Cognitive Load Theory

Applied to Distance Education

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Abstract

With the rise of distance education, instructional design practices are constantly tested. Cognitive load theory seeks to define human processing and present solutions to information overload. Educators are still researching the best instructional design practices for distance education. The various media tools in distance education create some solutions for cognitive overload. Researchers are still determining what tools in distance education are most effective for reducing cognitive load.

Keywords: Cognitive load theory, Distance education, Instructional design, Information organization

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Distance education is increasingly in demand today. While many students still prefer the traditional classroom experience, others are in need of the flexibility of a distance course, and therefore choose to learn online. Research has shown that instruction delivered at a distance is just as effective as classroom learning (Simonson, Smaldino, Albright, & Zvacek, 2012). However, just as traditional education keeps changing and progressing, distance education is perpetually changing. In addition, the challenges faced in traditional education are also relevant to distance education, but distance education presents its own set of issues as well.

This research paper examines one significant element of distance education known as Cognitive Load Theory (CLT). CLT will be defined and discussed in relation to distance education. Two specific questions will be explored: "How can various media tools assist with cognitive load?" and "What does a reasonable cognitive load look like to promote the best learning possible?"

Cognitive Load Theory

CLT is "…an instructional design theory based on our knowledge of human cognitive architecture" (Sweller, 2008, pp. 370). Human cognitive architecture refers to how human cognitive processes are organized (Sweller, 2008). Instruction must take into account how the human thinks and learns in order to be effective.

Human Cognitive Architecture

Human cognitive architecture contains two major components known as long-term memory and working memory (Kalyuga, 2012). Long-term memory refers to organized

information already stored in the human brain, while working memory could be described as a conscious information processor (Kalyuga, 2012, pp. 183). When the brain is dealing with new information for which is has no prior knowledge, working memory is used to process this information. However, the capacity of working memory is extremely limited when compared to long-term memory (Sweller, 2008).

Schema Theory

Schema theory states that knowledge is organized into units (Spector et al., 2014). Information is stored inside of these units of knowledge. Knowledge from long-term memory links to new information in working memory (Sweller, 2008). The pattern of stored information is called *schemes.* Schemes are used to help us find out about and act in the world (Slavin, 2012, pp. 31). For example, someone who has seen a dog knows it has four legs, ears, fur, a tail, etc. This information is organized into a unit, allowing one to recognize a dog whenever they see one, rather than needing to figure out what kind of animal they are seeing all over again.

Intrinsic, Extraneous, and Germane Cognitive Load

According to the CLT, two types of memory loads affect working memory. These are known as intrinsic and extraneous cognitive loads. (Misook & Chow, 2005). Intrinsic cognitive load is based on the difficulty and nature of the learning task (Misook, et al., 2005 & Spector, Merrill, Elen, & Bishop, 2014). The intrinsic cognitive load cannot be adjusted by the instructor because it pertains to the learner's prior knowledge.

The extraneous cognitive load refers to non-essential information, or instructional design. The extraneous cognitive load can be reduced if instruction is arranged to eliminate unneeded information (Misook et al., 2005 & Spector et al., 2014). Various elements in

instruction create an extraneous cognitive load for the learner. These include split attention (information presented non-concurrently), redundancy, transiency (information that is not given adequate time to process), advanced prior knowledge, or inadequate prior knowledge (Kalyuga, 2012).

Cognitive load theorists suggest that when the intrinsic load is high, the extraneous load should be lowered. Likewise, if poor instruction design demands a higher extraneous load, the intrinsic load may be lower; the cognitive load could still be within working memory capacity (Van Merriënboer& Ayres, 2005). Although poor instruction is not the desired outcome, it is best to stay within working memory limits to avoid cognitive overload.

