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Enhancing Undergraduate Critical Reading Skills in Neuroscience Using Instructor-Developed Study Guides

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This study proposes an innovative instructional method for enhancing critical reading skills. Students enrolled in an undergraduate neuroscience course offered at the University of Toronto Scarborough reported that they often experience difficulty in analyzing and interpreting empirical and review journal articles. Our research focuses on student attitudes and perceptions of learning following exposure to instructor-developed study aids based on course readings from various scientific journals. The results of this study can be translated across disciplines to courses that use journal articles as part of the reading requirements, and can further impact course development to better facilitate student learning.

Introduction

Learning and Motivation is a third-year half-credit lecture and tutorial course offered at the University of Toronto Scarborough (UTSC) as part of both the major and specialist programs in Neuroscience. Tutorials are intended to familiarize the students with the general knowledgebase of neuroscience, namely the published literature. However, based on previous course feedback, the vast majority of undergraduate students enrolled in *Learning and Motivation* experience difficulty analyzing and interpreting empirical and/or review journal articles due to the emphasis on methodology, the abundance of results from previous studies, and the heavy use of scientific language (Anderson, 1992; Hartley, Trueman, & Meadows, 1988).

Lectures and tutorials are focused on delivering course-specific content, and typically, minimal class time is dedicated on developing higher-level thinking and article-analysis skills (Kreber, 2002; Lopez & Whittington, 2001; Steele, Medder, & Turner,

2000). To date, previous research on teaching and learning in the sciences has not addressed the importance of developing study aids to enhance critical analysis skills when reading scientific journal articles. Furthermore, the use of student feedback at midterm and at the end of term has not been documented. This paper summarizes an innovative instructional technique that aims to improve critical reading skills in undergraduate neuroscience students, and has the potential to be translated across multiple disciplines and courses that rely on scientific journal articles as part of their reading requirements.

Objectives

The current study had three main objectives: 1) to develop a series of content-related questions based on the assigned article readings to be used as study aids, and to examine student attitudes and perceptions of learning; 2) to evaluate students' ability to write potential exam questions following prior exposure to instructor-developed study aids; and 3) to evaluate the ability of students to rate potential exam questions written by themselves and their peers, based on difficulty and fairness, to be included on a course exam.

Research Methods

Each week, from September to November, 2007, the questions for 13 of the 16 assigned scientific articles were posted on the course's website. These questions identified the essential concepts in the articles and served as a guideline for student learning and comprehension of the readings. In October, as part of the mid-semester evaluation, a voluntary and anonymous feedback questionnaire assessed the usefulness of the study aids, frequency of use, whether or not the weekly study guides improved concept learning, and the students' study habits. By mid-semester evaluation, four instructor-developed study aids had been provided to the students.

Subsequently, students were asked to write potential exam questions (multiple choice and short-answers) for two assigned empirical papers without study guides. This was not a mandatory assignment, but the students who submitted both the questions and answers received 1% bonus mark added onto their final grade. We hypothesized that following exposure to the instructor-developed study aids students would mimic the guides, identify the important concepts, and integrate these content-related keywords to form clear and well-structured questions.

The student-submitted questions were selected and re-organized into PowerPoint slides consisting of 15 multiple-choice and seven short answer questions. During an in-class exercise, the slide show was presented and students were asked to rate the questions written by themselves and their peers based on the following choices:

a) Too difficult and unreasonable to use on the NROC61H3 final exam.
b) Moderately difficult but fair enough to include on the NROC61H3 final exam.
c) Moderately easy and fair enough to include on the NROC61 final exam.
d) Easy! Please include this on the NROC61 final exam.
e) No opinion.

This assessment was conducted during the tenth week of the twelfth-week course. The student-submitted questions included in this assignment were made available to all members of the class prior to the final exam. At the end of the course, the students who participated in the rating exercise were given an anonymous survey to determine whether the questions written by themselves and their peers were effective study tools for the final exam.

Research Findings

Eighty-nine percent of respondents (33 of 37 students) found the study aids useful. Eighty-six percent (32 of 37 students) believed that the study guides improved their ability to identify important concepts in the articles (Table 1). Student feedback included the following comments:

TABLE 1
Quantitative Data on the Journal Article Study Guides

Userfulness	**Yes**	**No**	**Sometimes**		
	33	2	2		
Study Habits	**Alone**	**Small Groups (3-7)**	**Large Group (>7)**		
	35	2	0		
Looking at the Questions	**Every Week (answer)**	**Every Week (glance)**	**Week of the Exam**	**Day of the Exam**	**Other**
	9	6	17	1	4
Concept Learning	**Yes**	**No**	**Sometimes**		
	32	1	4		

- I found the questions very useful.
- The question sheet was designed in a very constructive way. It really streamlined the focus of the article when studying them.
- I think the journal questions were quite good in helping us to break down the articles.
- The questions were well-written to help us understand the articles. A couple of multiple choice questions may be helpful.

