2011

Using computer-based tools to self manage cognitive load

Shirley Agostinho
University of Wollongong, shirleya@uow.edu.au

Sharon Tindall-Ford
University of Wollongong, sharontf@uow.edu.au

Kylie Roodenrys
University of Wollongong, kylier@uow.edu.au

Publication Details

Agostinho, S., Tindall-Ford, S. & Roodenrys, K. (2011). Using computer-based tools to self manage cognitive load. In T. Bastiaens & M. Ebner (Eds.), World Conference on Educational Multimedia, Hypermedia and Telecommunications 2011 (pp. 3374-3378). Chesapeake, VA: AACE..

Using computer-based tools to self manage cognitive load

Shirley Agostinho, Sharon Tindall-Ford & Kylie Roodenrys
Interdisciplinary Educational Research Institute
Faculty of Education
University of Wollongong
Australia
shirleya@uow.edu.au

Abstract: This paper presents a work-in-progress exploring how learners can manage their own cognitive load through the use of computer-based tools. Cognitive load refers to the amount of mental processing undertaken in working memory by a learner. Cognitive Load Theory (CLT) has identified evidence-based design principles that inform the development of instructional materials to support the efficient use of working memory. Much of the CLT research has focused on how to present learners with optimally designed learning materials. There has been little research that has examined how learners can implement CLT design principles to manage their own cognitive load when exposed to non-compliant CLT instructional materials. This work builds on a current PhD study that investigated how university students can self-manage their cognitive load when exposed to print-based non-compliant CLT instructional materials. This study investigates how students can use computer-based tools to manipulate instructional materials and reduce cognitive load.

Introduction

Cognitive load refers to the amount of mental processing undertaken in working memory by a learner. Cognitive Load Theory (CLT) has identified a number of design principles that inform the development of instructional materials to support the efficient use of working memory (Paas, van Gog & Sweller, 2010). CLT is premised on human cognitive architecture that views the memory as an information processing framework where information can be inputted into sensory memory, processed in working memory and stored and later retrieved from long-term memory (Sweller, 2004). Working memory (very limited in capacity when processing new information) and long-term memory (relatively unlimited in capacity) interact: working memory processes information and for learning to occur the information needs to be organised and saved (schema development) into long-term memory. CLT suggests that efficient learning requires: i. reduction of irrelevant/unproductive load (extraneous), ii. an increase in productive/relevant load (germane) and iii. management of intrinsic load (the complexity inherent in the information to-be learned) (Sweller, 2010). Extensive empirical research has found that when learners engage with instructional materials that comply with CLT design principles, efficient learning occurs (Clark, Nguyen, & Sweller, 2006). Some design principles include: providing worked examples to guide learners and integrating instructions to reduce learner search – split attention (Clark et al, 2006); mixing auditory and visual presentation modes (Tindall-Ford, Chandler & Sweller, 1997); asking students to imagine procedures (Tindall-Ford & Sweller, 2006); eliminating redundant information and the expertise reversal effect (Kalyuga, 2007).

The focus of CLT research has been on instructional designers reducing working memory load for learners (Paas et al, 2010) - *instructor managed cognitive load*. Whilst this is certainly important, it is unrealistic to expect that learners, particularly in today's educational context where they can access a range of online resources, will always be exposed to CLT-based optimally designed educational content. If learners are to reap the full potential of CLT research findings, the proposition is made that learners should be empowered to manage their own cognitive load by being taught the design principles (implemented by instructional designers) so that they can apply them when exposed to non-compliant CLT instructional materials – *self-managed cognitive load*. The aim of the research is to support learners to optimally design their instructional materials using computer-based tools – and in doing so enable them to self-manage their cognitive load.

Today’s learners are exposed to a range of online learning environments (Conole, 2010), online textbooks, and a variety of digital media resources accessible from the internet which can be produced and published by anyone. It is evident that not all these resources will be designed based on CLT principles, hence there is a growing importance for learners’ to develop skills to self-manage cognitive load. Surprisingly, there is little research that has examined how learners can manage their own cognitive load. A doctoral study (Roodenrys, Agostinho, Roodenrys & Chandler, 2010) investigated how university students can be guided to self-manage their cognitive load (specifically split attention) when exposed to print-based non-compliant CLT instructional materials. The research project described in this paper builds on Roodenrys et al. work exploring how learners can manipulate digital media resources based on CLT split attention design principles through the use of computer-based tools.

