and include access to multiple modes of representation to allow learners to examine materials from multiple perspectives.
4. Nurture reflexivity, or awareness of one's own thinking and learning processes.
5. Emphasize student centered instruction, where students are actively involved in determining their own learning needs and how those needs can be met.

As the following discussion illustrates, our materials incorporate each of these recommendations.

1. Provide complex learning environments that incorporate authentic activity. We recognize that classrooms are complex environments where many events occur simultaneously. Using interactive videodiscs of actual classroom lessons, the preservice teacher can enter a classroom virtual world. Viewers can begin to identify problematic classroom events through the rich visual and verbal cues provided via videodisc. Rather than provide brief vignettes of exemplary teaching (see, for example, Goldman & Barron, 1990), we choose to present three complete units of science instruction. The viewers witness the natural progression of events as they unfold over a one or two week time period. They see things that work and things that don't. They witness the teacher's daily reflections on the classroom events, her frustrations, her pride, and her careful consideration of alternatives for action. In this way, the complexity of the classroom environment is maintained in authentic recordings of the classroom events.
2. Provide for social negotiation as an integral part of learning to allow insights to emerge through the group process that may not come about otherwise. As these cases are used in university methods classes to coach preservice science teachers to become reflective practitioners, social negotiation is an integral part of the teaching/learning process. A series of written and oral reflective tasks cumulate in large group discussions where students critically analyze various classroom episodes from the videodiscs. As they examine their beliefs and values about teaching science, they may find that their theories are challenged by other ideas that emerge through group discussions (Abell, Cennamo, Anderson, Bryan, Campbell, & Hugg, in press). Although the class may seldom reach consensus, each student builds upon his or her own personal theories based on these experiences. In this way, insights about teaching and learning science emerge through the group process that may not occur otherwise.
3. Juxtapose instructional content and include access to multiple modes of representation to allow learners to examine materials from multiple perspectives. The materials provide students with access to multiple modes of representing the classroom events. The videodiscs contain dual audio tracks that allow the users to either hear the naturally occurring classroom audio or the teachers' reflections on the classroom events illustrated in the video. The videodiscs are accompanied by a HyperCard stack that includes student products, background information on the school, additional information on the teacher and students, lesson plans, and reference materials. As students explore

the materials, they can read the lesson plan, see the classroom events, listen to the teacher's reflections on the classroom events, examine student products, read more about the students, learn more about the teaching strategies used in the lesson, or access several other frames of information related to a single classroom event. With the random assess possible with computer-controlled interactive videodisc, users can juxtapose information in a sequence of their own choosing and examine the content from multiple perspectives.

4. Nurture reflexivity, or awareness of one' own thinking and learning processes. Our interactive video cases are designed to encouraged preservice teachers to become aware of their own thinking and learning processes. A number of written and oral reflective tasks have been developed for use in conjunction with the video cases. These tasks systematically and developmentally attempt to help preservice teachers: 1) uncover their local theories of science teaching and learning; 2) recognize the role that personal histories of science learning play in their local theories; 3) realize that classrooms are complex and that classroom observers focus on various attributes; 4) frame issues that arise during science instruction; and 5) reassess their own theories in light of their own and others' classroom practice. Thus the video cases encourage reflection about teaching and learning.
5. Emphasize student centered instruction, where students are actively involved in determining their own learning needs and how those needs can be met. As described above, the materials allow users to choose several modes of representation in order to meet their information needs. In addition, several lines of investigation can be pursued. These materials can be used to better understand the lesson stages in conceptual change science teaching (Cosgrove & Osborne, 1985), children's ideas about science, the science content, or reflection on teaching. The materials are designed to be used with ease in large groups, in small groups, or individually. Thus, the materials provide students with the flexibility to explore in ways that allow them to determine their own learning needs, to determine how those needs can be met, and to pursue information to meet these needs within the context of elementary science instruction.

Implications for the design process

In designing the interactive video case materials, our beliefs about the nature of learning also had implications for the instructional design process. Just as constructivists emphasize the process of learning, rather than merely the product, we believed that the process of designing these materials, not just the product, should be consistent with constructivist theory. Not only should the materials themselves be developed for use in a constructivist learning environment, but we believed that the materials should evolve though a process of construction of knowledge, reflection, and social interactions. In retrospect, we propose that Driscoll's (1994) five conditions for constructivist learning environments can be transformed to apply to the process of designing materials from a constructivist perspective. We suggest the instructional design process should include the following conditions:

1. Embrace the complexity of the *design* process.
2. Provide for social negotiations as an integral part of *designing* the materials.
3. Examine information relevant to the *design* of the instruction at multiple times from multiple perspectives.
4. Nurture reflexivity in the *design* process.
5. Emphasize *client-centered design*.

