Technologizing Math Education: The case of multiple representations

Preliminary Research Report

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Abstract: Technology is a cornerstone for NCTM and is agreed to be beneficial, but the level of effectiveness is still very vague. This research questions exactly how effective is technology in the mathematics classroom, and what are the definitive benefits. After studying over 300 articles, technology has proven to be beneficial in five ways: providing instantaneous visual feedback, creating student-centered learning environments, providing multiple representations of similar concepts, combining learning environments for generalizations, and retracing previous steps for self-assessment. The most frequently discussed topic was multiple representations, usually in the form of CAS and dynamic geometry systems. The research shows that providing multiple representations allows students with varying levels of intelligence to better understand tricky and abstract concepts.

Keywords: Technology, Multiple representations, Multiple intelligences, technology effectiveness, mathematics education

One of the ultimate goals for general technology use, regardless of the subject, is the level of relevance to the student's natural surroundings. This research focuses on creating a framework evaluating the effectiveness of technology, utilized in teaching, learning, and curriculum development. There were two major questions that were central to this presentation: is technology use beneficial the classroom, and how exactly is it effective? During the course of the research, approximately 300 articles were reviewed, all of which being NCTM publications, PME proceedings, or ERIC database articles.

It is worth noting here that a major difficulty throughout these article reviews was due to the vague interpretations of the results. Others have expressed their difficulty in answering open-ended questions about technology's effectiveness, claiming that "research on this mode of teaching is sparse and open research questions are plentiful" (Engelbrecht & Harding, 2005). Many of these research-based studies do not completely answer the question of effectiveness, provide an adequate amount of quantitative results, nor show favor for technology use. The crux of the research focused on the effectiveness of technology, and even with the limited studies available on the topic of technology in the math classroom, fewer articles stress exactly *how* technology is beneficial in the classroom.

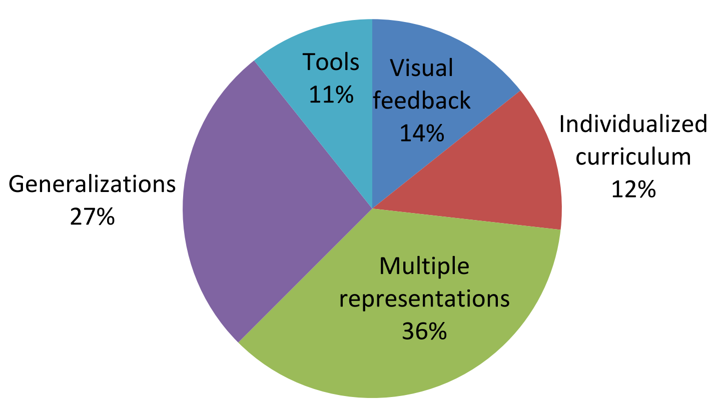
Our research project began with the review of over 300 articles that focus on technology and mathematics education. These studies were classified into five groups, revealing effectiveness of technological use to students learning of mathematics. First, technology has the capacity of providing *instantaneous visual feedback*, allowing the student to observe how a correct or incorrect input will alter the solution. Second, the use of technology assist in design of *student-centered learning* environments, allowing the student essentially personalize curriculum, focusing on student's individual needs. Third, technology provides *multiple representations* for the same content, allowing students to utilize a variety of tools, methods and algorithms to investigate mathematics, otherwise unavailable. Fourth, the *combination of learning environments* (technology and non-technology or two different technology programs) helps students create generalization of problems and allow them to solve similar yet more advanced problems. Finally, through the use of history, recordings and other technological remembering (memory) tools, students are able *to retrace the steps and reevaluate the solutions* to identify past mistakes and recognize patterns that will achieve success in the future.

The breakdown of the five subgroups is illustrated in figures 1 and 2:

Figure 1:

Topic	Number of Articles	Percentage(out of 300)
Instantaneous visual feedback	8	4.67
Individualize curriculum	7	2.33
Multiple representations/multiple intelligences	20	6.67
Combination of environments and generalizations	15	5.00
Tools (history, save, etc.)	6	2.00
Research without explicit assessment of technological benefits	244	80.33

Figure 2:Technology Impact in Learning



The aim of this presentation is to discuss one of the most popular and best represented categories of the five subgroups: *multiple representations*. This domain of the research focuses on a particular result of effective technology use; articles stress how technology deepens students' understand of mathematical concepts due to multiple ways of learning.

A number of positive results were discovered, revealing how technology supports the learning environments that accommodate students' diverse intelligence levels. Several examples are discussed, illustrating commonalities among outcomes. First is an experiment conducted by Pitta-Pantazi and Christou (2009). A pre- and post-test was administrated to forty nine 6^{th} graders before and after using dynamic geometry software Euclidraw Jr. After the pre-test, lessons focused on constructing lines, shapes, and angles were implemented. The students then took a posttest, which focused its results on how students did on the topic of area of triangles and parallelograms. From the results of the posttest, taken without a computer, students, who used the dynamic geometry in class, increased their scores compared to the pretest by a mean score of .10 to .25. What is unique about this study is that it focuses on multiple intelligence levels and methods students learn best, such as "analytic verbalisers" or "wholist imagers" (2008). All students, regardless of their primary method of learning, increased their mean scores compared to the pretest. In another experiment, Dugdale (1994, 2008) used the program Green Globs with 49 students, 25 in a geometry class and 24 in an Algebra II class. Students were to create functions, located in the designated place on the Cartesian plane, working for approximately three hours over a three-week span. After administering a pre- and posttest, students increased mean scores in both the Algebra and Geometry classes by 15% and 42%, respectively (2008). The Green Globs program allowed students to work on an individual basis and small group settings, and was able to contribute to the learning of both Algebra II and Geometry classes, according to the increase in the pre- and posttest. Finally, Borba and Confrey (1993) look at a case study and the uses of Function Probe through interviews which implement Function Probe's ability to make transformations of graphs and the corresponding tabular values. It this case study, participants were asked to predict tabular values from graph manipulation, and during each interview the participant's algebraic language increased. One particular individual was able to hypothesize about different properties of quadratics, using primarily the correlation between graph and table, and understanding their interdependence. These are a few examples of research on the topic, all of which highlight the effectiveness of using technology to enable the design of multiple representations to enhance learning.

Technologically enhanced learning environments impact the quality of student learning mathematics. By identifying ways that technology has proven to be effective, a foundation for bettering technological methodology can emerge. This presentation is a part of a larger research study that focuses on the design of the system of interpretive frameworks that enable the design of meaningful assessment of technological impact, and effective technologically-based learning situations. It will also enable us develop a better understanding of the terms of cyberlearning and cyberteaching.

References

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