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Observations on How Students Approach E-Mathematics Courses

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Abstract. As a part-time mathematics faculty member, I have had many opportunities to work with a variety of students using various online mathematics platforms. I have made some observations about how students approach e-mathematics courses. Here, I report on my experiences of how students, developmental mathematics students in particular, approach e-mathematics courses, point to possible reasons students do not fare as well as we would like in these courses, and discuss approaches I and colleagues have used to better support students when using e-resources.

Background

For various reasons many community colleges and universities have turned to computer-based electronic, e-mathematics courses. The reasons range from lack of resources to support the population of students who need developmental mathematics (i.e., need mathematics skills that are one to four levels below college level), to limitations in the number of instructors, funding, and classroom space for the needed developmental courses. One of the major challenges for developmental mathematics courses at community colleges is the high turnover in enrollment (from failure in, or dropout from, the course). Moreover, students in developmental mathematics often repeat a course two or more times. A recent study indicated that only about 13% of students who start four levels below college level mathematics ever complete a college level mathematics course (Perry, Bahr, Rosin, & Woodward, 2010), Even for the successful student, it could take four semesters of coursework to reach the college level mathematics needed to complete a two-year degree.

Publishing companies have designed textbooks containing internet and computer-based software packages for e-courses and as resources to supplement face-to-face and hybrid classes. The number of e-courses offered and the enrollment in them has increased dramatically during the past several years (Bailey, Jeong, & Cho, 2010). Yet research shows a wide variation in the effectiveness of e-courses in mathematics with results not generally statistically significantly better than more traditional courses (Spradlin, 2009; Stoneham, Moore, Slate, & Martinez-Garcia, 2017).

Mathematics Learning Labs or Centers

These types of on-campus spaces have been an integral part of the community college mathematics curriculum for the last fifty years and are finding their way into four-year colleges and universities. One aspect of these labs is the tutorial, self-paced, programs for students who need remedial work. Over the years, the mathematics lab has seen several variations of self-paced innovations. "Audio-Tutorial" is one example where segments or entire courses were presented via synchronized audiotapes and slides. "Computer Assisted Instruction," where the computer is programmed to act as a teacher-tutor is another example, and continues to be a common platform, especially when available online (as opposed to only being available as software on a lab computer). Most colleges that offer mathematics e-courses have math labs equipped with many computers that students can use for the course. These labs generally have hours that start early in the morning and go late in the evening on weekdays. Many are also open half days on the weekends, making the math labs convenient and accessible for students who have busy schedules and may not have computer access elsewhere. In my experiences, mathematics tutors and mathematics faculty generally staff the labs.

As a part-time mathematics faculty member, I have had many opportunities to work in such labs at various community colleges over the past five years. Through my work with students at the labs and conversations with students enrolled in the e-courses, tutors, and faculty, I have made some observations about how students approach e-mathematics courses.

I am happy to report that, in general, students take advantage of the campus computers, math labs and the lab staff. In informal discussions, students have reported that the benefit of using the labs (as opposed to a home computer) is the access to math tutors and faculty at the labs. Though some models I have seen for such courses require students to spend a certain amount of time per week in computer labs, students seem not to object to the time commitment because of the access to the tutors and faculty at the labs. They also report that the attendance requirement forces them to set aside time to focus on their mathematics course.

Illustrations

In the self-paced courses I have observed, student success is determined by a series of exams. To prepare for those tests, students are generally prompted to approach the coursework in the following manner:

- Step 1. Complete a given section by watching video lectures, reading multimedia textbook sections and/or viewing narrated lectures with slides (e.g., a PowerPoint®presentation) and notes.
- Step 2. Do multimedia textbook exercises on the computer or from a textbook; typically, there are exercises for each section to be covered in the chapter.
- Step 3. Once the exercises are completed for a given chapter, take a chapter quiz on the computer.
- Step 4. After taking a chapter quiz, review and practice the topics that they had difficulty with and take the quiz again.
- Step 5. Once all the chapters and quizzes pertaining to a given exam are complete, take a test on the computer. In most cases, students may review and practice topics that they had difficulty with and take the test again.
- Step 6. When students have a score of 80 or better on the chapter test, then they take the associated written exam, upon which grading is based. Otherwise, it is recommended that they review the material again before they take the written exam.

