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Abstract. Even though students often manage to find their way around the internet in their search for information; information problem solving skills do not develop naturally. Previous research shows that adults and teenagers often encounter problems when solving information problems, indicating that formal training in this domain is needed. This study is an attempt to develop such a training. It compares the learning results of different instructional approaches: completion problems, emphasis manipulation, and a combination of both. In addition, the study will investigate which of these instructional approaches imposes the least amount of cognitive load, as measured by subjective mental effort ratings.

Keywords: information problem solving; completion problems; emphasis manipulation

Introduction

An information problem occurs when the knowledge to solve a problem, or the answer to a question, is lacking and a search has to be undertaken to find this knowledge. This process is called information problem solving, and is generally divided into five phases which are indicative of the required skills: 1) defining the problem, 2) searching for information, 3) selecting information based on relevance, reliability and correctness, 4) presenting the information, and 5) evaluating and regulating the process (Brand-Gruwel, Wopereis, & Vermetten, 2005). In order to effectively execute these steps, an individual needs a flexible set of complex cognitive skills. Strangely enough, universities, schools, and businesses in present-day society often expose their students or employees to assignments that require extensive information problem solving skills without providing adequate formal training in this domain. However, these skills do not emerge spontaneously. Research has shown that teenagers and adults encounter significant problems when searching for information online (Walraven, Brand-Gruwel, & Boshuizen, 2008). Novices especially lack the necessary skills for formulating good search queries, and are less capable of evaluating and judging search results and information sources (Brand-Gruwel, et al., 2005). These findings make it evident that there is a need for carefully designed formal training to develop information problem solving skills.

This research is aimed at developing a theoretically sound instructional approach to foster information problem solving skills. Information problem solving is a complex higher-order skill that involves the coordination of a set of constituent skills, combined with a body of knowledge and a critical attitude. For teaching this complex cognitive skillset, we chose to follow the guidelines presented in the Four-Component Instructional Design model by Van Merriënboer (Van Merriënboer

& Kirschner, 2007). In this model, training is constructed with four components: learning tasks, supportive information, procedural information, and part-task training.

When the training of a complex higher-order skill like information problem solving is embedded in existing educational curricula (for example: geography lessons), students continually have to deal with two content-levels: mastering the problem solving skills, and learning about the content of the problems (geography). This is mentally very taxing for a student. Therefore, when instruction is embedded in existing educational activities, it is imperative to avoid overloading the student with double-content instruction. To manage the cognitive load placed upon the learner's mind, two instructional approaches were tested: completion problems and emphasis manipulation.

Completion Problems. In the beginning of the learning process, learners have a restricted and incomplete schema of solution procedures, and they will most likely fall back on naive strategies like means-ends analysis or a trial-and-error approach to solve the problem. Even though this may be effective, this method places high demands on working memory. By integrating sufficient support for learners into the learning tasks, teachers can avoid these high amounts of cognitive load. One way to integrate support into the learning tasks is to provide a partially solved problem, then ask the student to solve the remaining steps. By providing worked-out steps, the correct strategies and domain-principles are reinforced, while the strain on working memory is reduced.

Although it may be useful in the early phases of a learning process, integrated support can eventually become detrimental to learning. As the training progresses and learning occurs, knowledge is constructed and problem solving strategies are incorporated into schemas. The support that was necessary in the beginning now becomes redundant, since it is already present in the learner's memory. Redundant information is a source of extraneous cognitive load and can hamper learning; see the *redundancy effect* (Sweller, Ayres, & Kalyuga, 2011). It is important to provide sufficient support in the beginning of the training, but to fade this support when it is no longer needed. This means that the implemented worked-out steps need to fade away as the training progresses. Offering completion problems in which the number of worked-out steps is gradually reduced is referred to as the completion strategy.

Emphasis manipulation. A second initiative to lower cognitive load is to emphasize only one of the constituent skills in each learning task, instead of all the skills. Contrary to part-task training, the student still performs the whole task, but instructional emphasis is placed on just one sub-skill (Gopher, Weil, & Siegel, 1989). In this emphasis manipulation approach, learner support is focused on a single sub-skill, but then shifts to a different sub-skill in the next learning task.

One way to emphasize a specific sub-skill is by providing prompts at the moment the target skill is executed. A prompt at that time can offer information to the learner, or ask to reflect on the skill after it was performed. By prompting for specific principles that are at play when executing the target skill, the relevant knowledge and procedures are activated in the leaner's mind. By using reflective prompts, learners can evaluate their own performance and identify any existing gaps in their knowledge.

This research addresses the question: which form of learner support (completion problems, emphasis manipulation, or a combination of both) is most effective? And which form of learner support requires the least mental effort? We expect that the combination condition, which offers the most learner support in the form of completion problems and prompts, yields the best learning results while requiring the least amount of mental effort.

Method

A total of 118 first-year university level students participated in the computer-based training that took place at the Katholieke Universiteit Leuven in Belgium. The training session consisted of: filling out a demographic questionnaire and a prior knowledge test, watching a 15 min instructional video, watching a video of a step-by-step worked out example while answering several explanation prompts in between, executing three learning tasks (in which students are required to search the web) and a performance task (another search but without any support), and completion of a post-test. Each learning task ended with an evaluation and a subjective measurement of mental effort by means of the Paas and NASA-TLX rating scales. Only the learning tasks differed between the conditions.

In the completion condition, two steps were worked out in the first learning task, while only the first step was worked out in the second learning task. In the third learning task, no steps were worked out. Worked out steps were presented as video fragments. In the emphasis manipulation condition, principle-based prompts were presented on the third step, second step, and first step in the first, second, and third learning task respectively. These prompts asked the learner to briefly explain the important principles at play in the current step. After answering the prompt, the correct answer was presented before the student engaged the problem solving step. After performing the step, a reflective prompt asked the learner to evaluate the performance. The combination condition combined both approaches as described above. Finally, the control condition entailed learning tasks without any instructional support.

Answers to all tasks and prompts were collected, and screen recordings provide an extensive view of the search behavior during the training. Scores on the post-test and performance task will give an indication of learning performance. Additionally, subjective mental effort ratings will show the experienced mental effort during the individual learning tasks.

Results and Discussion

The collected data is currently under analysis. Preliminary results will be presented at the conference.

References

Brand-Gruwel, S., Wopereis, I. G. J. H., & Vermetten, Y. (2005). Information problem solving by experts and novices: analysis of a complex cognitive skill. *Computers in Human Behavior, 21*(3), 487-508. doi: 10.1016/j.chb.2004.10.005

Gopher, D., Weil, M., & Siegel, D. (1989). Practice under changing priorities: An approach to the training of complex skills. *Acta Psychologica, 71*(1-3), 147-177. doi: 10.1016/0001-6918(89)90007-3

Sweller, J., Ayres, P., & Kalyuga, S. (2011). The Redundancy Effect. *Cognitive Load Theory.* (Vol. 1, pp. 141-154): Springer New York.

Van Merriënboer, J. J. G., & Kirschner, P. A. (2007). *Ten steps to complex learning. A systematic approach to four-component instructional design*. Mahwah, NJ: Lawrence Erlbaum.

Walraven, A., Brand-Gruwel, S., & Boshuizen, H. P. A. (2008). Information-problem solving: A review of problems students encounter and instructional solutions. *Computers in Human Behavior, 24*(3), 623-648. doi: 10.1016/j.chb.2007.01.030