Cognitive Flexibility Hypertext: Characteristics and Applications

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Abstract

This paper explores the pedagogical model of cognitive flexibility hypertext (CFH). The model's relationship to various learning theories, its characteristics and instructional applications, and its implications for design are discussed. A brief description of objectivism, pragmatism, and constructivism is followed by a discussion of how the CFH model comes from cognitive flexibility theory (CFT) which falls under the epistemology of constructivism. Characteristics of the model are explained using citations from and references to professional research publications related to CFH. The types of learning for which a CFH learning environment is best suited are discussed as well as implications for the design and application of the model. An instructional example of how a CFH called FLiPs (Flexible Learning in the Periodic System) was used to increase student understanding of relationships between elements is also discussed.

Cognitive Flexibility Hypertext: Characteristics and Applications

Since the dawn of time, mankind has learned. His earliest knowledge likely centered on things necessary for his survival; food, shelter, and other basic needs. For centuries philosophers have considered and theorized about learning, knowledge, and the mind. By the 1800s such study was established as a legitimate pursuit for research (Driscoll, 2005).

Many epistemologies evolved which attempt to explain how learning occurs. Objectivism is the belief that reality, and therefore, knowledge exist outside the learner and that the learner acquires knowledge through his interactions with the world and the consequences those interactions bring. This epistemology serves well the types of learning which are well-structured and which have pre-defined solutions, but does not take into consideration the types of learning which involve ill-structured problems with no pre-defined solutions, which are situated around circumstances or problems, or which make use of reason in conjunction with the information received from the outside world.

These types of learning are better addressed by pragmatism and interpretivism. Pragmatism is the belief that reality cannot be known directly, that knowledge is provisional, and that it can be obtained through empirical or rational processes while interpretivism is the belief that reality is constructed by the learner and that knowledge emerges inside the learner's mind as he negotiates his interactions with the outside world, including his associations with others (Driscoll, 2005).

Many learning theories developed based in these different epistemologies. The theory of constructivism is grounded in interpretivism and is much better able to address the types of learning which involve ill-structured problems with multiple solutions, which are situated around

circumstances or problems, or which make use of reason in conjunction with the information received from the outside world. CFH is an instructional model developed by Rand Spiro and colleagues because they felt much of what learners need to know lies within ill-structured domains and that a new way of thinking about learning was needed (Dabbagh, http://cehdclass.gmu.edu/ndabbagh/Resources/IDKB/theorists.htm#spiro). CFH falls under the constructivist umbrella of learning theories and its primary outcome is "the ability of the learner to take a flexible view of the content domain" (Godshalk, Harvey, & Moller, 2004, p.509).

Characteristics

Cognitive Flexibility theory has to do with how the learner spontaneously changes his knowledge structures in response to the dynamics of the situation, transfers skills and knowledge to new situations, and the construction of the learner's own perspective on the topic at hand after having been exposed to multiple other perspectives. It usually involves the study of different cases which present various perspectives about an authentic and often controversial problem or dilemma.

Rand Spiro and colleagues first articulated cognitive flexibility theory and argued that oversimplified instruction can lead to misunderstandings, especially within complex domains (Jonassen, 2011). They further postulated that while simplification of concepts was necessary to facilitate the novice learner's understanding, there was a danger with using oversimplified prototypical singular analogies as such do not convey the full complexity of the problem the way the use of multiple perspectives would. Jonassen (2011) explained that while novice learners need to have concepts simplified to some degree, they need not be shielded from inconsistencies and complexities as they attempt to solve more ill-structured problems. In fact, they need to recognize inconsistencies in knowledge by applying it in other contexts and viewing from other

perspectives (Jonassen, 2011). Godshalk, et al. go on to explain that "The goal [of cognitive flexibility] is to make participants more aware and more sensitive, which means they may need to be exposed to information contradictory to their beliefs". Further, Chinn and Brewer explained that when the learner is confronted with information that contradicts his current beliefs, he must do one of four things: reject it, reinterpret it to make it fit with his own beliefs, partially change his beliefs to accommodate the new information, or completely restructure his current beliefs around the new information (Chinn and Brewer, 1993).

