Planning to Succeed in a Computer-Centered Mathematics Classroom

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Most developmental mathematics students in community colleges, particularly those of color, are unsuccessful and fail to reap the benefits of higher education. In-class computer-centered (ICCC) classes are a possible solution to this issue because students work independently at computers during class time while instructors facilitate learning by answering students' questions. This case study focuses on one student's ICCC classroom experience by focusing on how the student's plan to pass the course were validated by the classroom environment. Ultimately, that plan was insufficient to address the needs of the student.

Keywords: Developmental mathematics, computer-centered learning, student agency

Many high school graduates who want a postsecondary education turn to community colleges to further their academic development or acquire credentials and job training leading to hitherto inaccessible opportunities. Yet their mathematical background obstructs this path when they place into developmental, not college-level, mathematics courses. Mathematics departments have introduced in-class computer-centered (ICCC) classes to support these students, providing a flexible environment to help struggling students proceed at their own pace, meeting their academic and personal needs. Whether or how students use this flexibility is not yet clear.

Research examining the ICCC class compares achievement outcomes and result vary. What has not yet been fully explored is the set of actions students take to learn mathematics in this setting. Plans and actions are key to student learning – and in a computer environment in which students have significant independence – it is important to consider the role of agency in students' engagement in the course. In this study, I focus on the plans students make to achieve their goals, how the course structure validates a plan, and what interferes with a plan's execution. Ultimately, this study sheds light on how a classroom setting designed to be flexible around the needs of as-yet-unsuccessful students supports or hinders their mathematics learning.

Addressing Remediation in the Community College

Many students do not complete postsecondary degrees because they are not successful in required developmental courses. Of students who entered a public two-year postsecondary institution in 2003 – 2004, 68% took at least one developmental course, with mathematics being the most common (Chen, 2016). Furthermore, passing rates in developmental classes are low and generally disfavor students of color (Bahr, 2008, 2010). Students who need support in such courses are not an anomaly; those who succeed in them are. Furthermore, forty percent of students enrolled in postsecondary institutions and who required remediation did not complete a Certificate, Associates, or Bachelor's within six years (Green & Radwin, 2012). Enrolling in developmental courses reduces the likelihood that a student will achieve their academic goal.

Computer-centered instruction has grown in the United States and is being utilized in many postsecondary institutions to help students improve their mathematics proficiency (Allen & Seaman, 2011). These courses combine student individualization and flexibility with instructor support. In ICCC classes, at least 80% of the content is delivered via stand-alone software during scheduled class time using prerecorded video lectures. Students work online answering questions to test their learning, advancing at their own pace. They can also work outside scheduled class

times. Instructors monitor student progress, offering assistance by answering questions. The individualization and autonomy offered by these courses gives students opportunities for agency.

Overall few studies on ICCC mathematics classes focus on the student experience (Webel, Krupa, & McManus, 2016). However, there is no shortage of quantitative studies on computer-centered classes which compare student achievement in a computerized class with another format, usually lecture-based, instructor-centered classes. Results vary as to whether ICCC mathematics classes have higher achievement rates than traditional lecture courses (Bishop, 2010; Carrejo & Robertson, 2011; Herron, Gandy, Ningjun, & Syed, 2012). Many of these evaluative studies do not provide a pedagogical rationale for incorporating technology into the classroom or consider the pedagogical differences between computerized learning and traditional courses (Tallent-Runnels et al., 2006). Such studies for example do not differentiate the role the computer plays over that of a traditional instructor.

One way to theorize the relationship between technology and learning is to consider the student experience rather than achievement since these courses provide options like the flexibility to work at convenient hours and the ability to rewatch lectures, options heretofore nonexistent in traditional classes. This research is needed since this course structure harkens to Earlwanger's (1973) Benny (Webel, Krupa, & McManus, 2015). Recent research in this area showed that computer-centered courses better serve students who do not require significant remediation and improves students' ability to answer familiar problem sets (Webel et al., 2016). Short, focused computerized interventions have also been successful (Li & Ma, 2010; Wladis, Offenholley, & George, 2014) Students in ICCC classes also felt that course requirements necessitated a significant time commitment (Ariovich & Walker, 2014), supporting other findings that time on task related to successful completion (Fay, 2017). Overall, more research is needed to better understand the student experience in this realm.

