LIFELONG LEARNING: APPLYING COGNITIVE LOAD THEORY TO ELDER LEARNERS SUFFERING FROM AGE-RELATED COGNITIVE DECLINE

MACKENZIE R. GRAVES

Simon Fraser University

Abstract

The struggles faced by elder learners suffering from age-related cognitive decline are often overlooked by instructional designers. However, existing educational theories that already inform learning strategy development for other populations should also help establish instructional methods used to help elder learners. In this article, cognitive load theory frames an exploration of proposed means to slow or counteract the effects of age-related cognitive decline in elder learners. Attention is given to the ways in which multimedia learning methods adhering to certain principles of cognitive load theory can increase available working memory capacity. Evidence is provided to show that cognitive load theory-based practices can also facilitate one's activation of prior knowledge and betters one's attentional control. Additionally, elder learners benefit from tasks that include worked examples and goal-free problems, whereas conventional, goal-oriented problems impose greater extraneous load on an already taxed working memory. The outcomes of the present analysis can also be applied to stroke victims' rehabilitation plans and may offer implications for individuals suffering from other brain injuries, attention deficit-hyperactivity disorder, or dementia-related illnesses.

Keywords: cognitive decline, elder learners, cognitive load theory, working memory, attention, multimedia, stroke

Lifelong Learning: Applying Cognitive Load Theory to Elder Learners Suffering from Age-Related Cognitive Decline

Elder learners, specifically those experiencing various degrees of age-related cognitive decline, are largely disregarded when the designing of instructional methods takes place. Perhaps these learners are not considered because the elderly make up such a minute subset of the learner population. Nevertheless, their diverse needs should not be ignored, nor should those of other atypical groups such as individuals with autism spectrum disorder or Down syndrome, for example. Age-related cognitive decline, not to be confused with dementia-related diseases such as Alzheimer's, occurs as a result of normal aging and refers to the general dwindling of certain cognitive processes as one grows older (Van Gerven, Paas, Van Merriënboer, & Schmidt, 2002). Typically, this decline impairs one's working memory, executive functioning, processing speed, and ability to ignore extraneous information (Paas, Camp, & Rikers, 2001). Although some degree of cognitive decline is natural and inevitable with age, this shouldn't stop attempts to limit or slow this decline as much as possible. Afterall, while the notion of cognitive decline is unavoidable, the rate at which it occurs is certainly subject to influence. However, in spite of this point, a recent review of the literature revealed a shocking lack of research outlining programs that aim to help elder individuals improve their cognitive abilities, and subsequently their learning. Instead, most programs aim to teach elders strategies to work around the issues that accompany their declining cognitive abilities, or find alternative ways of completing certain cognitive tasks, rather than directly dealing with their declining cognitive capacities. Notably, despite the effects of age-related cognitive decline, elder individuals continue to process information in the same way as younger populations. Therefore, addressing the specific learning needs of elder learners is not a matter of developing new instructional methods to suit the elder population, but rather a matter of applying existing instructional theories to this new group. Following this line of thinking, an existing model that would fit the specific needs of elder learners especially well, yet is quite under-represented in the literature, is cognitive load theory. Because the goal of cognitive load theory is to reduce extraneous load, therefore leaving more room for necessary processing in the working memory, it seems to be an effective means of counteracting the diminished working memory capacity witnessed in typically aging elder individuals. In accordance with this notion, programs that account for the limitations outlined by cognitive load theory should be applied to elder learners in an effort to combat the negative effects that age-related cognitive decline has on the working memory of typically aging elder individuals.

Multimedia instruction that accounts for the knowledge surrounding cognitive load theory would be extremely advantageous for elder learners as it promotes the efficient use of an individual's available cognitive resources. Multimedia learning methods can use a number of tactics that cut down on sources of extraneous load, leaving more working memory available to process germane information. Some of these strategies include: presenting information across multiple modalities simultaneously, as this reduces the odds of overloading a single processing area (Bruning, Schraw, & Norby, 2011; Van Gerven, Paas, & Tabbers, 2006); grouping close together informational sources that refer to one another, therefore eliminating the need for unnecessary visual search (Van Gerven, Paas, & Tabbers, 2006); and omitting all unnecessary information or features, in turn maximizing the cognitive resources available for relevant processing and reducing the effort needed to identify what information is crucial (Van Gerven, Paas, & Tabbers, 2006).

However, despite the substantial evidence speaking to the benefits that multimedia instruction has for working memory (Diamond & Lee, 2011), programs specifically targeting elder audiences are still not being developed (Van Gerven, Paas, & Tabbers, 2006). This fact is troubling, as the elder population is perhaps the one most in need of these working memory improvements. Furthermore, given the fact that programs of this nature lead to improvements in working memory-related tasks, and these improvements are still present up to six months after training (Diamond & Lee, 2011), these approaches should yield significant benefits for elder individuals attempting to hinder the progress of their age-related cognitive decline. Thus, care should be taken to optimize existing multimedia programs that target younger audiences in a way that matches the needs of the elder population. This would not only reduce extraneous cognitive load and encourage better use of available cognitive resources during learning, but also would lead to lasting improvements in working memory.

