NADE
National Association for Developmental Education

# Math Monograph

Fall 2018

## SPECIAL EDITION

2018 Best Practices in the Mathematics Classroom

Sponsored by the NADE MATHEMATICS NETWORK



## IN THIS ISSUE



NADE publishes articles of interest for developmental education professionals including administrators, faculty, learning assistance personnel, academic counselors, and tutors who are interested in the discussion of practical issues in post-secondary developmental education. Articles are indexed in ERIC.

# Preface

The NADE Mathematics Network is one of the largest NADE Networks and very active in supporting Developmental Education and Learning Support professionals in providing quality mathematics experiences for higher education students. This "Special Edition" of the NADE Math Monograph has resulted from panel presentations and various discussions over several years by the members of the NADE Mathematics Network. Seeking to find better ways of engaging and retaining all students, the following articles were submitted as "Best Practices" for the mathematics classroom. The work and content of each of the articles are the sole responsibility of the contributing author or authors. Also, the views expressed are not necessarily those of the NADE Mathematics Network.



**NADE** Math Monograph

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## MISSION

NADE seeks to improve the theory and practice of developmental education at all levels of the educational spectrum, the professional capabilities of developmental educators, and the design of programs to prepare developmental educators.

# Test Review with Student Collaboration

Lindsey Gerber, PhD, Utah Valley University

Collaboration in the classroom is essential for learning especially in developmental mathematics. During each class, there should be some form of collaboration between students, especially the day before the big exam—review day. Students use this time to ask questions about problems, and the faculty member usually stands at the board and writes out the solution for each question. This traditional method of review is not helping students learn, because the student is going through the motions—writing down everything the professor writes down—without thinking of the meaning behind the process or the operations being used to solve the problem. Instead, the review day should be used to promote collaboration between students, so they can solve the problems together. To help promote collaboration, a description of a typical review day is provided.

Everyone is given a review with approximately ten open-ended, multi-step questions to work through in groups of four or five. To avoid the traditional method of review, as described above, the students are not allowed to ask the professor any questions for the first 30 minutes to one-hour of class (depending on class length). This constraint forces students to ask each other for help. The professor monitors the classroom and encourages students to work together. If a student, working alone, asks for help, the professor advises them to ask their neighbor. This gives students the opportunity to meet their classmates and to form a peer relationship with each other. They are not required to collaborate in groups; but usually by the end of class, no one is working alone. After the 30 minutes to 1 hour, the professor will answer any questions that students may have while he/she is monitoring the classroom. In addition, an answer key is provided so students can check their work. Sometimes students work in their groups until the end of class, and other times the class will come together and students will present solutions.

This form of collaboration and discourse allows students to think about the questions, explore various problem-solving strategies, as well as teach each other mathematics. Collaboration and discourse is important because it enhances student learning by alleviating math anxiety and increasing critical thinking skills (Cafarella, 2014). Students also have a deeper understanding of the content (Reinhart, 2000).

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Reinhart, S. C. (2000). Never say anything a kid can say. *Mathematics Teaching in the Middle School*, *5*(8), 478 – 483.

# Making Math Meaningful (M$^3$)

Lindsey Gerber, PhD and Debra Ward, PhD, Utah Valley University

Developmental mathematics educators are well aware that students in their classroom often lack interest in course material and view developmental mathematics courses as yet another hoop to jump through on the road to a degree. It is, therefore, important for developmental educators to find ways to make the mathematics meaningful, relevant, and engaging to students. One way we can help students see the relevance of the mathematics we teach is by incorporating meaningful tasks, projects, and experiential learning. Researchers assert that the incorporation of these types of tasks result in cognitively and affectively engaged students who are invested in the learning process and recognize the value of learning (Attard, 2012). Piggott (2007) points out that student favor lessons that involve choice and creativity as well as

have the ability to make connections between real-life and mathematics. Therefore, these types of activities bridge students' interest and experiences with mathematical content fostering positive attitudes toward the learning environment (Davidovitch, 2014).
While there are many different ways to approach and incorporate experiential learning, we have included four sample activities that can be extended or truncated to fit the needs of various students.

## Sample Experiential Learning Activities

*Topic: Set Theory*

**Activity: Venn diagram Activity**

Each student will develop a question that will allow the students to place a person's response in one of three categories or a combination of those categories. For instance, "have you ever been snowboarding, skiing, or have done rock climbing?" The responses can be in one category, multiple categories, or none of the above. The students take 20 to 30 individuals' responses and develop a three-circle Venn diagram. In addition, they are required to develop a worksheet with their Venn diagram and 5 questions for a classroom activity. In the classroom, students will exchange their worksheet with 3 other students and they will solve the 5 questions on the worksheet. Lastly, they will discuss the differences in their responses and write a reflection.

*Topic: Linear Functions*

**Activity: Global Warming**

The instructor will give the students the temperature for the area for the past 100-years. The students will plot the points on a coordinate-plane. They will then draw a line of fit and develop a function to predict future temperatures. To complete the project, the students will draw conclusions on global-warming based on data and not assumptions.

