Examining Graphing Calculator Affordances in Learning Pre-Calculus among Undergraduate Students

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ABSTRACT

This study examines graphing calculator affordances in learning mathematics among college precalculus students. The study draws from the Cognitive Load Theory (CLT) and the “Intelligent Technology” theoretical framework proposed by Salomon, Perkins, and Globerson (1991). From these perspectives the effects “with” the graphing calculator technology include the potential for this technology to offload students’ extraneous cognitive load (e.g., the presence of unwieldy numbers), and in turn optimize their germane cognitive load (e.g., freeing students to focus on the key mathematical ideas). To examine students’ perceptions on the adoption of the graphing calculator instructional approach a questionnaire was administered towards the end of the semester. The findings showed that the graphing calculator afforded students’ learning in a variety of ways. Also considered is the challenge for educators to develop strategies that encourage appropriate use of graphing calculators in mathematics classroom in order to ensure that their integration is effective in instruction.

KEYWORDS

Cognitive Load Theory (CLT), Graphing Calculators, Intelligent Technology, Precalculus, Affordances

STATEMENT OF PROBLEM

Mathematics is viewed by many students as one of the most challenging subjects and one which they would not undertake if they had an option. From my experience, a lot of students come into the math classroom prejudiced that math is a hard and boring subject and that they do not need it for anything in the real world. To counter these preconceived notions and to develop students’ interest and motivation in learning mathematics, scholars have come up with various innovative techniques that teachers can adopt in their mathematics classrooms. One such technique is the incorporation of technological tools (The National Council of Teachers of Mathematics (NCTM), 2000). The ability to produce visual images of mathematical ideas, the power to organize and analyze data, and the power to compute quickly and accurately are all characteristics of electronic technologies that augment student learning. Of the potentially available technologies in the classroom, the graphing calculator is more accessible to students because of price, portability and ease of use (Dick, 1996; Waits & Demana, 2000).

Research has shown that the use of graphing calculators facilitates students’ understanding of functions and graphing concepts. For example, Schwarz and Hershkowitz (1999) found that the treatment group who used the graphing calculator were better at selecting appropriate dimensions for the axes when graphing functions, preferred graphical representations of functions for problem solving, exhibited a dynamic notion of function, and were better able to develop representations of
whole graphs of functions from partial graphs. Results from several studies also indicate that graphing calculators provide an opportunity of a multiple representation approach of mathematical concepts by promoting a multiplicity of linked approaches (numeric, algebraic, graphical) to the same problem (e.g., Graham & Thomas, 2000; Hollar & Norwood, 1999).

Moreover, graphing calculators have been found to be useful in helping students acquire mathematical modeling skills. For example, Drijvers and Doorman (1996) found that students gained a significantly better understanding of the concept of modeling real-world problems when compared to those who lacked access to this technology. Graphing calculators were also found to facilitate the development of spatial visualization skills (Ruthven, 1990) and to encourage students to explore mathematics ideas and use flexible solution procedures (Doerr & Zangor, 2000). In addition, Farrel (1996) found that students using graphing calculators had greater perseverance and focus in trying to understand the problem conceptually rather than simply focusing on the computation. In sum, the consensus of research reviews is that the use of graphing calculators has the potential to increase students’ achievement, understanding of function and graph concepts, problem solving strategies as well as their conceptual understanding of mathematical concepts. More importantly graphing calculators enhance students’ ability to handle complex mathematical problems and concepts.

This study was conducted in a precalculus class of which the author was the instructor. As mentioned earlier, graphing calculators have the potential to influence students’ understanding of the concept of function, which is the central focus of precalculus. The aim of the study was to examine students’ perceptions towards the adoption of the graphing calculator instructional approach in learning precalculus. The focus of the study, thus, was in exploring the students’ opinions of the ways in which the integration of the technology in the course afforded their learning. More specifically, this study addresses the following research question:

• What are undergraduate students’ perceptions of the affordances of the graphing calculator in learning precalculus?

THEORETICAL FRAMEWORK

The Cognitive Load Theory (CLT) is an instructional theory that emanates from the notion that the human working memory is limited with respect to the amount of information it can hold, and the number of operations it can perform on that information (Sweller, van Merriënboer, & Paas, 1998). This theory provides a framework for investigating the structure of information and the cognitive architecture that allows a learner to process that information. The key aspect of the theory is how the interplay between the long-term memory and the working memory information interact with this cognitive system. Although learners allocate most of their cognitive resources to the learning activities when learning, often times the instructional format results in an overloaded working memory. As such, cognitive load theorists assert that learners should be encouraged to use their limited working memory efficiently especially when learning a difficult task (Sweller, 1988; Sweller et al., 1998).

In order to enhance meaningful instruction, the design of instructional activities should be geared towards optimizing the working memory by reducing the external load (Cooper, 1998). Cognitive load is a construct that refers to the total amount of cognitive activity imposed on working memory in any one instant (Sweller et al., 1998). According to Sweller et al. (1998) the main contributing factor to cognitive load is the quantity of items that need to be attended to. Moreover, there are three categories of cognitive load namely intrinsic, extraneous and germane. Intrinsic cognitive load is a measure of the demands, which are intrinsic to the material being learned, on working memory in use due to the interactivity of the amount of information being processed (Sweller et al., 1998).

While different instructional materials differ in their complexity or difficulty level, they cannot be modified by instructional design. Extraneous cognitive load result from poorly designed instructional activities that are irrelevant to schema acquisition and automation. While extraneous load interferes
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