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Cognitive Flexibility Theory: Implications for Teaching and Teacher Education

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Traditionally, instructors present information using a linear model. For example, a video may be shown from beginning to end or a text book will be covered from chapter one to the next. One theory that can guide the design of instruction, cognitive flexibility theory, suggests that this is not a problem when the information being presented is well-structured and simple. Often, however, as the difficulty of the material increases so does the ill-structuredness. When the knowledge domain to be taught is complex and ill-structured data, the use of traditional linear instruction may be ineffective (Spiro, Feltovich, Jacobson, & Coulson, 1992; Spiro & Jehng, 1990). Straightforward, linear instruction in the form of tutorials, lectures, and many other formats will, according to cognitive flexibility theory, fail to accomplish important educational objectives in part because of oversimplification of the material presented. This oversimplification results in the inability to transfer knowledge across to new and varied domains (Spiro, et al., 1992).

A critical goal of many education programs, especially in professional education, is to help the students transfer what they have learned to different, even unique, situations. This ability is often referred to as "cognitive flexibility." "[T]his includes the ability to represent knowledge from different conceptual and case perspectives and then, when the knowledge must later be used, the ability to construct from those different conceptual and case representations a knowledge ensemble tailored to the needs of the understanding or problem-solving situation at hand" (Spiro, et al., 1992, p. 58). According to cognitive flexibility theory, the way students are taught is a significant influence on the type of cognitive structures they create and the way they store and structure knowledge they acquire determines to a great extent how flexible they will be when they must use that knowledge. Encouraging cognitive flexibility requires a flexible teaching environment. Information must be presented in a variety of ways, as well as for a variety of different purposes. Flexible instructional methods help students learn the contours and complexity of the material they are studying, and it helps them work with that content from several different perspectives (Spiro, et al., 1992).

The computer, with appropriate supporting material, is well-suited to flexible instruction. It can provide the varianbility needed to present ill-structured knowledge domains and to help students explore more than one perspective on a topic or issue. For example, hypertext systems provide a nonlinear, multi-dimensional medium in which to present complex subject matter that traditional systems (textbooks, lectures, etc.) lack. It is important, however, to keep in mind that traditional instruction may be very successful in teaching well-structured, simple subject matter. When the information is not simple and well structured, the power of the computer and the format of hypertext support a more flexible approach to instruction that some have called random access instruction (Spiro, et al., 1992). This allows the learner to access information as needed in any order pertinent to the his or her needs.

> In summary: Ill-structured aspects of knowledge pose problems for advanced knowledge acquisition that are remedied by the principles of Cognitive Flexibility Theory. This cognitive theory of learning is systematically applied to an instructional theory, Random Access Instruction, which in turn guides the design of nonlinear computer learning environments we refer to as Cognitive Flexibility Hypertexts. (Spiro, et al., 1992, p. 59).

Basic Assumptions of Constructivism

According to one critic who supports a more behavioral approach to instruction (Merrill,1991), constructivists subscribe to the following six basic assumptions.

1. *Learning is constructed*. People learn from experience. It is a process in which one builds an "...internal representation of the world" (p. 46).
2. *Interpretation is personal*. Reality is not shared. What a person learns is based on his or her personal interpretation of his or her experiences. [Note: many constructivists would agree that each of us builds our own interpretation of the world, but they would not necessarily agree that each of us lives in our own, separate reality.]
3. *Learning is active*. The learner takes an active role in developing knowledge through experience.
4. *Learning is collaborative*. Conceptual growth comes from interacting with others and sharing multiple perspectives. Through sharing perspectives, people change their "internal representations" (p. 46).
5. *Learning is situated*. Learning should be placed in real world situations. Settings should be realistic. [Note: many constructivists believe learning should occur in situations meaningful to students and relevant to the context in which the new information will be used. That can often be accomplished in settings other than "real world" contexts.] Anchored and situated learning strategies are preferred.
6. *Testing is integrated*. Testing should not be a separate activity. It should be integrated with the learning experience.

Cognitive Flexibility Theory

Spiro, et al. (1992) offer a constructivist theory of learning and instruction that emphasizes the need to treat complex, ill-structured knowledge domains differently from simple, well-structured domains. Examples of ill-structured domains such as history, medicine, law, literary interpretation, and teacher education are prime targets for flexible instruction, in part because learners must apply what they have learned to novel and unique situations. According to Dick (1991), "Spiro points out that the approaches used to teach novices are counter-effective when developing higher level transfer skills" (p. 42). When people first learn, they discriminate and categorize the knowledge into a selected slot. As one learns more advanced principles and problem solving, generalization to other knowledge domains must occur, rather than simply categorizing the information. "Spiro's approach to instruction focuses on multiple presentations of information. Content must be covered a number of times with different purposes; therefore there are many concrete examples of the uses of a concept" (Dick, 1991, p. 43).

For those knowledge domains that are well structured, behaviorist methods of teaching work well. In other words, well structured information can be taught in a traditional linear fashion. When a subject is ill-structured and complex, Cognitive Flexibility Theory is most effective" (Dick, 1991).

