Best Teaching Methods for College Developmental Math Classes

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Introduction

In any given academic year, roughly two million students register for a developmental math class. Developmental math is listed as any class below the introductory college level math class and often serves as a placement to determine math competency for other subjects. For many students, this class serves as a remedial class allowing them to take other classes pertaining to their major or minor. More often than not, the students enrolled in these classes have had bad experiences previously with math, either in high school or before. These bad experiences often lead to math anxiety that hinders mathematical academic success in these college developmental math classes.

Many colleges and universities that offer these developmental math classes are looking for ways to increase student success. After recognizing that these classes are almost often the most historically difficult classes, extra research has gone into discovering ways to increase the pass rate. Previous research has shown that students taking these developmental math classes tend to have a much lower retention rate than their peers. In order to increase the retention rate and increase the pass rate as well, numerous studies have been conducted to determine the best practices for teaching developmental math at the college level.

Though many strategies have been researched and tested on students in these developmental math classes, some of the most successful are the ones listed; real life applications of math, early alert systems, collaborative learning, computer-based teaching and learning practices, and acceleration models. Together, these

strategies are the key to academic and student success for those enrolled in developmental math classes.

Real life application

When students are learning math in the classroom, it is often limited to memorization of formulas or graphs. While this might prove to be an easy task for some students, information is not retained and cannot be pulled out as easily for future use. Students also find it difficult to pay attention in class and to find interest in the subject when they feel as though it doesn't relate to or pertain to what they plan to practice in the real world.

To combat this problem, professors found that it would be useful to implement "problem based learning" where students can use real life applications of math and relate it to what they are learning in class. For example, questions pertaining to interest and banking seemed to increase student interest when they are able to see a tangible use for math in the real world. Other examples of the real life application include contextual learning, in which scenarios made by the students or using qualities similar to the students in the math class. This allows them to relate to what they are learning and provide a more comfortable math environment. Some universities have even gone as far as creating "shop" classes, in which all the math is taught in a hands-on matter that allows them to use concepts learned in class in a different, more abstract way.

By having these relatable situations such as balancing checkbooks, determining interest rates, or the linear growth of a commonly used plant, students feel more comfortable with the material and also feel comfortable being able to

implement math in the real world (Galbraith and Jones 2006). Knowing that the knowledge that they are learning in the classroom has a use outside of the classroom often allows students to pay more attention and ask questions if they feel as though they do not understand the material.

In an urban community college in Dayton, Ohio called Sinclair Community College, a study was conducted on twenty professors who have taught at least six developmental math classes over the past few years (Cafarella 2014). These professors were then interviewed with open-ended questions often to assess their teaching practices in these classes as well as to discuss the success of the class. Cafarella noted in his study that professors teaching these developmental math classes notes that when real-life application methods were used to teach and relate the math concepts to the students, there was an increase in the attentiveness of the students based on their body language. He also noted that of the professors that did use real-life applications, such as explaining the proper use of order of operations and how it can be used in daily life, tended to have students that were more engaged in the classroom and who also exhibited better attendance.

Based on research conducted by Hammerman and Goldberg (2003) who teach at Molloy College and Queens College respectively, one of the most successful strategies for teaching developmental math includes relating the application of math to real life scenarios. Students should be able to understand rules of math rather than just memorizing them. For example, an experiment was conducted in the classroom where the professor told students a story about a patient who needed to undergo a surgery where 0.8% of the patients do not survive the surgery. Rather

than telling students there is an 8/10th percent chance of not surviving and telling students that instead, there is a "zero point eight" percent chance, the experiment had students walk around the room intro groups for who would take the chance and have the surgery if they were the patient and who wouldn't risk it. Then the experiment was repeated telling students it's an 8/10th percent chance and similarly, students were told to move to respective corners of the room based on whether they would or would not have the surgery. Hammerman and Goldberg found that once students were able to realize that these were both the same numbers, they were able to use this example to remind them of decimals and percent when they are working through a problem set. Hammerman and Goldberg also found that teaching students unit conversions and how this can relate to everyday life, such as the price per gallon or per gadget, increases the competency in these math subjects because students see the need for learning these concepts. By finding common background themes on which ideas can be further expanded, students can relate more to the class material and increase the level of effort in which they are contributing to the class.

In a study conducted by Galbraith and Jones (2008) based on dialogue with a professor who teaches developmental math in a rural college, success rates were greater when the professor connected learning to daily life activities, such as checkbook balancing or determining the annual salary based on hourly rates and time worked. Elizabeth, the professor, noted that students seemed more engaged when the skills and concepts they were learning in class were connected to life outside the classroom. In another study conducted by Galbraith and Jones (2006),

they found that engaging experiences that pertained to real-life situations, such as being a "consumer of goods" increased student involvement in learning and becoming an active participant in the classroom.

Early Alert

Many universities are also implementing early alert systems. What this does is it allows for ongoing feedback throughout the course of the math class. Students have a more personal approach with their professor and feel the comfort in asking for help if needed or asking for alternative resources. This early alert system proves useful in that it allows for communication early on in the course and then sets the foundation for students to know their progress throughout the course.