Student Agency and ICCC

In ICCC courses, students can choose from a variety of learning activities. This freedom provides students with extensive agency, defined as the set of actions students take to achieve their goal. For example, students have the flexibility to work at their own pace in and out of class (Aichele, Francisco, Utley, & Wescoatt, 2011; McClendon & McArdle, 2002; Vassiliou, 2012; Xu, Meyer, & Morgan, 2009). For example, a single parent can make up for days missed or can work ahead or at home to account for unexpected absences to care for their child.

The agency available in the ICCC classroom is not infinite. The software's didactic approach limits mathematical agency, the ability to develop mathematical conjectures or explore mathematical concepts, by only accepting specific answers or methods. Thus, while students have significant student agency by being able to study when, where, and as much as they want, WHAT they must do to succeed and HOW they demonstrate knowledge is narrowly defined. This paradox of limited mathematical agency, and unlimited student agency provides a tension likely to yield findings on student actions.

In this study, I sought to understand a part of student agency in an ICCC mathematics classroom. More specifically, this study focuses on the intention a student sets, a future goal, action or purposeful outcome, and the basic plan for achieving said goal (Bandura, 2001, 2006, 2008). Without intention to establish purpose, a person's actions could not be considered agentive since they cannot be distinguished from unintended outcomes. Intention is one of four characteristics of agency which Bandura places in the realm of Social Cognitive Theory (Bandura, 1986). According to Bandura, a person's agentive acts are a part of his or her behavior and both affects and is affected by environmental and personal factors.

Methods

The data presented here come from a larger body of work researching four cases of student agency in an ICCC developmental mathematics classroom. This study reports on only one case, Eduardo, a 24-year-old Hispanic student entering college for the first time. Three research questions were considered: (1) What are the student's intentions in an ICCC developmental mathematics class, (2) what portions of the course structure validate this plan, and (3) what challenges does the student encounter when attempting to fulfill his intention? These questions consider Eduardo's intention while taking into account social-cognitive factors that may contribute to success. The site of this study was a developmental-level mathematics class in a community college in the Southwestern United States, a designated Hispanic Serving Institution where at least 25% of the student body is of Hispanic origin. In the ICCC course, students move from developmental coursework to college-level content using Pearson's MyMathLab software to complete modules, similar to a chapter in a mathematics textbook. Students demonstrate mastery of a module by answering questions on assignments and exams. They are expected to complete twelve modules per semester, completing the course in approximately three semesters.

Over the course of one academic semester, I collected four main sources of data. The first was Eduardo's classroom activity to understand his actions with respect to his intentions. This included over eleven hours (nine classes) of video recordings covering what Eduardo did in class, corresponding recordings of his computer screen, interactions with his instructor, photographs of his written work, and supplemental field notes. Two interviews with Eduardo comprised the second and third sources. They addressed Eduardo's mathematics background, his study habits, his intentions in the class, and clarifying questions to understand his actions. Interviews with the instructor, Shaun, was the fourth source of data and asked about his philosophy when teaching this course and discussed Eduardo's progress.

Eduardo's intentions were identified and coded using template analysis (Ray, 2009). Actions were intentive if a second datum (action or utterance) supported such. In other words, a second source of data must support the determination that a given act had intention. Actions and utterances were also coded based on Bandura's remaining characteristics of agency, forethought, reflection, and reaction. Codes were sorted and counted and explored for code co-occurrences. A second round of descriptive open coding allowed other themes to emerge.

I wrote analytic memos to make sense of the data as they were coded. Analytic memos clarified my reflections on the coding, overall inquiry process, and emergent patterns and themes (Saldaña, 2009). These analytic memos asked and addressed questions of the data. An example of such a question is "What did the participant do after answering a question incorrectly?" Answering these questions helped sort through the data so themes could emerge. These memos were shared with peers to check analysis and findings.