When the approaches recommended by Cognitive Flexibility Theory are used, the learner develops the ability to transfer the information from one situation to another. One way transfer is facilitated is the use of multiple contexts or perspectives the student can use to explore the subject.

From case to case, complex situations are irregular (ill-structured domains). This poses a problem for traditional instructional theories. The cognitive complexity of a subject usually leads to learning failures. These failures are due to the oversimplification of the subject matter and the inability of the student to apply the newly acquired knowledge to various situations (failure to transfer). The remedy for these problems related to complexity and irregularity of content requires the learning of processes that produce greater cognitive flexibility. Cognitive flexibility

> "...includes the ability to represent knowledge from different conceptual and case perspectives and then, when the knowledge must later be used, the ability to construct from those different conceptual and case representations a knowledge ensemble tailored to the needs of the understanding or problem-solving situation at hand" (Spiro, et al., 1991, p. 24).

Hypertext

As noted earlier, one computer-supported approach that supports instruction aimed at cognitive flexibility is hypertext. Hypertext is a term used generically in this paper to refer to nonlinear documents produced most efficiently on a computer. It includes information knowledge bases such as hypermedia and/or hyperdocuments. The basic building blocks of many hypertext documents are nodes and links. Nodes are pieces of information. They may be as small as a picture or as large as an article. Links allow the users to navigate between the associated nodes. The way in which each user chooses to move between the nodes is unique. There are two basic types of links: referential and organizational. Referential links simply direct a user from node to node. "[O]rganizational links communicate the type of relationship that exists between the nodes" (Jonassen, 1991, p. 84). It is quite possible to create hypertext instructional materials that are based on behavioral (linear) instructional models, but Spiro and his colleagues at the University of Illinois have developed a model for Cognitive Flexibility Hypertext (see any of the Spiro references at the end of this article) that applies Cognitive Flexibility Theory to the design of instructional hypertext. This model has considerable promise for teacher education.

Applications Toward Teacher Education

Currently, Cognitive Flexibility Theory is being used in a variety of contexts. Stephens (1995) incorporated the use of Spiro's theory to develop a video-based learning environment for preservice teachers learning about a particular approach to literacy instruction - the reading-writing workshop. First, she videotaped master teachers that use this approach in their classrooms. She recorded the interactions between the teacher and students, as well as, between students. Although the dynamics of the classrooms vary, the teachers all use the reading-writing workshop approach. After the classroom taping and editing was complete, Stephens produced a laserdisc.

There are many advantages to using a laserdisc. It provides the ability to access information randomly. Video clips are a rich source of information that is not provided by printed media. Video shows gestures, environments, sounds, emotional states, etc. It also provides an opportunities to see dynamic interactions between people. This may facilitate a better understanding of the information (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990).

A hypertext document was produced by Stephens to control the laserdisc. As the students click on different nodes, the computer links to various clips on the laserdisc. Teaching with the workshop approach could be explored from several different perspectives: the diverse roles of the teacher, the roles of students, the physical arrangement of the class. Students may watch the video clips several times for different reasons. For example, one clip shows the role of the teachers, while later it reappears to show the environment. It is the same clip, looked at from different perspectives. In this hypertext system, the teachers in training are able to experience real world situations, with all the complexity and diversity included. The film clips were not scripted. While filiming the classes were asked to continue normally. The result of Stephens' work is a Cognitive Flexibility Hypertext.

Cognitive Flexibility Hypertexts (CFH) are compared to "intellectual erector sets." They provide structure in which to create or build. Open-ended exploration is permitted "in the context of some flexible background structures, [and teachers can] aspire to the goals of making knowledge a manipulable, `three-dimensional' entity for the learner, and providing the tools for creating knowledge arrangements for different purposes" (Spiro, Feltovich, Jacobson, & Coulson, 1991, p.

24).

Application in Today's Classroom

It is not necessary to produce such complex instructional designs like CFHs in well-structured knowledge domains (Spiro, et al., 1991). As previously discussed, this type of instructional approach is best utilized for complex ill-structured domains. Content areas such as science and history can benefit from this instructional model. For example, students could be taught by providing them with problems, that require them to look up information and ask questions. As they are busy constructing the solution, the problem is presented by the teacher in several ways. First, the problem is discussed amongst a small group of students and the teacher. The students brainstorm to generate prior knowledge as well as new questions that need to be investigated. Next, the teacher provides the conditions and circumstances of the problem, some of which the students have seen before in a previous case. Although the knowledge domain is familiar, the students must reapply it in each special case. These students must learn to transfer their knowledge from case to case.

If a flexible teaching method is used, then assessment should be complimentary. In classrooms that use cognitive flexibility theory, behavioral and objective testing methods will not adequately assess what the students have learned. More subjective methods should be employed, such as portfolios, projects, and visual essays.

Conclusion

Cognitive Flexibility Theory supports the basic assumptions of constructivism. It promotes authentic, realistic experiences for each individual. It encourages the use of multiple pathways and multiple purposes when approaching problems. The theory presented in this paper has been recently developed. There is a great need to test the application of Cognitive Flexibility Theory in various knowledge domains.

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