

Behnaz Rouhani, Ph.D.

Assistant Professor of Mathematics

Georgia Perimeter College

2101 Womack Road

Dunwoody, GA 30338

(770) 274 – 5368

brouhani@gpc.edu

Curriculum of an Online College Algebra Course: How is it Different, and Why should it interest Mathematicians?

This article looks at different aspects of the curriculum when a college algebra course is put online. It begins by presenting a brief overview of the history of online education, and the influence of the online education in the design of the mathematics courses. Next, it focuses on the various aspects of the curriculum that are likely to change as a result of putting this course online and those that are not expected to change. Finally, this article concludes by discussing the reasons why mathematicians should be interested in exploring the changes that entail in presenting the college algebra curriculum in an online setting.

The invention of the World Wide Web in 1992 (Harasim, 2000) has provided universities and colleges with a powerful tool that if used properly, could furnish an effective and efficient teaching tool to bridge the distance between teacher and students and among students themselves. Web-based instruction is an innovative approach for delivering mathematics instruction to a remote audience. As West (1997) explained, in today's economic situation a worker's frequent career changes make lifelong learning or continuing education necessary, despite the pressures of work, family, and social life.

Distance modes of learning have become popular worldwide over the past three decades, especially in the areas of mathematics and mathematics education (Arnold, Shiu, & Ellerton, 1996). Online learning has become a recognized method of education for traditional and nontraditional students, and a great number of colleges and universities offer online mathematics courses. Online learning offers a solution to meeting

educational needs at all levels. It makes college education available to students who are not otherwise able to attend school.

The computer communications revolution of the 21st century brought a “paradigm shift in attitude towards online education,” and “our new understanding of the very nature of learning has affected the definition, design, and delivery of education” (Harasim, 2000, p. 42). Computers have increasingly been used as tools for computational purposes and understanding of abstract mathematics. Van Weert (1994) argued that computers will also force mathematics education to change its focus, its organization, and its use of technology. He continued:

The focus will change from teaching to learning, its organization will change from rigid class based learning to flexible team based learning, technology will be integrated into the learning process and will support both this new organization of learning and the learning tasks of the individual student. (p. 621)

During the 1990s, many distance education course developers believed that the main goal of any mathematics education course was for the teacher to enable the student to learn basic knowledge and skills (Arnold et al., 1996). These course developers viewed mathematics as a body of facts, definitions, and theorems that were independent of human reasoning. Most conceded that while mathematics was associated with reasoning, distance mathematics courses should not be very concerned with this aspect of the field. This kind of orientation, as described by Ellerton and Clements (1990), has given rise to the notion that mathematics curriculum for distance courses “should be hierarchical in nature” (p. 719), and that online mathematics teachers should emphasize the importance of basic mathematical facts and skills.

Online education influences the educational process and the individual learners in different ways. As more and more colleges and universities embark on offering mathematics courses to geographically scattered populations of students, it is best to know if this method of course delivery is a successful and appropriate method of teaching and learning mathematics. The discipline of mathematics is often considered to be culture free (Ellerton & Clements, 1989) in the sense that, online education materials in mathematics prepared in one part of the world could be used elsewhere with minor modifications.

Online Mathematical Learning

The vast body of research on the learning of complex subjects such as mathematics has demonstrated that conceptual understanding is one of the significant components of one's proficiency in mathematics (Bransford, Brown, & Cocking, 1999). Moreover, conceptual understanding is needed in order for the learner to be able to deal with the new problems and circumstances.

Brown (1978) suggested that there are four types of mathematical learning, namely simple recall, algorithmic learning, conceptual learning and problem solving. Students face problems when asked to remember facts in mathematics, and to learn algorithms meaningfully, but it is the conceptual core of mathematics, which is the hardest feature for students.

Surprisingly, it is not easy to explain what a concept is. A dictionary might state that a concept is a 'generalized idea, or an abstract notion.' Skemp (1971) explained how we learn concepts. He suggested that there is no way we can help an adult born blind but given sight by an operation understand the concept of "redness" by means of a definition.