CFT, therefore, makes use of case-based examples to present the multiple perspectives needed for the learner to construct his own knowledge and perspective on the content. In contrast to the use of simplistic scenarios, CFT does not seek to minimize the ill-structuredness of the problem or dilemma, but conveys it in all its situational complexity to the learner for his own consideration. "Rather than abstracting ideas and theories from cases (problems), the contextual richness that defines cases needs to be conveyed to learners" (Jonassen, 2011, p. 211).

When this is done, another characteristic of cognitive flexibility theory emerges: that of common themes among the cases presented which supports learner transfer of knowledge and skills to new situations. "CFT conveys this complexity by presenting multiple representations of the same information and different thematic perspectives on the information. In order to construct useful knowledge structures, learners need to compare and contrast the similarities and differences between cases." (Jonassen, 2011, p.212) In other words, as the learner examines different cases and multiple perspectives, he can often see common themes emerging between them and as he considers these themes, he can more easily recognize or transfer them to a new learning situation.

Two additional characteristics of CFT are random access and learner-controlled access. In contrast to traditional objective approaches to instruction, CFT does not follow the teacher-to-learner conveyance of information. Rather, the learner chooses which cases or perspectives to study, to what depth, and in what order. This is what makes hypertext (non-sequential, dynamic text which can be accessed at random) such an effective medium for implementation of CFT (Jonassen, 2011). "In traditional text, the readers or learners are expected to follow the author's organization and sequence of text, which reflects the author's knowledge structure. Hypertext, on the other hand, allows the user immediate access to related text at the moment of need" (Jonassen, 2011, p.212). Further, Su and Klein (2006) explain how learners are offered more control through the use of hypertext because it provides them the means to make choices about how their path through the content will proceed. This results in unique paths for every learner as they each bring their own prior knowledge and experience to their moment of interaction with the text. This prior knowledge and experience then influence the choices they make with how to proceed through the text (Su & Klein, 2006). This self-direction facilitates the learner's exploration of new ideas and allows the learner to proceed at his own pace, taking time to consider various perspectives, adding to his current knowledge base in meaningful ways, and possibly making changes to his own beliefs in the process.

The use of hypertext, however, does present a number of challenges. Conklin (1987) discussed the disorientation the learner may experience in trying to navigate in a CFH environment (Conklin, 1987). He may feel lost about where to go next or how to get to where he desires to go. Additionally, Su and Klein explain that the learner control afforded by a CFH environment can actually increase the learner's cognitive load because of the attention they have to give to the

navigational decisions they make. Such split attention can then result in a decrease in the learner's resources which can be devoted to understanding the content (Su and Klein, 2006).

Finally, the learner's degree of confidence with using a computer can significantly influence the degree of learning he experiences when using a web-based CFH. Learners with a low confidence level and less experience with using a computer tended to learn less when using a CFH than did those with a high confidence level and greater experience (Brinkerhoff, Klein, and Koroghlanian, 2001). These challenges are things an instructional designer would need to keep in mind when creating a CFH so as to minimize their effects for the learner.

Applications

A comparative analysis by Dabbagh and Dass in 2012 found that the cases used in the CFH instructional model tended be dilemma type problems. Citing Jonassen (2011), Dabbagh and Dass explain that "Dilemmas, which often appear as decision making problems, are the most ill-structured and unpredictable types of problems, because there is no solution that will be acceptable to a significant portion of the population affected by the problem" (Dabbagh & Dass, 2012, p. 172). Topics which may be appropriately addressed by a CFH include such social and political issues as abortion, civil rights, gun control, foreign policy, and educational issues such as social promotion, year-round schooling, and home schooling. Generally speaking, a CFH could be used to explore any topic for which there are multiple perspectives or representations. Examples of manual hypertext systems could include index cards used for research or reference books such as dictionaries and encyclopedias (Conklin, 1987). More modern examples of hypertext systems can be found on the World Wide Web which offers many sites that present multiple perspectives of complex issues with links to more information. Examples of websites

that contain many of the aforementioned characteristics of a CFH include http://www.successful-homeschooling.com/, http://www.clean-energy-ideas.com/solar/solar-energy/pros-and-cons-of-solar-energy , and http://www.buzzle.com/articles/pros-and-cons-of-gun-control.html.

