The Effectiveness of Computer-Assisted Math Instruction in Developmental Classes

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While there are numerous pedagogies used in teaching mathematics, this literature review will shed a light on those with a focus on learning through computer-assisted instruction (CAI), in both hybrid format and online instruction. The efficacy of CAI will be compared to traditional, face-to-face instruction of mathematics in developmental classes. Exposing students to the course content is often not enough for them to achieve academic success in mathematics. Implementing a variety of instructional strategies that increase students' motivation and meaningful learning are also necessary. Implications from this research study suggest that institutions should offer developmental mathematics courses in a variety of formats (other than traditional format), assist students in selecting the mode of instruction that best suits their learning style, and provide professional development in computer-assisted instruction.

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Traditional Instruction

Traditional instruction is teacher-centered and includes various components, including facilitation of lecture material, teacher modeling of concepts, thinking aloud, and guided practice and drill, followed by teacher correction and feedback (Kinney and Robertson, 2003). In this direct mode of instruction, the teacher takes the role of an expert who decides what and how material is to be learned (Brown, 2003; Kinney and Robertson, 2003). A study by Grasha (1994), which examined the teaching styles of 381 faculty members at 200 U.S universities, showed that 60% were adopting a teacher-centered mode of instruction. This often happens as a perpetuation of the same instructional method that these faculty members were taught or felt some comfort with. Therefore, students at the developmental mathematics level are still receiving the traditional method of instruction (Armington, 2003; Kinney and Kinney, 2003; Miles, 2000).

Traditional methods of mathematics instruction present some disadvantages due to teachers' focus on content and standards more than on students' needs (Brown, 2003). According to Mahmood (2006), direct instruction is comparable to the teacher being the "sage on the stage, but not guide on the side" (p.25). Brothen and Wambach (2000) found no major significance in learning mathematics when lecturing is chosen as a mode of delivering math instruction in developmental classrooms. This was causing high dropout rates, such as at Southwest Texas State University, where it reached almost 50% in intermediate algebra (Armington, 2003).

In most colleges and universities in order to enhance learning, the traditional instruction of developmental mathematics has been supplemented with some technological tools such as whiteboard, chalkboard, overhead projectors, PowerPoint, or graphing calculators (Armington, 2003). Other pedagogies, such as peer collaboration, tutoring, and math computer labs (Kinney, 2001), together with group learning activities (Wright and Lamb, 2002) have found their way into math classrooms that previously relied solely on traditional modes of instruction. In his study, Armington (2003) suggested limiting teacher presentation of the material to 15 minutes and using cooperative learning afterwards, which empowers students to contribute to the learning process. Graphing tools are also incorporated to allow students to visualize math problems and solve application problems (MacDonald et al., 2002). All of these pedagogies and instructional tools help students construct their own learning, increase their confidence in solving math problems, and decrease

their math phobia, which results in higher math performance (Hall and Pontoon, 2005).

Despite the variety of these pedagogical tools, a qualitative study by Kinney (2001), which used student surveys, focus groups, and questionnaires, claimed that students were still attached to the traditional "way" of teaching as it provides them with more human interaction and opportunities to ask questions and receive frequent teacher feedback.

It seems safe to conclude that a balanced traditional instruction that includes (at most) 15 minutes of presentation coupled with practice and drill is more efficient for student learning of developmental mathematics. In addition, traditional instruction is even more effective when it implements a variety of sound pedagogical tools that fit into the curriculum and fulfill students' needs and objectives.

Hybrid Method of Instruction

A common mode of math instruction in developmental classes is the hybrid mode, in which traditional face-to-face instruction is supplemented by online instruction. This computer-enriched pedagogy, which includes both teacher-centered and student-centered instruction, provides online tutorial and practice material, together with assessment tests and multimedia materials (Kinney and Robertson, 2003). It is designed to only supplement the face-to-face instruction. Today, many textbook publishers compete in providing the best computer software to supplement their math textbooks, especially in developmental mathematics (Kinney and Robertson, 2003). This provides instructors with an opportunity to assign online homework, quizzes or exams, in addition to supplementing a variety of text and media tutorials to re-emphasize the covered material during the face-to-face instruction (Olusi, 2008).

The previously cited qualitative study by Mahmood (2006) on the efficacy of online interactive tutorials and guided practice in students' learning of math concepts revealed that students become more engaged and more participatory in the learning process. A study by Hannfin and Foshay (2008) that surveyed 236 students-users of math web instructional material claimed that providing individualized study guides and regulated review plans were the features that students found most appealing. This again increases students' participation and gives them a reason to compete for a better score. The frequency of testing and feedback are among the significant pedagogies of computer-assisted instruction of mathematics, as

confirmed by the National Association of Developmental Education (Boylan, 2002). The media tools available online enable students to better visualize math contents and experience their various applications, including manipulation of the different parameters that contribute to the solution (Mahmood, 2006).

From these studies, one can conclude that there is strong evidence that computer assisted traditional math instruction exposes students to combined modes of instruction, both face-to-face and online, and offers a variety of tools and features to promote students' understanding of math topics. In addition, computer-assisted instruction helps students correct their misconceptions and increases their motivation and contribution to the learning process.

Online Distance Learning

Online distance learning has shown remarkable growth in all fields of education, including mathematics. More colleges and universities are reaching out to a variety of students by promoting their distance learning education programs and offering a wide range of specializations and degrees. According to the National Center for Educational Statistics (NCES, 2003a), the number of institutions offering online or distance learning math classes increased by 14% from 1994 to 2001. These programs were serving a student population of about 837,892 individuals.