The video lectures, multimedia textbook and/or narrated slide lectures and notes in Step 1 are often glossed over by students. Many will skip directly to the exercises. For some, the links go completely unnoticed, or so they report. When working in the lab I ask students, especially those who do not seem to make progress without tutor or faculty support, if they have considered the available online textbook, video lectures or notes. They respond by reporting their perceptions: "There is no book you just have to figure it out from the examples," "I didn't understand the example" or "Not all of the problems have videos." These students seem surprised when I point out the multimedia textbook and narrated slide lectures and notes links.

Students spend a great amount of time on Steps 2 through 5, striving for perfect scores on the computerized assignments. Generally these section exercises, chapter quizzes, and tests can be repeated as many times as the student wishes, though there are deadlines associated with the written exams. However, high scores on these aspects are not indicative of high scores on the written exams. Since written exams are generally the bulk of the grade, students become frustrated that the time commitment does not correlate with their grade.

For the exercises in Step 2, the students get immediate feed back on the accuracy of their answers. Generally a green check appears for correct answers, and a red X for incorrect answers. Whether their answer is correct or incorrect, students are given the option to try a similar exercise for more practice or to move on. I have noticed that students are unlikely to opt to try a similar exercise if the answer they entered was correct, even if the correct answer came after many tries and/or assistance from a tutor. If the answer was incorrect, students are very likely to try a similar item because they want that green check. Some students have reported that there is something really fulfilling for them to see that little green check. But before trying again, students tend to select the Show Answer or other help links. Students can copy the solution and/or compare it to what they wrote and try to adjust their solution accordingly, as an exercise in mimicry (not meaning-making). They then repeat the same procedure on the next item. For example two successive problems in the software might be:

$$\text{Simplify the rational expression } \frac{3-x}{4x-12}.$$

$$\text{Simplify the rational expression } \frac{5-x}{2x-10}.$$

The benefit is that the student gets to practice the same learning objective. If the student clicks on Show Answer, a way of representing the mathematics is modeled. The detriment is that students can develop a process view of problem type rather than a concept view of the mathematics. The process view does not allow for generalization and application to questions of a slightly different form. To continue the example given above about simplifying rational expressions, after watching a student successfully reason through the second of the problems based on what they learned from the Show Answer link, I stepped in and asked the student to:

$$\text{Simplify the rational expression } \frac{2-3x}{6x-4}.$$

The student responded that my follow up question could not be simplified because a 6 cannot be factored out of the denominator. Over the next few days I found that many students had the same misconception that the coefficient of the x is what is to be factored out. The e-course software did not push students to confront this assumption.

A related procedural approach to using e-course resources is a pattern matching, a sort of "find and replace" method for doing problems. For example, I went over to talk to one student because I noticed that she had spent a lot of time looking at the View an Example help option. I was interested in what she was getting out of the tool. This student spent a lot of time in the math center, was making great progress through the self-paced material, earning perfect or close to perfect scores on the homework, and passing the exams. She reported that problems with any sort of geometry were a big stumbling block for her and explained her method of understanding them for the test as she walked me through her work on the problem in Figure 1.