Although we addressed these five conditions throughout the entire instructional design process, for simplicity, we will illustrate each condition as we describe one aspect of designing and developing our materials. After recording approximately 60 hours of videotaped footage, a we faced a major task in selecting the video segments to be included within two hours of disc space. The process we followed in accomplishing this complex task is described below:

1. Embrace the complexity of the *design* process. Instructional design has traditionally been a prescriptive science (Regeluth, 1983); however, we found that attempting to simplify the design process and apply strategies that had worked in other situations had the potential for limiting the richness of our product. Foremost in our minds was to create "cases" of conceptual change science teaching in elementary classrooms. In order to make decisions on the footage to be included on our disc, the project team had to agree upon what would constitute a classroom "case." At first we looked for prescriptions for this design dilemma. However, our cases were different from most in that they were video-based, rather than print-based, thus, guidelines for constructing cases (e.g., Carter, 1992; Shulman, 1992) were insufficient. Guidelines pertinent to videodisc cases in elementary mathematics (see Goldman & Barron, 1990) provided some clues. Yet, the nature of science compared to mathematics teaching presented some unique needs. In addition, we knew that our lessons extended over several days and that it would be necessary to capture the instruction over this extended time. Thus, instead of relying on

any existing set of prescriptions, we accepted the need to embrace the complexity of our task and to create our own process for selecting video segments.

2. Provide for social negotiations as an integral part of *designing* the materials. After rejecting a prescribed way of selecting scenes for inclusion on our disc, we engaged in extensive negotiations to identify appropriate scenes. Our selection process began by establishing a shared perspective among team members (2 methods course instructors, 1 graduate assistant, 1 science content specialist, and 1 instructional designer) on the types of scenes needed. We discussed the needs of our particular audience and instructors relative to our content: the need to illustrate key stages in the lesson, problematic classroom events, and examples of the teachers' reflection in action. We decided to search tape logs for scenes that would represent topics we discussed in our classes, that exemplified particular teaching strategies, that demonstrated children's conceptual development, and that illustrated the complexities of classrooms.

   Throughout this process each team member had to negotiate his or her perspectives with other team members. Since each of us came to the project with different experiences and expertise, we needed to share our "cultural knowledge" (Driscoll, 1994) in order to defend our selections. Our reasoning often included what we did in our classes, what we believed about teaching and learning, and what we understood about the science content involved. Through this negotiation of shared meanings we were able to create a richer product. Our collaborative problem solving became a key component in the design process.

3. Examine information relevant to the *design* of the instruction at multiple times from multiple perspectives. Spiro and his colleagues (Spiro, Feltovich, Jacobson & Coulson, 1991) state that "revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition" (p. 28). We contend that it is also important for the instructional design team to continually revisit the same data or ideas at different times, in rearranged contexts, and for different purposes in order to create rich environments for learning complex skills.

   As we identified segments from our videotaped footage, we noted how they could be used to illustrate multiple ideas in the university classroom. We found that we needed to revisit our footage several times. After our initial selection, we created a rough edit of our footage that was approximately twice as long as our finished product. We reviewed this tape extensively to determine whether the continuity of the lesson was maintained and to identify segments that could be shortened or eliminated. A second rough edit was necessary before we made our final edit decisions. We found that we often had to add sections to maintain the continuity of the lesson. Using our second rough edit, we began to match the teachers' reflective segments to the classroom footage. As the tape was reviewed by potential users of the product (university elementary science methods instructors) and the instructional designer, each individual examined it from his or her perspective as influenced by our previous discussions. As we revisited this data at different times, in various contexts, and with different purposes in mind, we maintained the richness inherent in the original event, yet shortened it to a manageable time frame for classroom use.

4. Nurture reflexivity in the design process. When reviewing instructional materials, instructional designers and subject matter experts typically focus on different facets of the instruction (Saroyan, 1993). Reflexivity is critical to understanding multiple perspectives and to articulating and defending individual beliefs. As we engaged in the social negotiations necessary to finalize our edit list, we were forced to clearly articulate our reasoning and to become aware of other positions. We had to explain not only which segments to keep or cut, but why. Each of us viewed the footage from our individual perspectives, influenced by our past experiences and beliefs. Each of us had a valid perspective on the information needed on the disc. It was critical for each of us to be aware of the reasoning behind our perceptions in order to clearly negotiate the selection of the final videotape segments.