The split attention effect refers to the condition where multiple sources of information, that is, text and diagram, are presented but cannot be understood in isolation that is information to be learnt can only be understood when textual material is mentally integrated into appropriate parts of the diagrammatical information. Split attention has been extensively researched across different domains (Clark et al, 2006) yet the focus has been on how instructional designers should avoid split attention when designing learning materials. Research on learners’ self-management of cognitive load in terms of reducing split attention when exposed to digital content is an innovative area of CLT research. Findings from Roodenrys’ PhD study (Roodenrys et al, 2010) have demonstrated that when learners are exposed to print-based instructional materials with evident split attention, those guided on how to self-manage split attention outperformed learners who were not provided with any guidance. Importantly, learners who self-managed split attention outperformed learners who were exposed to instructor managed split attention on test items that measured recall (of information on diagram) and near transfer (comprehension questions). The purpose of this project is to build on this work for the self-management of split attention by examining how learners can manipulate digital content to reduce split attention. Participants will use features of Interactive Whiteboard (IWB) software - SMART Notebook (referred hereafter as Notebook) to manage extraneous cognitive load by reducing split attention. Some features include dragging text, circling and highlighting text, drawing arrows, handwriting text using pen tools. It is possible that by learners manipulating instructional materials in a Notebook file (software used to create IWB resources), they may increase germane cognitive load (Van Merriënboer & Ayres, 2005) and decrease extraneous cognitive load (reference Sweller 2010) .

The Study

Research questions

The research project aims to investigate the following question:

1. How can learners self-manage extraneous cognitive load such as split attention through the use of computer-based tools?

A similar research design, instructional and testing materials as implemented in the doctoral study by Roodenrys (Roodenrys et al, 2010) will be adopted. The project will investigate how learners use movement of text objects in Notebook as a means to manage extraneous cognitive load by reducing split attention. Instructional materials will be developed in digital form as Notebook files. Notebook has been selected because it is a software application that the participants of this research study learn as part of their pre-service teacher education. The instructional content used for this experiment is also relevant to participants as the content focuses on multimedia learning; a concept that can be applied by these pre-service teachers when developing interactive whiteboard resources.

Hypotheses

The study will test three hypotheses:

1. When learners are exposed to computer-based instructional materials with evident split attention, those who are guided on how to self-manage split attention (Group 2) should outperform learners who are not provided with any guidance (Group 1) due to Group 2 utilizing computer-based tools to reduce extraneous cognitive load.
2. Learners exposed to computer-based instructional materials where split attention has been managed (Group 3) should outperform Group 1 due to Group 3 instructional materials having reduced extraneous load.
3. Learners who are guided on how to self-manage split attention (Group 2) should outperform Group 3 on test items that measure recall and near transfer due to Group 2 experiencing an increase in germane load.

Participants

Approximately 300 first year undergraduate education students enrolled in a first-year compulsory technology unit in 2011 will be invited to partake in the study. The experiment will take place during tutorial time. Tutorials are held in a computer laboratory (90 minute duration) where there are 24 computers and Notebook is installed on each computer. One Interactive Whiteboard is installed in this room.

Procedure

There will be two phases to the study, a Learning Phase (conducted prior to implementation of the experiment) and an Experimental/Test Phase. A pilot study will be undertaken for Phases 1 and 2 prior to the implementation of the study to inform any refinements required to the instructions, instructional materials and test materials.

1. Learning Phase

During tutorials prior to the experiment students will be instructed on how to use features of Notebook, such as moving text and other objects, inserting text, highlighting text, changing the colour of text, and drawing arrows, prior to the implementation of the experiment. Prior to the start of the experiment students will complete a small task to test whether they have acquired the specific skill of moving text objects. Students will also be asked to complete a short questionnaire to find out if they have previously studied the content of the instructional materials. If a student has not met the Notebook skills required for the experiment or is familiar with the content, they will participate in the study but their results will be excluded from the data set.

2. Experimental and Test Phase

The Experimental Phase incorporates three groups:

Group 1: Control Group (CG)- instructional materials with evident split attention (non-integrated format);
Group 2: Self Management of Split Attention Group (SMG) with non-integrated format;
Group 3: Integrated format Group (IG)

Students will be randomly allocated to one of the three experimental groups in tutorials. There are 24 computers in the tutorial room. The computers will be numbered and the instructional materials will be loaded on each computer in sequence, ie., Computer 1=Group 1; Computer 2=Group 2; Computer 3=Group 3, etc. Students that participate in the study will be randomly allocated by selecting a card (numbered 1 to 24) and being seated at that corresponding computer. For example, if 21 of 24 students in a tutorial participate in the study, cards numbered from 1-21 will be placed in a box from which participants will select a card and sit at that designated numbered computer. Students who do not wish to participate in the study are seated at the remaining computers and commence tutorial work (provided in a tutorial worksheet).

