Designing a Robot's Brain: An In-Class Learning Task

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ABSTRACT

In this article I discuss a learning task adapted for the college classroom in which students learn about the parts and functions of the brain by designing a robot's brain. This task is based on a four-phase model (engage, inform, practice, and feedback) of instructional design outlined by McAlpine (2004). I describe the four phases in relation to this learning task and provide samples of student feedback. I conclude with a discussion of how this model maximizes student learning.

Introduction

Over the past few decades, researchers have outlined the rapid and steady decline in student attention that occurs during extended lectures (Gibbs, Habeshaw, & Habeshaw, 1987; Silberman, 1996). Furthermore, Fink (2003) provides evidence that lectures are limited in their capacity to help students retain and transfer information and engage in higher-order thinking skills. The paradigm shift in higher education from a focus on content-centered instruction to learner-centered instruction (Barr & Tagg, 1995) highlighted the importance of involving students in the learning process. Attention and subsequent learning are enhanced when students are engaged in the task, when they perceive it as meaningful, and when they are given the opportunity to practice new material and to contextualize it. Active methods of teaching and learning satisfy many of these criteria and have been shown to promote both learner retention and transfer of information (Svinicki & McKeachie, 2011). According to cognitive scientists, the more engaged the student is with the learning task and the more he or she seeks to extract personal meaning from it, the greater the likelihood that underlying brain structures will change to promote learning that lasts (Leamnson, 2000).

Ramsden (1992) refers to this process of student engagement as adopting a deep, as opposed to a surface approach to learning. The author points out however that a student's approach to learning is not a characteristic of the individual learner but rather a function of how the learning task has been structured and what the student is being asked to do. It is therefore incumbent upon teachers to design instructional tasks that are meaningful for students and that will encourage them to adopt a deeper, more holistic approach, as opposed to a segmented, surface approach to learning. Fink (2003) and Whetten (2007) point out however that the area of course design represents the greatest challenge for teachers in higher education, as many lack the tools necessary to restructure teaching and learning activities that will bring about the significant learning experiences they desire for their students.

One noteworthy model of instructional design for higher education has been described by McAlpine (2004). This model, which is based upon contemporary theories of learning and Gagné's (1985) conditions of learning, outlines a framework for both instruction and learning that consists of four phases. During the first phase the teacher seeks to engage student attention by emphasizing the relevance of the learning task. The purpose is to encourage student motivation and to foster a deep approach to learning. During the second or informing phase, learners are presented with relevant background information. The third or practice phase is by far the most important part of the model. During this phase, learners "construct understanding and integrate knowledge in order to later retrieve and apply it at appropriate times" (McAlpine, 2004, p. 128). The author also maintains that during the practice phase, a learning environment which includes both structure and formative feedback will promote a deep approach to learning. The final phase of formal summative grading should mirror what students were asked to do during the practice phase. McAlpine provides general anecdotal evidence from teachers and students who attest to the efficacy of this model. In this article I provide an example of a learning task which extends this model to the CEGEP classroom. I also provide, through student feedback, evidence of learning throughout the four phases of engaging, informing, practice, and feedback.

Rationale

Introduction to Psychology is a compulsory course for all Quebec CEGEP (preuniversity) students who are enrolled in the Social Science Program. One of the modules in this course focuses on the human brain and its impact on behavior. This module partially meets one of the Ministry of Education's major learning outcomes for this course, which is to describe the biological, cognitive, and affective processes that underlie human behavior.

Most introductory psychology textbooks divide the human brain into three major sections: the lower brain or brainstem, the middle brain or limbic system, and the upper brain or cerebral hemispheres (Wood, Wood, Boyd, Wood, & Desmarais, 2011). There are approximately 30 different parts of the triune brain for students to master. Many Social Science students have limited background in biology and report difficulty learning the various brain structures and their related functions. The objective therefore was to design a task that would simultaneously engage student attention and enable them to achieve the following learning outcome: identify the major structures and the related functions of each of the parts of the human brain.