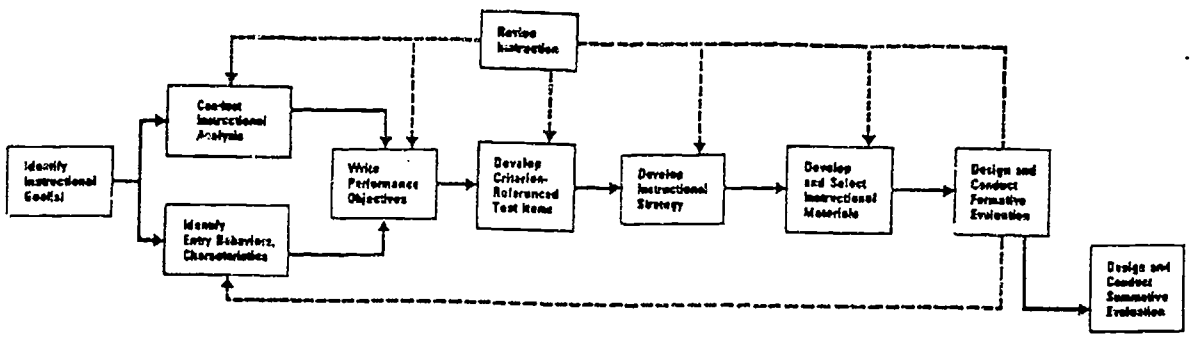
5. Emphasize *client centered* design. Most designers can recall situations where the client approved an initial product design, but when the final product was delivered, felt that it wasn't quite what they had in mind. Many clients are a little unsure exactly what they want initially; unlike experienced designers, they are unable to envision the finished product until they see it. With client-centered design, clients are defined as representative of those who will ultimately use the materials for instruction, rather than those who fund the project. These clients, in collaboration with the instructional designer, must be actively involved in determining what their needs are and how those needs can best be satisfied. As we designed our materials, those who would eventually use the materials for instruction were actively involved in all phases of the design process. At each stage in the process, they had an active voice in determining their information needs and how those needs could

best be satisfied. Using this approach, the clients were able to refine their needs as the project evolved, to clarify needs as additional data became available, and to constantly be involved in decisions at each stage in the design negotiation process.

Analysis of the Process

Although we did not follow a traditional model of instructional design, in retrospect, we believe that our design process was indeed systematic. Unlike the process outlined in traditional instructional design models (e. g. Dick and Carey, 1990; see Figure 1), we did not proceed through discrete stages of analysis, design, development, and evaluation. Consequently, the output of one stage in the model did not provide the input for the next stage. However, the majority of issues addressed by traditional models of instructional design were addressed as the design and development of the case-based interactive video materials evolved through the construction of shared meanings. As in Tessmer and Wedman's (1990) "Layers of Necessity Model" of instructional design, the design of our materials evolved in a spiral, layered fashion. But whereas Tessmer and Wedman's model suggests that designers select a layer of precision based on the time and resources available to the designer, in our "Layers of Negotiations model", we suggest that designers proceed to deeper levels in the process when additional data becomes available or relevant to the discussions. When designers embrace the complexity of the design process and emphasize client-centered design, social negotiations become an integral part of the design process. As designers and clients negotiate shared perspectives, both parties are required to become reflexive and articulate their thought processes. Through this process, ideas and data are examined from multiple perspectives.

Figure 1
Systems Approach Model for Designing Instruction
(Dick and Carey, 1990)



THE DICK AND CAREY SYSTEMS APPROACH MODEL FOR DESIGNING INSTRUCTION

Our "Layers of Negotiation" process is characterized by a number of distinctions when compared to traditional instructional design models:

Question driven rather than task driven. Rowland (1992) suggests that instructional designers should focus on asking good questions, rather than simply following the "steps" prescribed by traditional instructional design models. Using the Dick and Carey (1990) model as an example, we found that although we did not proceed through the steps in a linear fashion, we addressed most of the questions posed by the model (see Figure 2). However, the answers to many of the "questions" posed by the Dick and Carey model of instructional design were very different from those suggested by Dick and Carey (1990). In addition, as the design and development of the case-based interactive video materials evolved through a process of reflection and social negotiations of shared meanings, we never performed a formal instructional analysis or developed learning objectives. Instead, we performed a content analysis of our videotape footage to identify patterns of events and clustered them for access by the learners. Consistent with Jonassen's (1991) recommendations, our analysis focused on considering various interpretations of the content and providing the "intellectual tools that are necessary for helping learners construct knowledge" (p. 12).