Germane cognitive load is different from intrinsic and extraneous cognitive load, because it is separate from the instructional material and is only concerned with the learner. Germane cognitive load refers to the working memory resources that the learner uses to deal with the intrinsic cognitive load (Sweller, 2012). In a way, the germane cognitive load is the "processor" or "constructor" of the information. CLT seeks to increase the germane cognitive load and decrease the extraneous cognitive load in the learner (Veletsianos et al., 2014).

Information Processing Theory

The information processing theory draws a parallel between the human mind and a computer (Spector et al., 2014). This theory reinforces cognitive load theory for educators. Information should be grouped into meaningful parts so the learner can process it effectively (Spector et al., 2014). Rehearsal of information in short-term memory helps the learner store the information in long-term memory for later us. Finally, learners should be

given the opportunity to actively retrieve the information from long-term memory when needed (Spector et al., 2014, pp. 25).

Cognitive Load Theory and the Distance Learner

CLT can be effective in both traditional and distance education. Distance learning is convenient and necessary for many students. One of the primary forms of distance education today is online learning. While the available tools for learning are always changing, educators must be careful to keep class structure organized. Content should be focused and extra information kept to a minimum (Simonson et al., 2012).

Planning a Distance Course

One of the most important aspects of a successful course is one that is well planned. A good online course will most likely take months of planning (Simonson et al., 2012). Research has shown that when "…instruction is designed within a system, learning occurs" (Simonson, et al., 2012, pp. 152). This process of designing instruction can also be termed "intentionality." This means planning for the students' outcome (Slavin, 2012). In most cases, maximum learning will not happen by chance (Slavin, 2012).

Some elements to consider when designing a course include the students, the content, the method, and the environment (i.e. technology) (Simonson et al., 2012). An instructor should ask questions such as "Who am I teaching?" "What media will be used in this course to enhance instruction?" "What content is essential to learning?" and finally, "What outcomes do I expect from the learner?"

In some ways, planning an online course presents more challenges than a traditional one. The instructor is not physically present to teach in most cases, so the task of learning falls primarily on the student. Many distance learners are self-starters and can handle a

reasonable cognitive load (Darabi & Jin, 2013). However, educators should endeavor to find out more about their students so they can create the most efficient learning environment possible (Simonson et al., 2012).

Students and student interactivity.

One of the biggest challenges educators face is matching content to the learner's needs (Simonson et al., 2012). A student-centered approach to learning seeks to adapt the content to the student in such a way that they will genuinely learn the material. This may mean the course gradually changes based on the learner's response. Yet the content of the course should not be compromised, only adjusted to better suit the learner.

Distance educators are challenged to promote student interactivity when their students may never meet face to face. Traditional courses usually promote interactivity through group projects or class discussions. Distance learners can also interact in this way, although certain media tools are necessary to make this possible. One well-known method of promoting student interactivity is a *discussion board forum*. This tool can be used to introduce topics for students to research and discuss. Discussion boards can be a good way of reducing cognitive load if designed properly. For instance, the postings can be limited to two or three to help the learner focus on a specific topic without becoming overwhelmed. Also, the topics can build on one another, leading up to quizzes, tests and papers. In this way, much of the research needed for final projects has already been completed throughout the course (Darabi et al., 2013).

Organizing essential content and information.

The content of a course should "…reflect where the content relates to the rest of the curriculum" (Simonson et al., 2012, pp. 157). The content should be sufficient to

produce the desired learning outcome. Instructional goals can help an instructor achieve this. In fact, good instructional goals should be the basis of instruction (Simonson et al., 2012). Within these goals, the content should be clearly defined and reinforced through various assignments and research requirements (Simonson et al., 2012).

Organization of information is critical to reduce the learner's working memory load (Sweller, 2008). An instructor is responsible for maximizing students' learning abilities. This can be achieved through building on previous assignments, as mentioned earlier, moderate repetition, reducing distractions and communicating assignment parameters clearly.

Learning methods.