Description of the Learning Task

Engaging student attention: In order to address this learning outcome, students are told that they will work in small teams of two or three students during class time, to build a robot's brain. Members of each team collectively decide what job or task they want their robot to accomplish. They then brainstorm a list of skills that their robot needs, in order to execute its job effectively. Generating a list of prerequisite skills is important as it provides students with a series of advance organizers. The brain parts they eventually select must be considered in light of these requisite skills, in order to enable their robot to carry out its function. The team also names its robot. Typically students are intrigued by the novelty of this learning task. Their engagement is enhanced by the fact that they are able to customize their robot. They are also informed that they will receive a group mark for their team product.

Our robot is going to be a soccer player. Its name is Ronaldobot. It needs to be quick, coordinated, have anticipatory abilities and the ability to process information while the body is under physical stress. (Jordan and Felix)

Our robot's name is Maid Robot. Its job is to complete our chores. To do so it needs to move skillfully, remember its tasks and respond to touch. (Josianne, Jessica, and Nivart)

Our robot's name is T-Pain II. It goes to our classes (especially our 8:00 classes), assimilates information by creating lyrics with important information and it sings this to us in the evening. In short, it teaches us! (Julie, Youssef, and Olivier)

Designing the Robot's Brain

Inform: This assignment stipulates that for each of the three major sections of the brain, each team must select two parts that will enable its robot to perform its task most effectively. Thus, each robot that is designed must be able to execute its task reasonably well with just six brain parts. While students are required to learn the various parts of the brain, this selection process encourages the team to closely consider the function of each chosen part in order to maximize the robot's capabilities.

Beginning with the lower brain, I describe the structure and related function of the various parts. This is done in a 15-20 minute interactive lecture accompanied by PowerPoint slides. During this time students take notes and ask questions as they consider the various parts in light of their particular robot's task.

Practice and feedback: Team members then collectively decide which two brain parts of the lower brain are most appropriate for their particular robot. They are required to name each part, to describe the function of the brain part, and to explain why their robot needs this specific component to carry out its task. Students are encouraged to refer back to their initial list of required skills (advance organizers) as they justify the selected brain part. They also consult their textbook and notes when completing this exercise. The practice phase of this learning task, during which students are engaged in group discussions and in making collective decisions about what material to include and why, is by far the most important part of the learning process. Verbalizing the information provides students with the opportunity to verify their understanding of concepts and to receive feedback from peers on their comprehension. While students confer with their team members, I walk around the classroom listening to discussions and offering suggestions and feedback. The formative feedback that I provide during this time sometimes leads group members to reconsider and perhaps alter their choices or to provide a more substantial justification for their particular selection. The discussions that ensue between teacher and students help to reduce the power differential as learning is viewed as an ongoing and collaborative process. Both peer discussions and student-teacher discussions provide students with an opportunity to engage with the material on a deeper level.

Our robot Ronaldobot needs a cerebellum. This part of the brain coordinates skilled movement, regulates muscle tone and posture, and plays a role in motor learning and posture (Wood et al., 2011). Ronaldobot will need his cerebellum because in order to be a good soccer player, it will require a vast array of technical skills and coordination, which are largely controlled by the cerebellum. (Jordan and Felix)

The same procedure of inform, followed by practice and formative feedback is carried out, for the following two major parts of the brain: the mid-brain or limbic system and the cerebral hemispheres.

Our robot, Maid Robot, needs a hippocampus. This part of the brain plays a central role in the formation of long-term memories. It also helps our brain form maps of space that allow us to learn our way around the environment and remember where we have been (Wood et al., 2011). The hippocampus will enable our robot to remember all of its chores and also to be able to find its way around the house. (Josianne, Jessica, and Nivart)

The occipital lobes contain the primary visual cortex where vision is first registered and the association areas that are involved in the interpretation of visual information (Wood et al., 2011). This part will be useful for Ronaldobot—it will need perfect vision to be able to anticipate every move on the field the players make. (Jordan and Felix)

Final assessment: At the end of this exercise, each team must judge whether or not its robot will be able to carry out its task with just six brain parts. This segment of the learning task encourages the team to not only consider individual parts and their function, but also to reflect on the relationships between the parts and the whole. As the student comments below reveal, some teams are more cognizant than others of the interdependency among brain parts.