Sixty-eight percent of students submitted the voluntary assignment consisting of both short answer and multiple choice-type questions with an answer key and mark breakdown included. The trends illustrated clear, concise, well-written, and well-structured questions that were similar to the instructor-developed study aids.

Results of the in-class question rating exercise indicated that students found most of the questions written by themselves and their peers moderately difficult and fair enough to use on a course exam. However, a few exceptions were noted. The questions that were considered to be 'easy,' required rote memorization or straight recall of facts such as numbers or common brain structures. Two examples of such questions are provided:

1. According to Fields & Douglas (2004), the ratio of glial cells to nerve cells is:

   a) 100 to 1
   b) 1 to 100
   c) 9 to 100
   d) 9 to 1
   e) None of the above

2. A patient can no longer retrieve long-term memories, a condition known as retrograde amnesia, when the _____ is damaged.

   a) Cerebral Cortex
   b) Hippocampus

c) Cerebellum
d) Basal Ganglia
e) Amygdala

Questions that were perceived to be too difficult and unfair to use on a final exam required ordering a complex sequence of events or detailed explanations of scientific experiments. Two examples are provided below:

1. What is the correct chronological order that underlies the involvement of astrocytes in the regulation of neuronal signaling:

i. An influx of calcium is triggered into astrocytes
ii. An axon prepares to transmit a signal to a dendrite
iii. The release of a neurotransmitter and chemical ATP from the axon terminal
iv. The release of signaling molecules from astrocytes causing the axon to decrease the amount of neurotransmitter it releases when it fires again
v. As a result, astrocytes communicate among themselves by releasing their own ATP
vi. The signal is weakened by astrocytes due to the secretion of proteins that bind to the neurotransmitter preventing it from reaching its target

a. 2, 1, 5, 3, 6, 4
b. 2, 1, 3, 4, 6, 5
c. 2, 4, 1, 5, 3, 6
d. 2, 3, 1, 5, 6, 4
e. 2, 3, 6, 4, 1 5

2. Describe the research by Damasio, Jones, and Tranel on regions of the brain that require the placement of memories in the correct epoch. Discuss the researchers' objectives, methods, results and findings.

When surveyed about the effectiveness of the student-written questions, 58% of respondents (35 of 60 students) indicated that both the multiple choice and short answer questions were effective study tools for the final exam, while 28% thought they were not useful (Figure 1).

Research Implications

Our data suggests that study aids based on empirical and review journal articles are helpful for undergraduate neuroscience students in developing concept learning. The instructor-developed study guides are successful in helping students extract important concepts from the articles and improving their ability to write concise, well-structured questions. This indicates that students implement what they have indirectly learnt from the study aids and experience enhanced academic competence. Furthermore, respondents' comments are a good indicator that concept-based study guides are effective resources in helping students interpret journal articles.

We propose a three-step pyramidal model of learning: metacognitive concept-based learning that emphasizes a structured approach to analyzing and interpreting scientific articles (Figure 2). The bottom

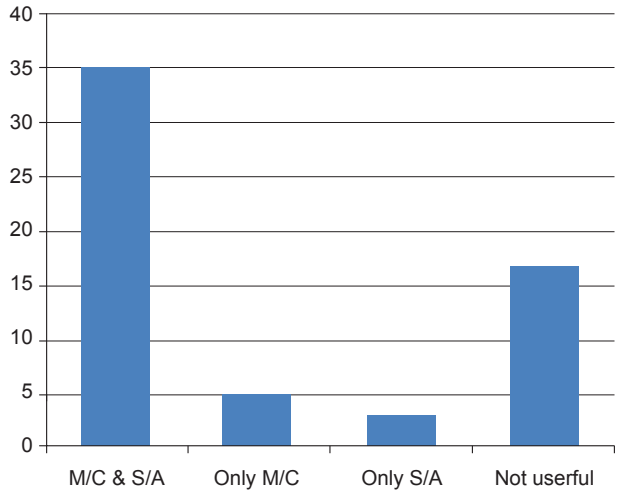

FIGURE 1
Effectiveness of Multiple Choice and Short Answer Questions as Study Tools