Professors who employed this early alert system would send emails to students when they notice that students are falling behind. This could be because of missed class, slipping grades, or if a professor notices that a student isn't mentally present in class or exhibiting some sort of behavioral issue not evident before. When professors contacted their students, students felt special knowing that someone cared about them to ask. This made students more receptive to the professor as well as the material taught by the professor. It also allowed them to ask for help if they felt the need. Professors noted that students were more willing to accept offered help when it came from the professor directly. This open communication also helped alleviate math anxiety when students knew that their professor wanted the best for them and was willing to keep in constant communication to ensure student success.

At Sinclair Community College, an early alert system was implemented with some of the professors who participated in Cafarella's study (2014). These professors noted that when students were made aware that they were falling behind in class, they had the opportunity to improve and made a dramatic comeback by the end of the course. One specific example used was when a professor, Jenny, would hand a sheet of paper with all their listed grades half-way throughout the course. Students would then use a formula that they came up with together as a class to determine their current standing in the class and the grade that they have. Jenny would walk around once all the grades have been computed to determine whether her official grade book agrees or disagrees with the students' findings. In situations like this, Jenny noted that students who were underperforming showed an increase in effort and tended to come ask her for extra help in order to succeed in the class.

Along with the early alert system implemented in the study at Sinclair Community College, Cafarella noted that effective communication goes hand in hand with early alert systems. Having a consistent student outreach allowed students to feel more comfortable asking their professors for help. Professors would email their students 36 hours before an assignment was due or they would individually email a student when they are absent to check up on them (Jacobson 2005). When students received emails like this, they felt as though they were being taken care of and that the professor was advocating for the success of the student by providing alternate resources. Many of the professors in Cafarella's study indicated that emailing was the best method to establish effective communication with students and also set the

foundation for building early alert systems by auto-generating emails when a student falls under the passing grade.

In a study conducted with Galbraith and Jones (2008) with Elizabeth teaching at a rural college, she stated that networking was highly encouraged with students. This did not only include networking within students but also between the students and the professor. She noticed that this network created a support system and enhanced learning relationships. It also fostered team-based learning, which was proven to increase success and retention rates that is later discussed. Elizabeth noted that having this open and effective communication between her students that allowed her to build alliances with her students increased their trust in her. Therefore, when she noticed that they were falling behind in coursework or their grades were slipping; she could intervene and provide students with resources that would encourage their success.

In a study conducted by Kinney (2001), he found that by delivering feedback to students in a prompt and timely manner, student responsiveness increased. Students were more willing to ask for and seek out help and were also more willing to accept help when offered by other students or professors. Similar to Jenny in Cafarella's study, in Kinney's study, he found professors implementing similar models – handing back grade sheets to students and allowing them to calculate their grade. Kinney found that students could learn about their progress based on the teacher communication and feedback given in the grade sheets and they were able to and "encouraged to engage in goal setting and strategic planning" based on their findings when calculating their own grade. By doing so, professors could ensure that

students were actively monitoring their own grades. This laid the foundation for an early alert system, providing intervention and resources as needed for students who may be struggling or on the verge or struggling. Kinney found that intervention, especially at an early stage, increased and promoted student success.

Collaborative Learning

Many universities and colleges are looking for ways to increase student success and they have found that collaborative learning has proven to be among the best methods for this. In collaborative learning, students work in groups alongside one another and are able to create a sense of community. This community provides them with the much needed resources to increase their math competency as well as the opportunities to ask for help when need be. In collaborative learning, students are actively learning, meaning that they have to participate in class and among their peers. When students know that they are not the only ones struggling in these developmental math classes, they tend to feel much better in knowing that they are not alone. By alleviating the math anxiety found in many of the students registered for these developmental math classes, they can focus on the course material and their personal and academic success.

In some colleges and universities, programs such as Supplemental Instruction (SI) have proven to have an outstanding success rate for collaborative learning. SI employs a student leader to attend all lecture classes and then host weekly review sessions pertaining to the class material. In the review sessions, the SI leader and students present use collaborative learning processes such as pair-share activities or working in groups teaching one another the different steps of the

problem. Many professors have noted that students fully understand the material when they are able to present it or teach it to other students. With that, students also increase their critical thinking skills in collaborative learning environments (Boylan 2002). It has also been noted in numerous studies that attendance in classes have increased when a Supplemental Instruction Leader is assigned to that class.

At Sinclair Community College, the professors who took part in Cafarella's study (2014) noted that using collaborative learning strategies was based not only on the professor's comfort with the teaching method, but also on the composition of the class. When students are willing to be engaged in a larger group setting rather than individually, they have the opportunity to communicate with other students and build a small community within their classroom. Some professors noted that they liked to use small groups for solving problem sets because students who did have trouble tended to ask other students for help before asking their own professor. One professor in particular stated that when she instructs her students to do pair-share activities, she can gauge if students understand the material because she says "if they can teach it, they can truly understand it."