There are now quite a number of methods proven to reduce cognitive load and assist with learning. Everyone possesses their own learning style. Therefore not every method will guarantee the same results. Worked examples are one way to reduce cognitive load by providing the learner with a problem that has already been solved. The learner is able to train their mind to accept the schematic of the current problem, so when they see it in the future, they are able to use less cognitive energy because the problem is already familiar to them (Sweller, 2008). A worked example for distance learning could be a simulation or tutorial that explains a certain process.

Cognitive tools for distance learning: environment.

According to Ozcelik & Yildirim, (2005), "Cognitive tools can help learners direct attention, isolate information, and tie previous knowledge by appealing to learners' memories and evoking existing schema" (Ozcelik & Yildirim, 2005, pp. 299). They can also make large amounts of information available to the learner almost instantly,

supplementing the limitations of working memory (Ozcelik et al., 2005). In distance education, some cognitive tools that may assist the learner include search engines, web site maps, site history, assignment calendars or schedules, syllabi, and online libraries, to name a few (Simonson et al., 2012; Ozcelik et al., 2005). One other tool was mentioned earlier, the discussion board forum. Also, a good class management system will provide the framework for handing in assignments and posting announcements (Kalyuga, 2012).

Visual support and analogies.

Visual support materials can be used in distance learning as a either cognitive support, or a hindrance, producing a heavier extraneous load. In order to enhance learning and lessen cognitive load, the visual arrangement of material should include the following traits: emphasis (content that is closely related to the center of interest), unity (the visual result displays its purpose), contrast (the object's characteristics stand out), and rhythm (repetition through variety that brings the learner through a visual picture) (Simonson et al., pp. 252). Following basic graphic design principles can make the course not only pleasing to the eye, but also highlight the content in such a way that students absorb more of what they see.

Visual analogies help us understand something new by comparing it to something already familiar (Simonson, et al., 2012). This technique borrows from schema theory, which uses information already stored and compares it to something new, drawing out the similarities. A good analogy can easily enlighten learners to a new subject. In distance education, the right photo or graph can make a huge difference in cognitive load (Simonson et al., 2012).

Interactive Study Guides.

One tool that has proven useful for distance educators is the interactive study guide (ISG). The ISG is a structured note-taking system that guides the learner through a variety of concepts. The guide requires interactive involvement on the part of the learner (Simonson et al., 2012). The ISG helps students through pre-organized material. This is a good worked example method because the structure for the notes has been provided, reducing the student's cognitive load.

The above-mentioned tools are not the only ones available for distance learning, but they represent some of the most proven methods at this time. The time and care put into planning a distance course will foreshadow the learning outcome. With the proper design and structure, extraneous cognitive load can be reduced and learning maximized. Though there is no one proven formula for distance education, there are some that have worked much better than others. The distance educator should spend time discovering what practices work best for an online course.

A Reasonable Cognitive Load

It's difficult to define what an individual learner's cognitive load will be. The processing of working memory is severely limited in comparison with the capacity of long-term memory, however (Spector et al., 2014). Therefore, one of the best ways of determining the cognitive load of the learner is through the quality of their work and good communication. This is not to say every student's quality of work will be there best effort. But when the desired outcome has been set, the instructor should be able to glean some information as to how the student is meeting that outcome (Simonson et al., 2012).

Good communication is essential in education. The mode of communication should be made clear to the student at the beginning of any distance course. The instructor's

availability should be made known as well so the student has enough time to pose questions about assignments (Simonson et al., 2012). Earlier, student interactivity was mentioned as a means of reducing cognitive load. Peer communication is important as well, There are times when students learn something more easily from their peers than if they had simply read about it on their own (Slavin, 2012).

Conclusion

To summarize, CLT is now a prominent component factored into distance education. The human mind is amazing at processing and storing information, and the boundaries of its potential (long-term memory) are still unknown. The goal of education is to make learning permanent and increase the learner's germane cognitive load (Sweller, 2008). Technology has provided many useful tools to make this possible in distance learning. While a reasonable cognitive load may look different depending on the student, the instructor can set goals to make this load possible and maximize learning potential.

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