Usually, students opt for an online course because of the variety of additional resources (including media), the self-regulated learning model, of the opportunity for more immediate instructor feedback, and the overall satisfaction from this learning experience (Kinney, 2001). However, both the opportunity for online learning and satisfaction with the experience are not necessarily shared by all students. In a survey study conducted by the Pew Internet and American Life Project (2002) on 27 public and private two-year and four-year colleges, the number of students who took an online course did not surpass 6%. Of these students, 52% found it to be a significant learning experience, while 50% thought they could have benefited more from a traditional mode of instruction.

The online mode of learning and instruction delivery has growing potential, especially for developmental classes, for numerous reasons, such as convenience of accessibility (asynchronous learning), self-paced and individualized learning and instruction, guided practice, and prompt feedback and assessment (Kinney, 2001; MacDonald et al., 2002). According

to a study done by the National Center for Educational Statistics (2003b), 31% out of 3230 surveyed colleges used computer-assisted instruction for in-class remedial math education, and 13% used distance learning. The access to computer technology has become less expensive and more engaging to students due to the wide range and quality of instructional math units (Trenholm, 2006). Students can revisit the same concept multiple times until they achieve mastery and develop confidence (Brothen and Wambach, 2000). Students also become engaged in an exploratory response to learning and acquire the necessary habits and skills to control their own progress and achievement (Brothen and Warmbach, 2000).

The first online mathematics courses were designed to replicate the traditional classroom (Englebrecht and Harding, 2005) and were limited to media and tutorial material, in addition to providing students with practice before testing (Armington, 2003). Later, this procedure was developed further to make the whole package completely accessible online (Armington, 2003; Coggins, 1999). Within this student-centered environment, the instructor takes a facilitating and coaching role (Brown, 2003) by providing needed resources, directions, and substantial feedback. In turn, students need to acquire skills such as motivation, self-efficacy, and focus in order to be successful in online developmental math classes (Heubeck, 2008). Data on how students learn and the challenges they encounter in online math education are usually gathered to improve the effectiveness of the learning and teaching strategies.

Meta-analyses conducted by Kulik (1986) on 123 colleges indicated significant effect size for developmental math instruction, where students' learning rate increased significantly, their post-test scores were higher, and their attitude towards learning improved. A more updated meta-analysis conducted by Kulik (1991) used 254 studies, in which he compared traditional modes of instruction with purely computerized models for an age-varied student population. This study supported the findings of his former one, with an even faster rate of learning. In addition, 81% of these studies indicated that students receiving computer-based instruction reflected higher examination scores, with an effect size of 0.37. According to Liao (2007), this pattern has increased in a more recent meta-analysis of 52 studies, conducted on 5000 subjects including math and statistics. This analysis found that overall, computer-mediated instruction showed a large effect size (0.552), and in math instruction, an even larger mean effect of 0.823.

Computer-assisted learning systems, such as ALEKS, were studied by Stillson and Alsup (2003) in order to examine their effectiveness in supplementing traditional instruction in developmental mathematics. The results demonstrated better math achievement, associated with higher mastery scores, and more extensive time devoted to the math units. A Blackboard platform implementing resources and instructional tools for developmental mathematics was studied by Boggs and Shore (2004). Their study revealed that the variety and accessibility to such resources, the automatic feedback, and the convenience of managing objectives allowed for mastery of math units and achievement scores. Studies conducted by Pearson Education (2005) on the use of the MyMathLab online learning system in two-year and four-year institutions, indicated that nearly 90% of student populations found substantial help in using the online supplemental resources, and that more than 80% achieved higher grades in their developmental math classes.

In all, it is safe to conclude that the above studies demonstrate a potential growth and success rate of online methods of instruction as opposed to traditional modes of instruction. However, research in this area has been limited because the online-learning concept is still a new and evolving phenomenon. In addition, not all students and their teachers find it a pleasant experience due to the nature of mathematics as a subject, and also because of the lack of direct human interaction in a computerized environment (Smith and Ferguson, 2004).

Conclusion

The above studies reveal that both purely traditional and completely online modes of instruction are less effective than a combined approach. A hybrid approach is more balanced and exposes students to a combination of both methods. It incorporates a variety of pedagogies and strategies that positively affect students' learning and allow for their smooth transfer from traditional to online environments (Wadsworth et al. 2007). This is especially essential to developmental math classes, where students often lack motivation, maturity and time management skills.

Substantial professional developmental programs need to be designed around teaching, training and the sharing of experiences among online instructors. Objectives should aim at effectively matching the needs of students, instructors, and the course curriculum in a blended format of instruction (Barabash et al., 2003). Further research on e-learning and internet use in developmental math classes is also warranted, as software

and hardware tools are evolving exponentially, which affects the conceptualization and implementation of effective technologies and pedagogies that enhance students' learning and instructors' delivery of math content (Woodward, 2004).

As reported, there are several critical factors that are significant to the success of online or blended format instruction (National Center for Academic Transformation, 2005). These factors include student motivation, self-efficacy, self-discipline, self-direction, and time management. Nevertheless, when used properly, computers can create an environment of effective interaction, active participation, constructive feedback, and significant learning outcomes (Roschelle, Pea, Hoadley, Gordin, and Means, 2000).

Finally, colleges and universities need to establish assessment and screening tools that determine the appropriate mode of instruction and environment to best meet students' needs. Educators must implement effective learning strategies that are aligned with academic objectives and are conductive to meaningful learning.

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