Figure 2

Sample Questions Based on the Stages in the
The Systematic Design of Instruction
(Dick and Carey, 1990)

Identify Instructional Goals

What should be included in the curriculum?
Is time and money available for development of the materials?
How should the needs be assessed?
Who are the learners?
What is the goal of the learners?
Can the learners achieve the goal?
Does the need of the stakeholders match with the goal of instructional materials?
Are there sufficient people to complete this material?
Is there sufficient time to complete this job?
Are these goals acceptable to those who must approve this instructional development effort?
Will the development of this instruction solve the problem which led to the need for it?
What is the content to be taught?
Is content stable enough to warrant the cost of development?
Are the learners available?
Is the designer experienced in content or instructional design?

Identify Entry Behaviors and Characteristics

What are the critical entry skills required of students before the instruction?
What is the learner's general ability level?
What is the learner's previous experiences?
What is the learner's expectations about instruction?
How will the learner's characteristics impact the design of instruction?

Conduct Instructional Analysis

What are the goals of instruction?
What will be taught?
What is the learning domain of the target skill?
What would a learner be doing when performing the goal?
What are the subordinate skills to reach the goal?
What is the relationship between these skills?
What skills can be omitted from the instruction?
What is it that the students must already know how to do, the absence of which would make it impossible to learner this subordinate skills?

Write Performance Objectives

What is it that the learner should be able to do at the end of the instruction?
Under what conditions should the learner perform the target tasks?
What are the skills the learner has to perform?
What criteria will be used to assess the performance of the learner?
What is expected of the learners?
What are the objectives for the entry behaviors?

Develop Criterion-Referenced Test Items

How will learning be assessed?
What will be tested?
When will be evaluated?

How often the learners be evaluated?
What is the criterion level to be considered as mastery?
What kind of feedback will be used?
Do the test items match with objectives?
By what methods will the learning be assessed? e.g. paper-pencil, observations, etc.
Do the test items match the behavior and the conditions specified in the objectives?
Do the test items provide students with the opportunity to meet the criteria needed to demonstrate mastery of objectives?
How many test items should be used?
What is the weaknesses/benefits of selected type of tests?
How long will the assessment require?
How much time is required for students to complete the test?
What will the testing environment be like?
What is the probability of guessing the answers?
Did the assessment undergo formative evaluation?
Who would administer the assessment to students?

Develop Instructional Strategy

How will the information be chunked (clustered)?
How will the information be sequenced?
What pre-instructional strategies will be used?
How will learners become motivated?
How will they become aware of the necessary prerequisite skills?
How will they be informed of the objectives?
How will the information be presented?
What information be presented?
How will examples be used?
How will the learners participate in instruction?
How will feedback be provided to the learners?
When will learning be assessed?
How long would it take the learners to learn the skills?

Develop and Select Instructional Materials

What are the instructional strategies to be used?
Should the materials be for individualized or group instruction?
Are there existing materials that can be used?
What is the intended delivery mode for the instruction?
Which media will be used?
How and when will the assessments be administered?
What should be included in the instructors manual?
What is the role of instructor?
How should the instructor use the materials?
What is included in the student materials?
How should the students use the materials?

Develop and Conduct Formative Evaluation

Does the content expert believe the content of the materials is accurate?
Does the content expert believe the content of the material is current?
Does the learning specialist believe the target population will have potential problems with the materials?
How does the learning specialist think the prospective learners will react to the materials?
What do the target learners say about the material?
What is the most obvious errors in the instruction when used by the target learners?
What is the initial reactions of the target learners to the content?
Can learners use the materials without interaction with the instructor?

Are the changes effective?
Are there additional errors or problems with the materials?
Do the target learners believe the instruction is interesting?
Do the target learners understand what they are supposed to learn?
Do the target learners believe the materials are directly related to the stated objectives?
Do the target learners believe there are sufficient practice exercises included?
Do the target learners believe the practice exercises are appropriate?
Do the target learners believe the tests really measure their performance on the objectives?
Do the target learners believe they receive sufficient feedback on their practice exercises?
Do the target learners believe they receive sufficient feedback on their test results?
Do the target learners believe the enrichment or remedial materials were satisfactory?
Can the materials be used effectively in the intended instructional settings?
Who will conduct the formative evaluation?
What instruments will be used?
What kind of data will be collected?
Are the materials designed efficient and effective?
What problems do the materials have when actually used?
What is the time needed to complete various components of the instruction?