Finney and Stoel (2010) found that in Valencia Community College, an urban community college in Florida, once a Supplemental Instruction program was implemented in developmental math classes, the success rates increased and were higher than those without an SI program. Students were able to participate in community learning and felt more comfortable with students similar to their academic level.

In a study conducted by Bonham and Boylan (2012), team learning with the help of a teaching assistant or a Supplemental Instruction leader increased math confidence and self-efficacy for the students in these developmental math classes. Team learning encourages small group instruction and allowed students to collaborate with one another and foster confidence in math while alleviating math anxiety.

Mireles et al. conducted a study in an urban university in Texas where they found that Supplemental Instruction has a positive impact on student performance. They speculated that this impact on performance is because of the techniques used in SI sessions that encouraged collaborative learning. Mireles also notes that the positive impact could be due to bonds with the SI leader as well as the other students that attend SI sessions. Mireles noted that students felt that SI sessions provided a "safe environment" where students felt less threatened by intimidating concepts in math. The positive impact on student success can also be attributed to the learning and study strategies implemented in SI sessions. SI leaders are trained to incorporate study strategies in their sessions that allow students to condense material taught in class and to also connect the material with material from previous lectures or to other real-life applications. Based on previous research about the impact of real-life applications in developmental math classes as well as the importance of collaborative learning, the Supplemental Instruction program has been proven useful for teaching developmental math. Lastly, Mireles notes that "study strategies need to be taught to students" in order for them to succeed in developmental classes. With this in mind and based on the way Supplemental

Instruction sessions are facilitated, this explains the reason for SI success as well as its success towards the best practices for teaching developmental math.

Acceleration Model

The last strategy that has proven extremely useful in teaching developmental math is what is referred to as the acceleration model. In this model, colleges and universities reduce the time needed to complete the math course, reducing the "burn out" effect for students and also reducing the cost for students, making this a more feasible solution for taking the developmental math courses needed.

Some colleges and universities have even gone as far as to create an "Emporium" model in which students take a placement exam to determine what their weak subjects are in the developmental math class. This allows them to be placed in modules focused directly at their weak topics which allows students to focus more time and effort on topics they are struggling with rather than focusing the same amount of time on all topics, even if they are already mastered.

Cafarella notes that based on his findings, acceleration models are not suited for all students, only students who exhibit strong organizational skills, a strong work ethic, and a higher ability in developmental math classes will succeed in the accelerated model. Though it does prevent burnout, it is a lot of material to learn in a short period of time and one class absence can be hard to recover from (Woodard and Burkett 2010).

In a study conducted by Bonham and Boylan (2012), colleges who used "Emporium" models exhibited a higher success rate. For example, at Foothills College in California, professors began implementing Math My Way, an emporium

based computer model that allowed students to determine what subjects they were struggling in and what subjects they excelled in and allowed them to spend more time in areas of need. Bonham and Boylan found that using this model increased student success by 20% when used in conjunction with supplemental instruction. Studies conducted in other universities, such as Cleveland State Technical College in Tennessee, Virginia Tech, and University of Alabama all exhibited similar results – higher success rates in classes that implemented an emporium model. Bonham and Boylan also found that using the emporium model in conjunction with computer based models allowed developmental math classes to be standardized and provided an opportunity for students to learn math by doing and applying, rather than just listening.

Computer-Based Models

With the increase in technological advancements in higher education such as online and hybrid classes, schools are looking for ways to implement technology in their daily teaching. Some colleges and universities are using computer-based models in which homework and quizzes are assigned online and practice material such as supplemental lectures and extra problems are available on an online portal. These resources have been proven to increase both success and retention rates (Speckler 2008). More notably, common software such as MyMathLab or MyLabsPlus has been found to be among the best for developmental math classes because students are offered options to see how a similar problem is solved.

A study conducted by Trenholm (2009) in the State Univeristy of New York (SUNY) developmental math classes showed that online sections for these

developmental math classes tended to be the "most efficacious" mode to teach based on passing rates. As compared to students in the traditional lecture style classroom and students in lab sections where there were computers along the walls of the room while the remainder of the room was set up in a lecture style, those taking the online course exhibited greater competency based on their average passing grade. This study also looked at the use of MyMathLab as a way to conduct all homework and quizzes as well as student and teacher interactions. This study found that students were able to utilize these online resources more readily than students who were in the traditional or lab style classroom.

In a research study conducted by Kinney (2001), he found that students who were in computer-mediated classes had a greater retention rate as compared to those who were in lecture-based courses. This finding supports the previous research that students who are self-paced and working with computer software increases student success.

Discussion

Based on the research conducted and the literature reviewed, the best practices for teaching developmental math are highlighted above, including the following; early alert systems, real-life applications, computer based models, acceleration models, and collaborative learning. Because of the steady number of students enrolled in developmental math classes, it is crucial to find effective and efficient ways to teach concepts that are historically difficult as well as based on an elementary foundation of math concepts. Once these topics are mastered, students have the opportunity to pursue higher-level math classes or more challenging classes that required the

prerequisites of these developmental math classes. With an increase in student success based on these learning practices, higher retention rates will be seen as well, as they are proven to go hand in hand.

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