Group 1: Group 1 will be provided with instructional materials with evident split-attention, formatted as a Notebook file. The text and diagram in the Notebook file will be locked so that participants are not able to move textual and pictorial information. Participants will be asked to study the instructional materials for 3 minutes.

After this experimental phase, participants will be tested on their understanding of the content by completing a paper-based questionnaire (coded to correspond with computer). Participants will move away from the computers and complete the post-test.

Group 2: Group 2 will be provided with the same instructional materials as Group 1 (with evident split-attention) formatted as a Notebook file. The text in the Notebook file will be unlocked so that participants are able to move textual information if they choose. Participants will be asked to study the instructional materials for 3 minutes and move text at their discretion.

A post-test as implemented for Group 1 will be administered.

Group 3: Group 3 will be provided with integrated instructional materials formatted as a Notebook file. The text and diagram in the Notebook file will be locked so that participants are not able to move them. Participants will be asked to study the instructional materials for 3 minutes.

A post-test as implemented for Group 1 will be administered.

The Notebook file for each participant will be saved and will be artefacts to be analysed.

Analysis

A one-way ANOVA for recall, near and far transfer test items will be conducted for the independent variable being the three types of instruction provided to students, the dependent variable being the performance test scores student achieve on the post-test. Results from the experiment are expected to support hypotheses 1, 2, and 3. If learners who are provided with explicit guidance on how to self-manage split attention (Group 2) outperform Group 3 on the test items this will indicate that self-management of cognitive load is indeed plausible.

Conclusion

This paper has presented work-in-progress that is investigating how learners can manage their own cognitive load, namely split attention through the use of computer-based tools. Whilst one particular skill (i.e., movement of text objects) of one specific computer based tool, and one CLT effect is the focus of this paper, it is hoped that this area of research could be extended to examine other editing features of Notebook, other software applications and other CLT effects. Overall, it is anticipated that the findings from this area of research can inform practice where learners can implement CLT design principles when needed. For example, it is hoped the following scenario could become standard practice: a learner (be it a high school or university student) reviews a diagram and text in her online textbook and identifies this an example of split attention. As part of her process of making study notes, she takes a screen shot of the diagram, copies it to a word processing application, uses colour to highlight key words in the diagram and text and uses draw features such as arrows and textboxes to overlay textual information to explain parts the diagram. She saves this to her computer and refers to these study notes when studying.

References

Clark, C., R., Nguyen, F., & Sweller, J. (2006). Efficiency in Learning: Evidence-Based Guidelines to Manage Cognitive Load, San Francisco, California: Pfeiffer; Chichester: John Wiley [distributor].

Conole, G. (2010). *What would learning in an open world look like? A vision for the future*. Proceedings of ED-MEDIA 2010, *World Conference on Educational Multimedia, Hypermedia and Telecommunications, 29 June – 3 July. Toronto, Canada.*

Paas, F., van Gog, T., & Sweller, J. (2010). Cognitive Load Theory: New conceptualizations, specifications, and integrated research perspectives, *Educational Psychology Review*, 22, 115–121.

Roodenrys, K., Agostinho, S., Roodenrys, S., & Chandler, P. (2010). *Managing cognitive load within split attention learning environments.* Paper presented at the 4th International Cognitive Load Theory Conference, Hong Kong.

Sweller, J. (2004). Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. *Instructional Science*, 32, 9–31.

Sweller, J. (2010). Element interactivity and instrinsic, extraneous and germane cognitive load. *Educational Psychology Review* , 22, 123–138.

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review*, 19, 509-539.

Tindall-Ford, S. & Sweller, J. (2006). Altering the modality of instructions to facilitate imagination: Interactions between the modality and imagination technique. *Journal of Experimental Psychology*: Applied, 34, 343-365.

Tindall-Ford, S. Chandler, P. & Sweller, J. (1997) When two sensory modes are better than one. J*ournal of Experimental Psychology: Applied*, 3, 257-287.

Van Merriënboer, J.J.G, & Ayres, P. (2005). Research on Cognitive Load Theory and its design implications for E-Learning. *Educational Technology Research and Development*, 53(3), 5-13.