Process-based versus procedure-based design. Whereas traditional instructional design models prescribe a set of procedures to be followed to design instruction, we found our emphasis shifted to the process of decision-making that is involved in designing instruction. With a client-centered design process that emphasized reflexivity, the act of decision-making became an important aspect of the knowledge building which contributed to the design and development of the materials. Just as learners come to an instructional experience with understandings, beliefs ,and values that have been shaped by their prior experiences, members of the instructional design team also begin the process of designing instruction with their individual sets of understandings, values, and beliefs. The process of designing instruction included negotiating a set of shared beliefs that guided the development of the materials. Initial discussions focused on creating a shared philosophy of learning, identifying the type of knowledge change desired, and determining ways to assess the learners' knowledge development. Examining instructional decisions from the multiple perspectives and "cultural knowledge" of the individuals in the design team enhanced the possibilities that emerged from the design process.

Spiral cycles rather than discrete stages. Whereas traditional instructional design models (e.g. Dick and Carey, 1990) include discrete stages for analysis, design, development, and evaluation activities, we addressed the questions of design in a spiral fashion, progressing through a series of steps at one level, then spiraling back and adding more detail within. We initially made decisions across stages based on the data we had available, then as more information became apparent or relevant, we spiraled back and added more detail across stages. In our model, as is Tessmer and Wedman's (1990) Layers of Necessity Model, "each layer is a merged set of tasks or questions that cut across the discrete stages of traditional models. Layers are not distinguished by the type of task *per se*, but by the level of complexity associated with the tasks in that layer." (p. 81). As we revisited the same material, at different times, for different purposes, we built on ideas generated at previous levels in iterative, knowledge building cycles (Rowland, 1992).

> While [traditional] models may have iterative features that allow for a reconsideration of earlier design activity outputs, they emphasize closure of each component in the process to serve as input to the next component. A layered approach assumes that components of the ID process will be repeated to a greater degree of precision and sophistication in subsequent layers of the process. This repetition is not for the purpose of revision earlier components ... but of adding onto the work that was done earlier. (Tessmer & Wedman, 1990, p. 80)

Conclusion

We apprcached the design process with the belief that believe that instructional design requires us to make decisions based on our assumptions about "how people think and learn rather than mechanically to apply procedures laid out in an instructional design model" (Winn, 1991, p. 38). A set of assumptions about the nature of the learner and the process of learning led to implications for the instructional design process. As we transformed recommendations for constructivist learning environments to the process of designing materials from a constructivist perspective, we attempted to embrace the complexity of the design process, recognizing social negotiations as an integral part of designing the materials. Furthermore, we emphasized client-centered design, examining the instructional content from multiple perspectives and

nurturing reflexivity in the design process. As we analyzed our design process, we found that it differed from traditional models of instructional design in three primary ways. 1) We did not proceed through the steps prescribed by traditional instructional design models (e.g. Dick and Carey, 1990) in a linear fashion; however, we addressed most of the questions posed by the model. 2) We found our emphasis shifted from the procedures of instructional design to the process involved in making the decisions that guided the development process. 3) Rather than following a step-by step progression in our decision making, we addressed the questions of design in a spiral fashion, progressing through a series of steps at one level, then spiraling back and adding more detail within. Just as constructivist teachers believe that "knowledge is constructed by learners as they attempt to make sense of their experiences" (Driscoll, 1994, p. 360), these materials were constructed by the designers as they attempted to make sense of the information available: Initially, knowledge of the learners' characteristics, needs that existed in science methods instruction, the purpose of the instruction, and the environment in which the materials would be used, and later, the videotaped footage available.

The intent of this discussion was not to prescribe a set series of events that should occur in designing materials for use in a constructivist learning environment. Rather, we wanted to share our process in order to provide one experience that conveys the way the concept of "design" fits into developing such materials, to illustrate that decisions are not random, but proceed intentionally and purposefully, continually adding detail to prior layers. We also suggest that individuals trained in traditional instructional design methodologies can work in concert with constructivists to create materials in a purposeful manner. When designing materials to be used in constructivist learning environments, instructional designers should be guided by, but not limited by, the decisions required by traditional instructional design models. With a knowledge of the questions inherent in each stage of traditional instructional design models, designers can examine the data that evolve through the construction of instructional materials, and make decisions in collaboration with the client based on shared assumptions about the content and teaching/learning process. We hope this discussion of our experiences will inform instructional designers trained in traditional instructional design models of ways to adapt their training to the altered requirements of designing instruction in a manner consistent with constructivist theory.

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