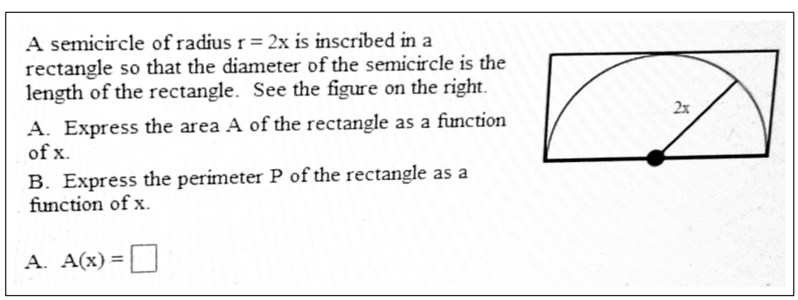
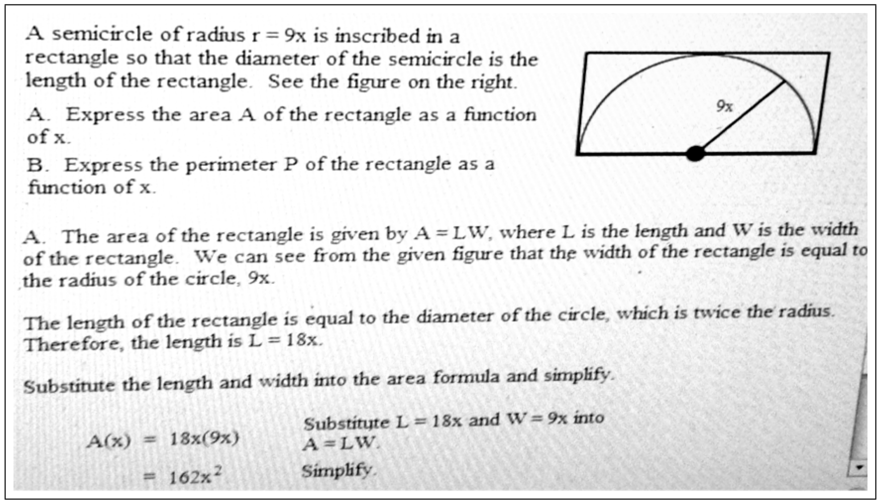


Figure 1. Online geometry item (notice $r = 2x$).

The help offered on the item in Figure 1, through clicking on View an Example, is shown in Figure 2 (next page). Notice that it is the same item as the original problem shown in Figure 1 with $2x$ replaced by $9x$.

The student pointed out that View an Example gave the same question and it was helpful because now she just needed to find the "parts that match." Since the example had a $9x$ and her homework question had a $2x$, she said that she just had to replace every $9x$ in the example solution with $2x$.

Skipping down to the end of the explanation, she decided the answer would be $18x(2x) = 36x^2$ and was prepared to enter $36x^2$ as her answer. I asked her, "Where did the $18x$ come from?" She pointed to the screen and said, "it says $18x$ times $9x$, so I need to put $18x$ times $2x$ because mine has a $2x$." Then I asked, "Why $18x$ and not $5x$ or $12x$ or anything else?" This prompted her to read through the explanation again. Then, again pointing to the screen, she said "they multiplied the $9x$ by 2 first to get the $18x$, so I need to multiply the $2x$ by 2 first and then that by $2x$." She went on to say and write in her notes that she needed to remember to multiply the part with the x by 2 first, then multiply it by itself again to get the area.


A semicircle of radius r = 9x is inscribed in a rectangle so that the diameter of the semicircle is the length of the rectangle. See the figure on the right.

A. Express the area A of the rectangle as a function of x.

B. Express the perimeter P of the rectangle as a function of x.

A. The area of the rectangle is given by A = LW, where L is the length and W is the width of the rectangle. We can see from the given figure that the width of the rectangle is equal to the radius of the circle, 9x.

The length of the rectangle is equal to the diameter of the circle, which is twice the radius. Therefore, the length is L = 18x.

Substitute the length and width into the area formula and simplify.

A(x) = 18x(9x)   Substitute L = 18x and W = 9x into A = LW.

= 162x²   Simplify.

Figure 2. View an Example screen for the item in Figure 1 (notice $r = 9x$).

This particular student had a great capacity for memorizing problem types, and recalling "how to" steps without connection to the underlining mathematical ideas. She reported that she enjoyed opportunities to rethink problems with me, or one of the tutors, because if she understood it, it would be one less problem type she would have to memorize for the test.

Steps 3, 4 and 5 are successively more taxing test-like situations for the students. More and more ideas are incorporated on a problem set and students may not have a View an Example type of link (generally only available in e-texts in practice or homework problems). Note that I wrote "a problem set" and not "a problem." The exercises in these steps are isomorphic subsets of the exercises from the sections and chapters students have worked on previously. Students may refer to their past work while doing these quizzes and tests. So, while more ideas are incorporated from various sections there is little need for synthesis, just recall and referencing past work.