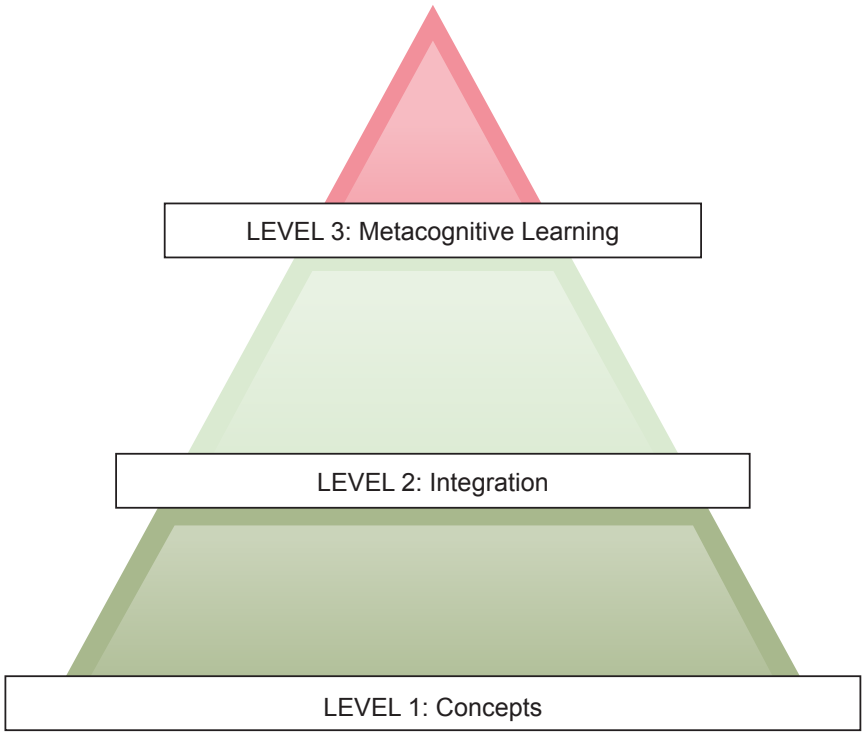

FIGURE 2
The Metacognitive Concept-Based Model of Learning

step of the pyramid emphasizes the understanding of concepts like keywords or definitions. When the students become familiar with these important terms, they will reach the second level and will integrate the learnt information. The students' ability to formulate questions such as why a certain phenomenon is occurring or how two or more concepts are related is a learning outcome. Learning takes place at the top of the pyramid and is defined by repeating the first two steps in order to consolidate the information. More importantly, learning refers to metacognitive learning outcomes – specifically the ability of students to monitor, change, and adapt their learning strategies (Ridley, Schutz, Glanz, & Weinstein, 1992).

This innovative model is similar to Bloom's (1956) taxonomy in its assessment of learning outcomes and its communication of expectations to students. The first level of the pyramid encompasses the first two learning outcomes of the taxonomy: knowledge and comprehension. Level two is reminiscent of Bloom's application and analysis, while learning (level three) emphasizes synthesis and evaluation skills. Both models are hierarchical and thus provide structure to students and instructional designers (Jonassen & Tessmer, 1997). However, unlike Bloom's taxonomy, the metacognitive concept-based model is not a static entity; it provides flexibility and structure to both students and instructors, and articulates the development of higher order thinking skills. It integrates learner-controlled thinking or metacognition by providing a step-by-step approach from mastering key concepts to synthesizing questions that test the ability to apply and analyze specific content.

An important issue in undergraduate education is for students to learn critical reading skills earlier on, preferably in the first or second year of their studies. To maximize academic success, students should transition from novice to expert learners earlier rather than later (Ertmer & Newby, 1996). Therefore, it is recommended that instructors implement empirical readings and metacognitive learning outcomes in introductory higher education courses to allow for the development of critical thinking skills.

References

Anderson, O.R. (1992). Some interrelationships between constructivist models of learning and current neurobiological theory, with implications for science education. *Journal of Research in Science Teaching, 19*, 1037-1058.

Bloom, B.S. (Ed.). (1956). *Taxonomy of educational objectives: The classification of educational goals – Handbook I: Cognitive domain*. New York: Longman.

Ertmer, P.A. & Newby, T.J. (1996). The expert learner: Strategic, self-regulated, and reflective. *Instructional Science, 24,* 1-24.

Hartley, J., Trueman, M., & Meadows, A. J. (1988). Readability and prestige in scientific journals. *Journal of Information Science, 14*, 6977.

Jonassen, D., & Tessmer, M. (1997). An outcomes-based taxonomy for instructional systems design, evaluation, and research. *Training Research Journal, 1,* 11-46.

Kreber, C. (2002). Teaching excellence, teaching expertise, and the scholarship of teaching. *Innovative Higher Education, 27*, 5-23.

Lopez, J. & Whittington, M.S. (2001). Higher-order thinking in a college course: A case study. *North American Colleges and Teachers of Agriculture, 45*, 22–29.

Ridley, D.S., Schutz, P.A., Glanz, R.S. & Weinstein, C.E. (1992). Self-regulated learning: the interactive influence of metacognitive awareness and goal-setting. *Journal of Experimental Education 60*, 293-306.

Steele, D.J., Medder, J.D. & Turner, P. (2000). A comparison of learning outcomes and attitudes in student- versus faculty-led problem-based learning: an experimental study. *Medical Education, 34,* 23-29.

Biographies

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