Because of the way in which cognitive load theory could help elder individuals make more efficient use of their working memory, it would allow them to more effectively access their wealth of prior knowledge and apply it to novel learning situations. It has been well observed that cognitive load theory promotes the application of previously possessed skills and knowledge to new situations due to the ways in which such practices free up space in the working memory (Paas, Camp, & Rikers, 2001). Presumably, since elder learners have had more learning experiences than younger populations, they will possess a much larger pool of prior knowledge from which to draw in their learning. However, elder learners are constrained in the sense that their diminished cognitive load capacity restricts them from accessing their large bank of prior knowledge efficiently. As such, much of the knowledge these individuals have accumulated over the years can unfortunately go to waste. Nevertheless, were cognitive load theory-based programs imposed to free up space in their working memory, an elder learner's wealth of prior knowledge could be better accessed and effectively applied to new learning situations. Accordingly, not only does cognitive load theory limit extraneous load and unnecessary processing, but it also promotes the efficient application of elder individuals' extensive prior knowledge, in turn furthering learning and comprehension.

Programs that conform to cognitive load theory produce increased working memory capacity by reducing extraneous load (Paas, Camp, & Rikers, 2001), which carries with it positive implications regarding one's attention. A concerning relationship between working memory and attention has been observed in studies on children (Diamond & Lee, 2011). Specifically, this relationship shows that poorer working memory is directly associated with decreased attentional control (Diamond & Lee, 2011). Considering this association, as one's working memory decreases with age, their attentional capacities could likely decline in a reciprocal manner. As such, an elder individual's decreased working memory capacity would lead to diminished attentional control, making them more susceptible to distraction while learning. This is particularly problematic in conjunction with elder learners' decreased ability to omit extraneous information (Paas, Camp, & Rikers, 2001), as these unfiltered extraneous details provide a multitude of distractions. These findings further affirm the need for instructional methods based on cognitive load theory for elder learners. Not only would such methods limit the amount of extraneous load elder individual's encounter, but the accompanying increase in working memory capacity would result in greater attentional control, and subsequently more efficient learning due to the decreased likelihood of distraction.

Instructional methods that adhere to the knowledge surrounding cognitive load theory can also be used to help stroke victims recover lost cognitive abilities. Many existing programs focus on the rehabilitation of physical abilities for stroke patients, but far fewer set out with the aim of restoring their cognitive abilities, an especially concerning state of affairs given the fact that 43-78% of non-demented individuals exhibit impairments in executive functioning, attention, and both short- and long-term memory after undergoing a stroke (Rand, Eng, Liu-Ambrose, & Tawashy, 2010). While exercise programs don't appear to lead to improvements in working memory or other cognitive domains, acute stroke patients who engage in simple cognitive tasks, such as counting, while engaged in physical activity show increases in cognitive flexibility (Rand, Eng, Liu-Ambrose, & Tawashy, 2010). This provides evidence that certain cognitive processes of stroke victims, such as executive functioning and working memory, can be subjected to improvements post-stroke if these specific processes are exercised or trained. Because cognitive load theory emphasizes the efficient use of available cognitive capacities, programs based on these principles would be especially beneficial in proficiently exercising and subsequently improving the processes associated with working memory and executive functioning. Cognitive load theory's link to improved working memory (Paas, Camp, & Rikers, 2001) further supports this claim. As such, time should be invested into the development of cognitive load theory-based stroke recovery programs in an effort to exercise working memory and other executive functions, therefore aiding in the reacquisition of stroke victims' cognitive abilities.

Elder individuals should analyze familiar problems rather than a wide array of novel ones, as this would save the cognitive capacities that would typically be absorbed by the understanding and interpretation of a new problem. In turn, these newly uninhibited capacities can be dedicated to gaining a more in-depth understanding of the problem at hand, rather than interpreting the incoming information associated with various novel problems. Worked examples and goal-free problems are both prime examples of this practice (Bruning, Schraw, & Norby, 2011; Paas & Van Merriënboer, 1994). These approaches, which are both centered in cognitive load theory, make more efficient use of available cognitive resources by negating the need to engage in means-end analysis, a process that is extremely taxing for working memory, and as such, imposes a large degree of extraneous cognitive load (Paas, Camp, & Rikers, 2001; Van Gerven, Paas, & Tabbers, 2006). Goal-oriented tasks, which often elicit means-end analyses, force individuals to think about the issue at hand in a backwards fashion in order to outline the steps needed to achieve completion of the problem. This results in extraneous cognitive load and, in fact, provides little insight into the problem at hand (Van Gerven, Paas, & Tabbers, 2006). However, goal-free problems eliminate the need to think of the query in a backward manner because there is no achievable goal for which to create steps. As such, the cognitive resources that would typically be occupied by a means-end analysis are freed up and can be dedicated to the processing of more relevant, germane information. Similar to goal-oriented tasks, when an individual is presented with a wide range of conventional problems, a degree of extraneous cognitive load is imposed on their working memory due to the backwards processing required to understand these novel queries (Van Gerven, Paas, & Tabbers, 2006). To combat this, worked examples provide an individual with a problem that has already been answered in full, as well as the steps taken to achieve completion of the problem. Evidence for the effectiveness of worked examples can be seen in Van Gerven, Paas, Van Merriënboer and Schmidt's (2002) study, where it was observed that elder individuals who were provided with worked examples spent less time studying, while achieving higher transfer performance and still maintaining a lower level of subjective cognitive load than their peers who were provided with conventional problems. Given this information, elders would greatly benefit from analyzing familiar problems, as this would eliminate the extraneous cognitive load that accompanies the necessary interpretation of novel problems. Their cognitive resources could remain relatively untaxed and in turn used more efficiently to develop a deeper understanding of the topic and exercise the skills at hand. Overall, goal-free and worked problems can be beneficial in helping compensate for the working memory limitations that many elder learners experience as a result of age-related cognitive decline.