We could make the person abstract the idea by pointing to different objects that are red or to ones that are not red. This would explain what is meant by 'redness.' Skemp claimed that learning of mathematical concepts is similar. We should not expect students to learn concepts through definitions.

More and more there is a trend in revising the conventional view of mathematics learning as the mastery of a fixed set of facts and procedures to processes that encourage investigations, sense making and communication in a classroom. Bringing about these changes in mathematics instruction requires that teachers possess beliefs about mathematics, teaching, and learning that is significantly different from school mathematics traditions (Battista, 1994; Thompson, 1992). Possibly the biggest obstacle for teachers is lack of familiarity with the processes that most have not experienced as students or teachers. The success of online mathematics education initiatives depends on the identification of ways to encourage teachers to make significant shifts in their beliefs and practices that are deeply tied to school mathematics traditions. Rosenshine and Stevens (1986) point out that all teachers will at some point use all the important teaching skills. However, the effective teacher is the individual who in response to student needs uses the skills at the right time in the right amount.

Mathematics Curriculum in an online college algebra course

The course under consideration is college algebra. To discuss the aspects of the curriculum that are likely to change in an online setting, it is important to note that the curriculum design in distance teaching is often extremely overt. First it is essential to draw attention to the three levels on which the curriculum for the college mathematics courses can be viewed:

- The *intended curriculum*: what is prescribed in syllabus
- The *implemented curriculum*: what teachers teach
- The *attained curriculum*: what students learn.

The course materials are an embodiment of the ‘intended curriculum.’ The overall view of the curriculum design must consider implementation of the curriculum that is how students transform the curriculum as they work through the material, and how educators view this transformation as they work through students’ assignments. Also, take into account the attained curriculum, which is the outcome of students, both in terms of assessment results and their readiness for further mathematics study. In an online version of a course the curriculum development also takes place within the same framework as the traditional mathematics courses.

The curriculum of an online college algebra course should be designed in such a way that it encourages distance-learning skills within the parameters of a mathematics course. It should also provide opportunities for advancement towards the criteria set out for the course as well as reflective learning for the students. A unique feature of an online college algebra course is the delivery of the curriculum-using computer based learning environment. As a result, in order to use the curriculum of standard college algebra course for an online setting it has to undergo significant changes. These changes have meant that online students will have access to the same course objectives in the intended curriculum but with more exploratory approaches that are based on interactivity.

Aspects of the Curriculum that is Likely to Change

Transition to an online setting requires us to give special attention to the following areas in the design and implementation of the online college algebra curriculum that would be different from a standard college algebra course.

Style and Mode of delivery

Text is the learning medium in an online environment, so the challenge is to initiate active learning as opposed to passive reading. As mentioned by Ausubel, “any text used for teaching-learning purposes must be developed in a way to facilitate learning not only by providing information but also by helping the learner to relate newly acquired knowledge to what is already known” (quoted in Holmberg, 1995, p. 88). It is important for the “mathematical descriptions to be precise, necessary, and complete” (Laurillard, 1993, p. 184).

In an online course text is delivered through Internet, so the presented material needs to be more explicit and supportive in terms of instructional guidance. Text will possibly contain questions within the teaching material in order to "provide the opportunity for the learners to respond and the provision of a corresponding answer or discussion" (Lockwood, 1995, p. 205).

Frequency of Contact and Meeting Place

The online classes are asynchronous (no meeting time) as opposed to standard courses that are synchronous (with attendance policies). As a result online students expect to be in touch with the teacher and other students 24 hours a day, and 7 days a week. Chism (1998) argued that distribution lists can be used to share cases, engage

students in collaborative problem-solving, and create an online community as students elaborate on discussions and continue to deal with unsolved issues.

Discussion in a traditional classroom is often spontaneous and free flowing. This means that for students to participate they have to respond immediately; it is a synchronous forum. This format may suit many students, but it could be interpreted as somewhat biased towards those who are not confident about their mathematical abilities and speaking in public. Several studies of student responses to online interaction suggest that students find it useful to see questions and responses from other students, as this helps them gauge where the broad standard should be in relation to others (Jones, 1999). The communication initiated by students and based on the questions that they raise and want further comment is very desirable and beneficial for students (Holmberg, 1995).

