2009 Sixth International Conference on Information Technology: New Generations

Learning Theories in Computer Science Education

Jesús Ubaldo Quevedo-Torrero
University of Wisconsin-Parkside
Department of Computer Science

Abstract

College instruction may be primarily concerned in most cases with the content of their academic lessons, and not very much with their instructional delivery. However, the effective application of learning theories in higher education has an impact on student performance. This paper surveys the applicability of constructivism, cognitive information processing and behaviorism in computer science education. However, student success in learning computer science theory is not limited to only those three learning theories. In general, research findings suggest that effective computer science instruction involves the design of cognitive models that facilitate retrieval, and a consistent application of positive reinforcement.

Key Words: behaviorism, computer science education, constructivism.

1. Introduction

Colleges and K-12 school districts do not follow the same procedures when hiring new educators for their institutions. K-12 school districts seek qualified state certified teachers that not only know their content area but also are knowledgeable in learning theories and effective teaching strategies. On the other hand, colleges prioritize their search in finding instructors experts in their fields, and their teaching qualification may be optional. Hence, we may think that research on applying learning theories to maximize student achievement is exclusive for K-12 systems. However, there are some research efforts in applying learning theories in institutions of higher education in academic departments, other than the school of education.

Computer science education should deal with the implementation of teaching methodologies to enable students to be actively engaged in the lesson, not passively absorbing knowledge from lectures. A constructivism study in computer science education [1] found that passive learning in computer science will likely fail, learning must be active. This same study [1] also found that students must construct knowledge assisted by guidance from the teacher and feedback from other students.

2. Constructivism in Computer Science

According to Ben-ari [1], "constructivist practices in computer science education place the expectations on students to discover knowledge by themselves when placed in the appropriate situation". Piaget in [5] claimed that learners "construct" new knowledge from their experiences through the processes of accommodation and assimilation. In fact, assimilation is the process of incorporating new knowledge into an existing schema while accommodation modifies such schema to accommodate new knowledge. For example, Ben-ari in [1] found that knowledge is acquired recursively: sensory data is combined with existing knowledge to create new cognitive structures, which are in turn the basis for further construction. Knowledge is also created cognitively by reflecting on existing knowledge.

Furthermore, constructivists consider knowledge as a process that is created by the activity of the learner. This assumption, which may seem contrary to traditional college styles of instruction such as lecturing and reading books, is not totally opposite to the constructivism paradigm. In fact, research finding in this area [1] found that constructivist teachers actively guide students to construct "viable mental models".

3. Cognitive Information Processing

In both, the cognitive information processing theory and in computer science, the processing of information involves the use of several types of memory. For instance, in Computer Science, these memories are RAM (Random Access Memory), ROM (Read Only Memory), and permanent storage memory devices such as hard drives, floppy disks, tapes, CDs, and flash drives. While, in the cognitive information processing theory, these memories are referred as sensory, short-term, and long-term

978-0-7695-3596-8/09 $25.00 © 2009 IEEE
DOI 10.1109/ITNG.2009.294

Amazingly, the cognitive information processing theory can be related to the computer science approach of processing information by using memory manipulation as well as the retrieval of information. In fact, according to [4], the cognitive information processing has its main focus on memory with the storage and retrieval of information. Furthermore, the cognitive information processing theory considers the role of three types of memory: sensory, short-term, and long-term. Sensory memory is affiliated with the transduction of energy. The environment in several forms such as light, sound, smell, heat, and cold provides information. The sensory memory can be related to the ROM memory and the communication with the input devices that are the sensors of the computer. Moreover, "the short-term memory is also called working memory and relates to what we are thinking about at any given moment in time [4]". This second type of memory could be related with the RAM memory in computer science; while, the long-term memory contains information that may be retrieved upon request. This last type of memory matches the permanent storage devices described in the computer science processing of information.

4. Behaviorism: Operant Conditioning

Reinforcement plays an important role in meeting academic expectations. When educators praise their pupils for accomplishing expected learning outcomes, students tend to repeat the behaviors that made possible their accomplishment. For instance, Ross and Neuringer in [6] conducted experiments on reinforcement upon humans for satisfying the three variable manipulations of drawing rectangles on a computer screen. Human subjects were expected to manipulate the area, location, and shape of rectangles to draw new rectangles. For their experiments, they have an experimental group that was reinforced for a specific level of manipulation on the three variables: area, location and shape of the rectangle; while the control group was reinforced too, but independently of their level of manipulation of any of the variables. Their results showed that "the experimental group varied significantly more along each of the variables than did the control group". Similarly, Ross and Neuringer in [6] conducted other experiments were the experimental group was reinforced for the manipulation of just one of the three variables. Their experiments showed that reinforcement controls the variability of the responses.

5. Conclusions

In conclusion, learning theories are applicable to the college level instruction of computer science. Educators, in this area, should guide students into the creation of effective mental models. Actually, several models of knowledge representation discussed by Davis, Shrobe, and Szolovits in [2] may be employed to follow a constructivism teaching approach. However, educators should not be tempted to substitute the creation of cognitive models with the physical presence of the computer. Furthermore, according to [3], "the cognitive information processing focuses on different aspects of instruction and how those aspects can either facilitate or hinder learning and memory". In fact, computer science education should take advantage of the similarities between the cognitive information theory, and the computer processing of information. These similarities should be employed to design instructional strategies that facilitate retrieval and encoding. Behaviorism may seem only applicable to little children, but it does impact learning performance on college students too. Hence, computer science educators should clearly identify their expectations for each classroom activity, and consider that reinforcing good learning increases student achievement.

6. References

[1] M. Ben-ari, M. "Constructivism in computer science education", *Journal of Computers in Mathematics and Science Teaching,* ACM, vol. 8, pp. 38-44, 1997.

[2] R. Davis, R.H. Shrobe, and P. Szolovits, "What is a knowledge representation?", AI Magazine, vol. 14, pp. 17-33, 1993.

[3] S. Flanagan, "Cognitive Information Processing", Retrieved October 29, 2008, from the College of Education of the Purdue University Web site: http://web.ics.purdue.edu/~smflanag/edtech/cip.htm, 2007.

[4] W. Huitt, "The information processing approach to cognition". *Educational Psychology Interactive*: Valdosta State University. Retrieved on October 28, 2008 from http://chiron.valdosta.edu/whuitt/col/cogsys/infoproc.html, 2003

[5] J. Piaget, "The Construction of reality in the child". Retrieved October 29, 2008, from http://www.marxists.org/reference/subject/philosophy/works/fr/piaget2.htm, 1955

[6] C. Ross, and A. Neuringer, "Reinforcement of variations and repetitions along three independent response dimensions". *Behavioural Processes*, vol. 57, pp. 199-209, 2002.