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A Reaction to Garofalo, Drier, Harper, Timmerman, and Shockey

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Teacher preparation programs cannot ignore their important role in providing many positive and instructive experiences with using technology in the teaching and learning of mathematics. This role is critically important when research points to the lengthy process of teachers developing competence and confidence in teaching with technology themselves (Dwyer, Ringstaff, & Sandholtz, 1991; Means & Olson, 1994).

Graduating preservice teachers (PSTs) should not need in-service training the moment they leave the college halls. Thus, we concur with Garofalo, Drier, Harper, Timmerman, and Shockey (2000) that an effective way to bring about enhanced student learning of mathematics through technology is to prepare PSTs to incorporate into their teaching an array of activities that engage students in mathematical thinking facilitated by technology.

The authors make this point even stronger by indicating that it is the most direct and effective way to bring about a positive change in student understanding, where "student" means a school student. Research is needed to document the relative impact on PSTs having such experiences, as compared to the other suggestions presented in the paper for incorporating technology in teacher education.

The activities the PSTs complete, as described by Garofalo et al., are designed for secondary mathematics students, and most (not all) of the mathematics they engage in is "old" mathematics for the PSTs. Granted, PSTs may have forgotten some of the mathematics they learned. The PSTs claim that, had they been presented the material in a fashion similar to the current mathematical activity, they would have understood it far better and retained it far longer. However, the "nagging" memory of how they first encountered and constructed the mathematical ideas typically prevails when confronted with their initial teaching experiences and a traditional text (Benkin & Wilson, 1998). Fine and Fleener (1994) found, too, that just having experiences with calculators did not cause PSTs to think differently about mathematics but that they need to be engaged with mathematics learning in a new way. In fact, if PSTs are not prepared properly for the appropriate use of technology, they may see its incorporation as an added and possibly unnecessary stage in learning new mathematical content. We believe the PSTs need to be engaged in more activities that are designed for *their* level of understanding, present *new* mathematics, and are facilitated by the use of technology in their *initial* constructions, so the PSTs can determine the impact of technology on their own "first" learning versus a "revisited" learning.

Jones (1995) noted that learners must develop an "intelligent partnership" with the technology they use. A follow-up on the PSTs retention of the concepts related to fractals and other new mathematical ideas from the activities would have been useful to include. Many of these types of experiences need to occur outside of their mathematics education courses. We are *not* saying that activities focusing on secondary school mathematics should not be included. Those activities are also a necessary component of preparing the PSTs, but we believe they need to go beyond that type of experience and include those in which the initial mathematical constructions were facilitated by technology.

Garofalo et al., stated that "in the course of completing these activities, PSTs not only learn how to use the technology, but also how to incorporate technology into their teaching." We would like to see more evidence of this claim. Based on our personal experiences, students are not prepared to incorporate technology into their teaching after being engaged in such activities. Their understanding of some mathematical concepts has improved dramatically, but the design of lessons making appropriate use of technology remains a challenge.

For example, when presented with crafting a lesson on linear functions and their graphs, the PSTs now may think of incorporating graphing calculators and motion detectors, but the assessment tasks will likely maintain a traditional focus on skill development. They may ask students to find the slope, but they will not connect the value back to the context of the problem. When students raise questions about other types of graphs, the PST falls back to the linear function objective and squashes further student learning. They do not know what types of questions to ask the students during the task to assess their understanding of *x-y* coordinates, their motion, slope, intercepts, etc. The actual development of questions was only a small part of (or perhaps nonexistent in) the PSTs' technology activities from their teacher education program. The inclusion of assessment design for lessons was not evident in the paper but perhaps it is a part of the activities presented. We believe that this aspect needs to be addressed more clearly.

The authors use five guidelines to shape the development of the activities: introduce technology in context, address worthwhile mathematics with appropriate pedagogy, take advantage of technology, connect mathematics topics, and incorporate multiple representations. These five guidelines encompass critical areas of concern when implementing technology in either content or methodology courses. We are curious about the assessment of the PSTs' understanding of the five guidelines. This connects back to the PSTs incorporating technology into their own lessons. Are they aware of how they are making use of the technology when they design a lesson?

The activities presented are great examples of how to make effective use of technology and include a variety of platforms, software, and mathematical topics. The authors have provided a good resource of ideas for others to implement in their mathematics teacher education programs.

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