Technology

As per Hillman, Willis, and Gunawardena (1994) there should exist an interaction between the learner and the technology that helps deliver the curriculum if students are to spend more time learning the lessons, and less time learning how to interact with the technology.

Assessment

The purpose of the assessment could either be *formative* or *summative*. Formative assessment could be looked at as a way to help form and develop student learning, and summative assessment as a way to sum up what has already been learned. In most distance settings there are usually both a formative and summative component in assessment (Morgan & O'Reilly, 1999). When the two components are well integrated and developed, it is then possible that deep and relevant learning can take place. If

assessment is structured in such a way that one assignment is built upon the next, with formative feedback, it could be important way to enhance students' learning.

The grading scale in the online course is different from the face-to-face class. It would possibly include different components. Unit (chapter) tests will differ, but students take the same-proctored final exam as the standard college algebra course, and the final exam will comprise a higher percentage of their grade. As with the face-to-face class, assessment in an online class is also a major determinant of the *implemented curriculum*.

Teacher's role

In an online environment the teacher is a coach or even a collaborator in the knowledge construction process (Reeves & Reeves, 1997). In this environment, the instructor does not remove himself from educational process. As pointed out by Portela (1999), the teacher's role is shifted from the deliverer of instruction to being the creator of learning experiences for the students.

Aspects of the Curriculum that are not Expected to Change

It is important to note that there are aspects of the curriculum for college algebra course that are not expected to change whether the course is online or face-to-face:

Course objectives

Distance education is not a distinct field of education. McIsaac suggested "distance education, is after all, simply education at a distance with common frameworks, common conceptual concerns, and similar research questions relating to the social process of teaching and learning" (1996, p. 408). When a course is put online, the components of the intended curriculum that deals with the course objectives will not change, however, parts of the syllabus that deals with participation, grading, and

assignments will go through some changes. Also, there will be some changes in the *implemented* and *attained* curriculums, so as to increase their effectiveness and significance.

Motivation

Student motivation is especially relevant to mathematics courses, as mathematics seems to be one of the areas that do not interest students, and they mostly have bad experiences with it. Teachers know that students' learning and memory are closely tied to motivation. Students learn what they want to learn and will have difficulty learning material that does not interest them. As in face-to-face classes motivation plays an important role in an online class.

Multimedia studies have indicated that learners soon tire of the media elements (such as graphics, animation, video, and a user-friendly interface), thus it is important that motivational aspects be consciously designed into online courses as any other pedagogical dimensions (Reeves & Reeves, 1997).

Interaction

As per Salomon (1981), education depends upon acts of communication. Not all communications are beneficial to the learner. According to Salomon, educational communication that facilitates learning should be reciprocal (i.e., two-way), consensual (i.e., voluntary), and collaborative (i.e., shared control). Without interaction, teaching becomes simply "passing on content as if it were dogmatic truth," and the cycle, knowledge acquisition to critical evaluation to knowledge validation, is nonexistent (Shale & Garrison, 1990, p. 29). As pointed out by Sherry (2000) unless the online participation of students is assessed, on average one third of students will seldom

participate in online activities. Likewise in many face-to-face classes participation of students is assessed.

Social context

The social context in which the curriculum is delivered is not likely to change regardless of what mode of delivery is chosen. It is important that in both settings students feel “social presence” (Short, Williams & Christie, 1976) by receiving encouraging gestures, and praise.

Distance education in any subject area is inclined to follow a curriculum design and text structure with specific aims and behavioral objectives (Arnold et al., 1996). These courses progress in a linear manner where answers will be found in the text, and interaction with regard to the subject matter, will be principally with teachers and fellow students in the course. Such designs have been common in mathematics courses offered at a distance. As pointed out by Chambers (1995), however, changes in emphasis leading educators away from behaviorism and toward constructivism and reflective learning present strong challenges to objective-driven course designs. The technological developments (Burge, 1995) have enabled educators to offer non-linear course designs through the use of hypertext and multimedia, and have provided students with the opportunity to access coursework through idiosyncratic paths.