Since multiple types of data were recorded, findings and interpretations were triangulated. Data were collected in multiple class sessions giving long-term and repeated observations that allowed for the development of accurate findings.

Findings

In ICCC classes, the plans students develop to achieve a specific goal may be validated by the classroom environment. However, these assumptions may have fundamental flaws which could adversely affect whether the goal, passing the class, is achieved. Eduardo is an example of such a case. Eduardo's plan for success centered around working outside of class and relying on the computer, rather than his instructor, to learn mathematics. This plan was based on assumptions that were insufficient because of Eduardo's weak mathematical skills.

Eduardo's Intentions

Mathematics courses were required for Eduardo to receive a degree in Business Administration and Management. Results of his placement exam placed him in developmental mathematics, MAT075. Eduardo had a specific goal for massing MAT075. "I'll get my 12 modules done in 5 months" (20:170). Eduardo planned to achieve this goal by working extensively on the course material outside of class and watching videos repeatedly. When Eduardo was asked, "What's your game plan for getting through your 12 modules?" He replied, "Definitely doing 'Homework'. As far as doing that outside of the classroom. Definitely doing that." (20:175). Eduardo intended to and was certain that he could get an A in the course by working outside of class. "I think I'm gonna be doing this more out of class because you get better in math if you practice and practice and practice and I don't think like an hour and a half is much time you know to finally get it" (22:1). Eduardo recognized how important it was to work on mathematics class outside of his class. He also had a computer and high-speed internet at home giving him the ability to work at home at his discretion. The other main component of Eduardo's plan was his decision to extensively use video lectures, which he favored over conventional class lectures. This was demonstrated several times, where Eduardo would replay videos or assert his intention to rewatch videos.

> I'm gonna go over this [video] again at home and then I'll do the concept check. . . . then I'll do it again [watch the video] like probably two more times until [I] master this small piece and then move on to the next one. (5:1)

Eduardo began his next class reviewing his previous work. "I started with the first page [of the corresponding text] so I could refresh my memory on it because I wanted to do that. I want to learn it" (20:75). By reviewing, Eduardo reaffirmed the importance of repetition.

Factors supporting Eduardo's plan

Eduardo's plan to pass MATH075 was validated through the design of the software and course structure. These factors supported Eduardo's plan to spend adequate time working through the course and consistently review the content.

The course encouraged students to work as often as possible, placing a stronger emphasis on seat time rather than conceptual understanding. The classroom was available for over 40 hours per week, and was designed so that computers were available to students who were not scheduled to attend, so students could feel free to come in when their schedule allowed. The online nature of the course also allowed students to work outside of class whenever they wanted. Students were also able to work ahead one module, encouraging them to keep working.

Shaun, Eduardo's instructor, expressed how critical it was to maximize seat time and reinforced the importance of working as often as possible. If they were not discussing procedural questions related to the course structure, Shaun and Eduardo's interactions were centered around the idea that spending time outside of class was essential to passing the course.

> [You] might think about what your time is like and can you be in here outside of class. Is there time between classes? Is there time after classes where you don't have to be somewhere right away or before? Can you come in early, you know? You think about your own personal circumstances and see if there's more time that you can squeeze. Any time you can be here, you're welcome here, right. (23:20)

Shaun attempted to help Eduardo with his time-management skills and help Eduardo see multiple opportunities during the day where Eduardo could work on the class.

Eduardo reflected on how the course structure allowed repetition and on the importance of replaying videos and to help him learn.

> I love the structure of it. I think this works out better for me because I could keep - go back and back and back, you know. Reread the video or replay the video over and over again. And sometimes, like, well, the way I learn, you have to, like, tell me a lot of times for me to, like, learn something new until I really get it. So I love it. (5:4)

The feature of the MyMathLab software that he used most often, the videos, was a feature that aligned with his belief in how he learned best. With the course being on computer, Eduardo had complete control over his learning the material, answering questions, and his ability to rewatch videos so he could advance at a comfortable pace.