When creating a CFH, an instructional designer will need to determine if the chosen topic is best addressed using this model and, if so, look for cases and/or examples which convey the multiple perspectives on the topic. The designer will also need to consider the navigational tools that will best facilitate the learner's use of the site as well as the site's function and appearance. Su and Klein (2006) state that, "Navigation tools, such as indexes, content lists, and concept maps, usually externalize part of or all of the hypertext structure and present it to the learner to show them an overview of the structure" (Su & Klein, 2006, p. 88). Additional studies by Dee-Lucas and Larkin (1995) found that such tools improved the navigational ease, memory of the content, amount of time spent at the site, and the attitude of the learner about the subject matter at hand (Dee-Lucas & Larkin, 1995).

Boechler and Dawson (2002) studied different types of support tools such as guided tours, outlines, and hierarchies and their effects on learner navigation. They found that the type of information in the support tool is closely related to the user's navigational patterns (Boechler & Dawson, 2002). In 2009, Antonenko and Niederhaurser found that "One mechanism that may reduce split attention and help learners develop better situation models from hypertext is a *lead*" (Antonenko & Niederhaurser, 2009, p. 142). They suggested that a lead may function much like an advance organizer, serving to prepare the learner for the forthcoming information. One example of such a lead might be a mouse-over-balloon feature which allows the learner to preview forthcoming content without actually leaving the current page. In short, the appearance and functionality of a web-based CFH needs to employ the features necessary to best support the

learner's navigation of the site thus lessening his frustration and increasing the amount of attention he can pay to learning about the subject matter at hand.

Many tools exist for creating web-based CFHs. HTML, DHTML, VRML, and Java Script are examples of scripting languages designers can use to create web-based hypertext links. Authoring tools such as Toolbook, Hypercard and Supercard, Macromedia Director, Authorware Professional also facilitate a designer's efforts to create an effective web-based CFH (Dabbagh, http://mason.gmu.edu/~ndabbagh/wblg/wblframework.html).

Instructional Example

Punya Mishra and Aman Yadav published a study in 2006 which they had conducted about the use of a CFH environment to foster chemistry students' understanding of the periodic table of elements. In their study they used FLiPS, a web-based hypertext based in the theory of cognitive flexibility. They described FLiPS as "a prototype multi-media, multiple representational hypertext for learning complex (and often hard to learn) concepts in chemistry" (Mishra & Yadav, 2006, p.37) They had observed that while expert chemists' concepts of the periodic table could be described as an abstract, relationship based, multidimensional conceptual framework, students' understandings about the periodic table were based in algorithmic rules and equations they could correctly apply even though they lacked an understanding of the relationships between the elements in the table. They wanted to see if a CFH environment could enhance student understandings and help them create their own conceptual framework like those of the expert chemists. The participants were four university students, three undergraduate and one graduate, all with at least two years of university coursework in chemistry.

The results of their study showed that a learner's interaction with FLiPS, a CFH environment which exposed learners to multiple representations of the periodic table, was intimately connected with and influenced by their own beliefs, motivations, and prior knowledge as each participant had different experiences with FLiPs. Some took a systematic and methodical approach to their navigation of the tool while others took a more random one. While all participants' scores increased significantly from the pre-test to the post-test and all reported having gained a greater understanding of the relationships between the elements in the periodic table, some reported getting lost among the different representations of the table they were exploring or feeling frustrated that the correct answer to the problem they were trying to solve was not given. "The findings of this study indicate that even the most thoughtful or theory based design of educational hypertext can be rendered relatively ineffective by the kinds of decisions users make and what they bring to the interaction" (Mishra & Yadav, 2006, p. 65). Their work served to further highlight how both the complexity and the variability of the learner can significantly impact the effectiveness of a CFH learning environment.

Conclusion

Cognitive Flexibility Hypertext is a powerful constructivist instructional tool, but one that is best used for concepts with multiple perspectives including dilemmas about which the learner is seeking additional information to confirm, add to, or change his current beliefs. Web-based CFHs have the ability to afford learners with at least some level of confidence and experience with computer usage the opportunity to explore an endless variety of topics at their own speed and in their own way. When creating a CFH, designers must take care to employ the navigational tools that would best facilitate and not detract from the learner's exploration of the topic.

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