Mathematicians and the Presentation of the Online Curriculum

The responsibilities of mathematics teachers are vast. They have to (a) set goals, and select or create mathematical tasks for the students; (b) stimulate and manage mathematical interaction; (c) create a classroom environment to support teaching and learning mathematics; (d) analyze student learning, and the mathematical tasks in order to

make instructional actions (NCTM, 1991). Also, it is important that teachers be more familiar with the research on teaching of online mathematics.

Brophy (1991) suggested that teachers' beliefs and knowledge of mathematical subject matter are important factors on how they handle the challenges of the classroom instruction. There exist a complex relationship between teachers' beliefs and classroom practices.

Cobb (1995) suggested that mathematics is learned through an active, social process of construction. Teachers' beliefs of how students learn mathematical concepts and engage in such activities are important factors in helping them to design and execute an effective instruction. Helping teachers to make sense of how students' understandings develop can help them anticipate the different mathematical activities that will help specific students' learning (Even & Tirosh, 1995). Shulman (1986) distinguished between three categories of teachers' content knowledge: (a) subject matter content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge. The pedagogical content knowledge is the knowledge that goes beyond knowledge of the subject matter to the dimension of the subject matter knowledge for teaching. Pedagogical content knowledge includes an "understanding of what makes the learning of specific topics easy or difficult: the conception and preconceptions that students of different ages and backgrounds bring with them" (p. 9). Simply put, "understanding of what makes the learning of specific topics easy or difficult" is basically the research on how to teach a topic, and the preconceptions are at times misconceptions, and the teachers need the knowledge and strategies in "organizing the understanding of the learners" (p. 10).

For instance, several researchers have found that students seem to prefer symbolic representation of functions to its graphical form, and do not have a full understanding of the information embedded in graphical representation of functions (Clements, 1984). On the other hand results of a research conducted by Norman (1992) of a group of teachers contrasted considerably with the findings of Clements (1984). He concluded that teachers in his research preferred graphical contexts to numerical and symbolic ones, and they all lacked deep understanding of the concept in spite of their years of experience.

Teachers need to develop an appreciation on how students' understanding develops so that they can put together mathematical activities that will help specific students' learning (Even & Tirosh, 1995). Ball (1993) describes this process as a "bifocal perspective - perceiving the mathematics through the mind of the learner while perceiving the mind of the learner through the mathematics." (p.159). This is an important concept for teachers to appreciate. The act of teaching is a learning process, which is entwined with teachers' beliefs about mathematics. In order for teachers to develop this perspective it is important that they be involved in the research as it offers substantive guide about different presentation of content, mathematical and pedagogical ideas, what students might believe or understand about a particular mathematical activity and content matter. Cooney (1988) states that it is teachers who decide how the innovations envisioned by researchers become implemented in mathematics classrooms.

Consider, the experiences of Mr. Allen, a high school mathematics teacher who was studied over the years as he taught functions using reform-oriented curriculum materials. In the first year that Mr. Allen was using this material, he like other teachers in Norman's (1992) study preferred graphical representation of functions. After teaching

with this curriculum unit his view that graphs offer optimal display of functions changed. At the beginning of the second year the researchers observed a marked change in Mr. Allen's beliefs as he explained to his class, "There are many ways to take a look at a function: there's a graph, there is a table, there is a word expression, or you can get an equation or a rule" (Lloyd & Wilson, 1998). Now, the question is what can we attribute Mr. Allen's change in beliefs to? From Mr. Allen's viewpoint his change was directly related to his experience teaching with this new curriculum. This case illustrates that teacher's knowledge of new curriculum, or research in the field of functions can extend teachers' knowledge to include more "conceptual and relational understanding" (Lloyd & Wilson, 1998).

Ball and Cohen (1996) state that implementation of innovative materials provide powerful tools for teachers to learn about themselves, their students, mathematics, and the teaching and learning of mathematics.

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