In many e-courses, the written exams in Step 6 count for most of the grade. Students can be disheartened at the contrast between their online scores and written test scores. I have had students tell me that they do not understand how they can get all As on the online work but fail the tests. As others have noted, the language and style of mathematics textbook presentation is a key aspect of this disconnect. Students in an e-course are asked to rehearse actions without the effort of communicating with others about concepts – an effort that would allow learners to practice standard terminology. Moreover, the exercise sets are not designed to support synthesis of ideas. For example, an exam question was given as follows

$$\text{Determine the domain of the algebraic expression } \frac{x-6}{x^2-13x+42}.$$

Students who have a procedural experience of algebra are likely to give one of two answers: $\frac{1}{x-7}$ or $x \neq 7$. The rational expression as an answer arises from the expectation that the default goal when seeing an expression is to simplify it. This is not unreasonable. The majority of rational expression problems, especially the most recent ones (i.e., closest in memory) the students have encountered only required them to simplify the expression (not consider the mathematical consequences of the simplification).

One reason Steps 1 through 6 may not support learning for many is that students do not follow the steps in the ways that e-course designers and implementers expect. This distance between the expected curriculum and the achieved curriculum has been described by Walker (2008). Her work indicated that in the absence of a compelling structure inside the e-course, the bridge between expected and achieved curriculum relied on the student's own self-regulation:

> The catalyst for success for a College Algebra Internet student, is that of self-responsibility. . . . It helped to have a solid mathematical background, a good attitude, and a strong structural support network. However, those participants who prioritized and devoted their time to enriching their mathematical skills and staying focused on the goal had the most success in the course regardless of any other factor. (pp. iii-iv).

Conclusion

In a classroom setting for developmental courses, beyond teaching the students mathematics there are opportunities to teach them how to be a college student. For example, there are opportunities to model how to look to the textbook and classmates as resources for learning, for students to articulate their mathematical reasoning and hear that of others. Arbaugh and Benbunan-Fich (2006) found that students in MBA courses reported significantly higher scores for perceived learning and delivery medium satisfaction in courses where teaching approaches were supported by the use of collaborative learning techniques. These findings empirically suggest that a collaborative learning model should be the foundation upon which online courses are designed and delivered.

Connor-Green (2000), Sappington, Kinsey, and Munsayac (2002), and Weinberg, Wiesner, Benesh, and Boester (2012) report that the vast majority of students do not read assignments ahead of time and do not consider the textbook to be a critical component of learning. Feedback from the students at one of the schools I work for has prompted the mathematics department to pilot hybrid courses where the students attend brief lectures to incorporate some classroom interaction to the course, though the majority of the learning is done online.

This report is not intended to criticize internet classes or e-resources, but to share what I have learned from my observations on how students use such programs. My observations inform my own teaching when making use of e-resources and I think it is important to share experiences so educators can better support student learning. While e-resources can be great supplements to developmental mathematics instruction, I do not think they are a replacement. There are things inherent in the classroom environment that are important to student learning that cannot be replicated in a course that is taught entirely online.

The main ideas that I have taken away from my experiences teaching developmental mathematics echo Walker's (2008) findings: that self-responsibility, a solid mathematical background, and a good attitude are key component to students' success in computer-based learning. When these are attributes that developmental students do not possess, then a strong support network is the factor that cannot be overlooked. It is extremely important to students at this level to be enculturated into the social aspect of mathematics learning at a college level. Guidance on how to participate in an e-course classroom environment is part of that enculturation.

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About the Author

Cassondra Lochard's current interests lie in undergraduate mathematics education, specifically in the ways computer learning platforms, the internet, and other multimedia electronic resources can support teaching and learning. In recent semesters she has worked to incorporate electronic resources like WebWorK, MyMathLab, WebAssign, YouTube and other electronic resources into both the traditional, and hybrid mathematics courses she teaches.