Eduardo also believed the software was fully contained, in that all answers to his questions could be found in the video lectures or another part of the software. When I asked what he would do if he had a question about the content, Eduardo was very direct. "The way he [the narrator] explains it there is no questions; well at least for me. You just have to read it. I mean he explains everything. If I did [have a question], maybe I missed it when he was talking (30:3)". Eduardo believed that the computer was the source to be trusted and if he was unclear about a specific concept, it was his fault. This assumption supported his belief that by spending more time engaged in the software and by reviewing material, he could pass a module.

The assumption that MyMathLab was designed to be a fully contained program was supported by the software. The program had no surprises in that questions presented to students on exams are of the exact form given in "Homework" assignments. There are no advanced, conceptual questions or questions in forms students have not seen before. This allowed Eduardo to work through challenges and answer questions on his own.

Shaun, throughout his discussions with Eduardo, supported Eduardo's belief that seat time was essential for success in MATH075. The course structure and environment also emphasized seat time over understanding. Thus, there was no indication that Eduardo's plan was not reasonable. However, relying exclusively on the computer's features to review and answer his questions and focusing on the time spent in front of a computer did not meet his academic needs.

Intention Thwarted: Eduardo's Plan Did Not Work

Eduardo's plan to pass the course did not work. Before the middle of the semester, Eduardo had stopped attending the course and ultimately failed the class. Eduardo's plan assumed that his arithmetic skills were sufficient to succeed and that he only needed the software to be successful.

Like all students new to MATH075, Eduardo began with Module one, which introduced whole numbers, rounding, the arithmetic operations, and orders of operations with whole numbers. Shaun strongly encouraged all new students to pretest this module, taking the Module 1 test without working through the content, saving the time of working through "Homework" problems that students could presumably do. Eduardo chose to work through the module.

Shaun's attempts to have Eduardo finish this module demonstrated the extent to which Shaun considered this material rudimentary. Shaun tried to encourage Eduardo to come into class ready to test Module one. "Do you think you can do the topics, finish the 'Homework', over the weekend, and test on Monday?" (33:6). In this interaction, Eduardo was expected to complete units 1.7 – 1.11 so he could test. Shaun's tone with Eduardo was more imperative than curious, attempting to motivate Eduardo rather than inquire if doing that much work was possible. This statement implied that Eduardo could complete these modules if he put in the time to work through the questions. There was no consideration as to the academic challenges these units may have posed for Eduardo. Unfortunately, Eduardo had significant difficulty with these units.

In an example of how weak his arithmetic skills were, Eduardo was asked to solve the division problem $7\overline{)469}$. Eduardo relied heavily on the calculator and the video lectures to help

him answer this question. He did not know the mechanics of dividing a three-digit number by a single-digit number until he watched the video. Eduardo relied heavily on his calculator to assist him through the intermediate steps. When the computer indicated that he had the wrong answer, Eduardo replayed the video on division and followed his extensive notes on how to perform long division. This single problem, including re-watching the video, took over thirty-five minutes to complete. The time and effort demonstrated here stand as a testament of Eduardo's dedication and resiliency, and as an indication of the extent of his mathematical deficiencies and the amount of effort necessary to overcome them. It was also an indication as to how challenging this course could be for someone with Eduardo's level of content knowledge when they relied exclusively on the computer software to advance.

Eduardo's progress through this division problem shows the extent to which he had difficulty with and needed mathematical support. His assumptions that the program was self-contained was demonstrated when Eduardo did not seek Shaun's help on solving the problem, even when Shaun interrupted Eduardo to discuss his progress while Eduardo was working on said problem. Furthermore, Shaun's classroom statements that the first module should be skipped along with his focus on how little time Eduardo was spending working at home may have prevented Shaun from recognizing Eduardo's challenges and intervening to help him.

The idea that the software was self-contained, that all questions could be answered in some way using MyMathLab, was incomplete. Although all questions could be answered based on definitions, examples, or lectures in the software, students were expected to have a certain amount of prerequisite knowledge, namely a command of addition, subtraction, multiplication, and division facts up to thirteen. This basic knowledge could have helped Eduardo with the aforementioned division problem and other problems in this module. In addition, without this basic knowledge, Eduardo could not pass the exam which did not allow use of a calculator.