Our robot will be able to carry out its task (doing our chores in the house) because it can move skillfully; it can remember its chores and how to do them and it can find its way around the house. (Josianne, Jessica, and Nivart)

It would be difficult for a human, let alone a robot, to function without all the parts of the brain. Although certain areas are specialized to perform particular tasks, it is the collective brain which allows us to function. As for individual sections, our robot Ronaldobot would need many additional parts not mentioned in this assignment such as the parietal lobes, which register touch, pressure, temperature, and pain. (Jordan and Felix)

Finally, each team reviews the assessment criteria before submitting its report. This verification encourages students to attend to the conditions upon which their work will be evaluated. Their robot assignment is then submitted for formal teacher assessment. There is a close match between what students are asked to do in this learning task and how they are subsequently assessed, for example, on class tests. The alignment between practice and assessment is key to the effective implementation of this model in terms of promoting learning and retention.

Advantages

There are several advantages to this learning task. First, all phases can be accomplished within a reasonable time frame (approximately two and a half hours of in-class time). This includes teaching the three major sections of the brain and setting aside time for each team to build its robot, while simultaneously providing students with formative feedback. The fact that the building or practice phase of this exercise is timed maximizes student time on task. As well, attention is enhanced throughout the lecture portion of this task, as students know they will have to do something with the material. Students achieve a deeper level of understanding when they are asked to apply acquired knowledge (Whetten, 2007).

This task also requires students to work cooperatively in a small group and to negotiate decisions collectively. This aspect of reciprocity, when situated within a well-structured learning task, increases learner motivation and responds to the social needs of students (Silberman, 1996). Students who might be reluctant to participate in class discussions do so within their small group. Peer feedback also serves as an important check on comprehension and can lead to significant cognitive outcomes, especially when carefully designed learning tasks are aligned with course outcomes (Svinicki & McKeachie, 2011). Finally, absenteeism is reduced since the team receives a group mark for its product. The fact that students must consult their course textbook, particularly when describing the function of each brain part, encourages them to view this resource as a valuable reference and repository of information. The final assessment wherein each team considers whether its robot will be able to carry out its task with just six brain parts raises interesting discussions and encourages students to reflect on the product they have created. Most importantly, students regard this learning task as fun and it helps them to master challenging course material.

In conclusion, the model described by McAlpine (2004) consisting of the four phases of engage, inform, practice, and feedback can be used to design instruction (both teaching and learning activities) inside and outside of class. As well, it can be adapted at various levels including a lesson, module, or course and across various domains. The in-class learning task *Designing a Robot's Brain* described in this article provides evidence of how this framework can be successfully integrated into a CEGEP classroom to teach challenging content. It highlights the importance of creating significant learning experiences for students wherein learning tasks are clearly aligned with course outcomes. Feedback from student work attests to the efficacy of this model of instructional design and suggests that it offers a good fit for today's learners.

Postscript

Some semesters I use an alternate form of this instructional activity in which I invite students to write an essay describing how they would design their robot's brain. The advantage of this latter learning task is that it provides students with the opportunity not only to learn about the structures and functions of the brain, but also to practice writing about psychology. In addition to producing a well-structured essay that includes an introduction, body, and conclusion, students are also expected to integrate APA in-text citations. This essay, which is typically assigned at the beginning of the semester, provides me with a writing sample for each student. This information enables me to identify early on any students who are experiencing difficulty with either the writing process or with the acquisition of content knowledge. I subsequently refer them for tutoring.

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