The research conducted for the present work revealed a surprising lack of programs aiming to improve the declining cognitive processes of typically aging elder adults. Instead, it seems that superficial, surface-level approaches are much more common, whereby individuals are given strategies to work around their declining cognitive processes, rather than attempting to improve them directly. Perhaps avoiding direct approaches to reducing their declining ability requires less effort than consistently engage in the challenging stimulation necessary to improve certain cognitive processes. It's also possible that more superficial programs are more efficient, and as such, might seem sensible to use with elder individuals who are nearing the end of their life. Nevertheless, because of the ways in which programs that account for cognitive load theory lead to improvements in working memory and attentional control, they should be employed whenever possible. This examination also provides implications for how future research should be approached. Specifically, rather than attempting to develop new educational methods to solve issues present in a specific age group, existing theories and practices that apply to other age groups should first be considered. The findings illustrating working memory's link to attentional control may also possess important implications for individuals suffering from attention deficit-hyperactivity disorder (ADHD). Since ADHD is largely associated with impairments in working memory (McInnes, Humphries, Hogg-Johnson, & Tannock, 2003), future research should set out to determine if methods conforming to cognitive load theory can be effective in treating the attentional challenges experienced by these individuals. Even if such practices are insufficient for improving the working memory and attentional control of individuals with ADHD, at the very least, employing approaches which attempt to limit extraneous cognitive load while teaching these individuals will prove advantageous. Additionally, although it admittedly seems an unlikely area for success due to the neurodegenerative nature of Alzheimer's and other dementia-related diseases, future research should examine the effects that cognitive load theory-based programs could have on individuals suffering from these diseases. In the future, working memory exercises should also be applied to individuals who are recovering from brain injuries other than stroke to determine the best ways to approach the rehabilitation of affected cognitive abilities. The discussion presented here makes evident the need for cognitive load theory-based instructional programs to accommodate the diverse needs of elder learners suffering from age-related cognitive decline. Significant resources should be applied with the aim of implementing such programs as a means of increasing working memory capacity for elder learners, as well as promoting more efficient use of such capacities.

References

Bruning, R. H., Schraw, G. J., & Norby, M. M. (2011). *Cognitive psychology and instruction* (5th ed.). Boston: Pearson.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959-964. doi:10.1126/science.1204529

McInnes, A., Humphries, T., Hogg-Johnson, S., & Tannock, R. (2003). Listening comprehension and working memory are impaired in attention-deficit hyperactivity disorder irrespective of language impairment. *Journal of Abnormal Child Psychology, 31*(4), 427-443.

Paas, F., Camp, G., & Rikers, R. (2001). Instructional compensation for age-related cognitive declines: effects of goal specificity in maze learning. *Journal of Educational Psychology, 93*(1), 181-186. doi:10.1037//0022-0663.93.1.181

Paas, F. G., & Van Merriënboer, J. J. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive-load approach. *Journal of Educational Psychology, 86*(1), 122-133. doi:10.1037//0022-0663.86.1.122

Rand, D., Eng, J. J., Liu-Ambrose, T., & Tawashy, A. E. (2010). Feasibility of a 6-month exercise and recreation program to improve executive functioning and memory in individuals with chronic stroke. *Neurorehabilitation and Neural Repair, 24*(8), 722-729. doi:10.1177/1545968310368684

Van Gerven, P. W., Paas, F., Van Merriënboer, J. J., & Schmidt, H. G. (2002). Cognitive load theory and aging: Effects of worked examples on training efficiency. *Learning and Instruction, 12*(1), 87-105. doi:10.1016/s0959-4752(01)00017-2

Van Gerven, P. W., Paas, F., & Tabbers, H. K. (2006). Cognitive aging and computer-based instructional design: Where do we go from here? *Educational Psychology Review, 18*(2), 141-157. doi:10.1007/s10648-006-9005-4