MyMathLab was able to support Eduardo in working through the problem by allowing him to watch online videos as often as necessary to understand concepts. However, it did not address that he did not understand how division is a grouping operation or recognize that he did not know his basic multiplication / division facts. Eduardo may have successfully completed one problem, but this did not ensure he could do similar problems without the same extensive support from the computer and calculator. Although the features in MyMathLab helped Eduardo work independently through confusing questions, because of Eduardo's weak arithmetic skills, the amount of time it would have taken him to work through the course would have been prohibitive.

Eduardo and Shaun's focus on overall time spent working may have deflected attention in the wrong direction. Shaun was consistently focused on whether Eduardo worked outside of class and did not realize the extent to which Eduardo was having difficulty with the content. Whenever Shaun initiated a conversation with Eduardo, it was always about Eduardo's pace or progress and Eduardo would indicate he was not working outside of class. It would then be reasonable for Shaun focus on Eduardo's pacing, rather than focus on any challenges with content since Eduardo spent minimal time working and not asking for help. Shaun assumed Eduardo's lack of progress was due to his sparse seat-time and directed his energy towards this area of need.

At no time did Eduardo's reflections on his progress in the course focus on factors other than whether he was spending enough time with the software. He in fact was not working outside of class, and was not implementing that portion of his plan due to transportation difficulties and other external factors. Yet it cannot be denied that Eduardo also had to overcome multiple hurdles due to his extensive arithmetic weaknesses. However, he did not look for help beyond the computer. Instead, he leveraged multiple electronic avenues to work through the immediate

question such as using a calculator and replaying a video to further understand the mathematical procedures. However, these avenues did not address his underlying arithmetic weaknesses, which were necessary for him to advance.

Discussion

In the MATH075 classroom Eduardo did not achieve his goals. He did not ask for help with difficult problems or concepts because the software was designed to be fully contained, in that no outside help was needed to work through the material. In addition, Eduardo had extensive deficiencies in his arithmetic which made the likelihood of success remote. Focusing on Eduardo's seat time became a distracting influence, preventing both Eduardo and Shaun from recognizing and addressing Eduardo's actual challenges with mathematics. Shaun never asked Eduardo whether he was having difficulty with the content and Eduardo did not reflect on his mathematical skills and how that may affect the assumption that seat time was sufficient for him to succeed. His plan also did not consider or account for the conceptual challenges he had with foundational topics in mathematics.

This case demonstrates how assumptions can be insufficient for a plan to successfully achieve a goal, consequently leading to intentions not being fulfilled. In this case, Eduardo established his plan, which was validated through the course structure. This plan turned out to be problematic and insufficient for student success. Eduardo's assumptions, that the computer alone was a reliable instructor, ultimately doomed his success in MATH075. Furthermore, no part of his plan accounted for how much help Eduardo needed to understand and work through basic arithmetic concepts. Eduardo's focus on the computer being the ultimate authority on learning did not take into account that the computer did not give more nuanced feedback to him. At no point did the computer indicate that he needed to, for example, learn his multiplication facts. Eduardo may have trusted the computer, but the computer was not providing him with the support he needed to succeed. Furthermore, both Eduardo and the instructor were preoccupied with seat-time rather than challenges with content.

Overall, Eduardo was not made conscious of his mathematical challenges. Furthermore, Eduardo believed strongly that MyMathLab was sufficient for him to learn, but MyMathLab did not provide the type of feedback that his instructor could. Likewise, Shaun did not recognize that Eduardo was held back mathematically. MyMathLab consequently created a wedge, preventing the instructor from diagnosing the student's challenges and discouraging the student from looking to the instructor for support. As each trusted in the software, the expertise in the course instructor was marginalized to the detriment of the student.

Students' failed plans may have devastating consequences. In Eduardo's case, as a student on financial aid, if he cannot succeed in his courses, he will be left with student loan payments, taking on a new financial burden without the added economic benefits of a college degree. Community colleges, and postsecondary institutions in general, must address students' assumptions about learning, the knowledge base they bring, and how success is achieved.

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