*Topic: Systems of Linear Equations*

**Activity: Creating a Business plan**

Students will be asked to come up with a product they would like to make and sell. They will conduct research to determine the costs of producing the product (including costs of materials, labor, etc.) and use this information to construct a cost function for their product. The students will also be required to determine a reasonable price for the product and use this price to construct a revenue function. Using the cost and revenue functions, students will be asked to determine and interpret the break-even point for their particular product.

*Topic: Quadratic Functions/Equations*

**Activity: Parabolic Pictures**

Each student will bring in a 4×6-inch picture of a parabolic curve in the real world (i.e., bridges, water fountain arc, etc.). They will use sketch paper to help trace the parabolic curve of the picture onto a coordinate plane starting with one end at the origin. Then they will develop a function to represent the curve.

## References

Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *APMC*, *17*(1).

Davidovitch, (2014). Mathematics and experiential learning—Are they compatible? *Journal of College Teaching and Learning*, *11*(3), 135 – 148.

Piggott, J. (2007). Cultivating creativity. *Mathematics Teaching Incorporating Micromath*, *202*.

# Attention Grabbers in the Mathematics Classroom

Dr. Meredith Anne S. Higgs, Middle Tennessee State University

Mathematics success often begins within minutes of students gracing the classroom door. According to their 1978 study, Hartley and Davies suggested the beginning ten minutes of the class was the best for student attention (as cited in Coffman, 2003, p. 3). Although others have challenged this timing concerning attention (Wilson & Korn, 2007), Coffman (2003) encourages both using the few minutes before class to set the mindset for the day and being very thoughtful in the structure of the first several minutes of class. One way to utilize these first minutes in class is to introduce new concepts is through attention grabbers. Attention grabbers may be most effective if they rely on information readily known to students

such as current trend-setters, media, films, music, or world events. The use of attention grabbers may focus student attention, develop interest in the concepts, and enhance participation. Attention grabbers can be inexpensive, creative, and modified to fit any mathematics content.

Samples of attention grabbers that I have used in my classroom include the following:

- Using photographs of a famous couple's wedding receiving line to demonstrate permutations.
- Introducing exponents through electricity saved by switching to LED lightbulbs.
- Illustrating the differences in length, area, and volume with everyday objects.
- Demonstrating theoretical and experimental probability with "loaded" dice.

In addition, I have used simple attention getting tricks, such as dressing in costumes or playing relevant songs, to get students involved in the day. Building a simple collection of educationally appropriate costumes from annual after-holiday sales is very cost-effective.

Taken together, attention grabbers are a simple, easy, cost-effective way of engaging students in mathematical content. A few minutes of preparation can result in an entire class period of student engagement.

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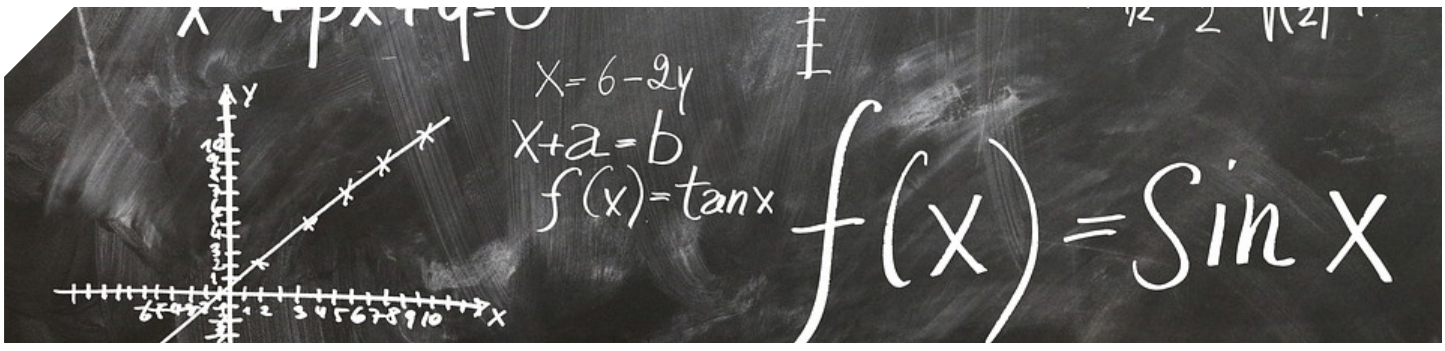
# Post-Exam Assessments by Students

Sean Bailey, University of Southern Maine

Developmental math students make a variety of errors on exams. Some errors are simple errors, such as arithmetic errors or transpositions of numbers. Other errors include notation or vocabulary errors. The most concerning errors are those where a student demonstrates a significant conceptual misunderstanding. At the University of Southern Maine, we have begun to implement student post-exam analysis. This analysis, completed with the first few days after students receive their graded exams, was designed to helped students better recognize their errors and thus correct them.

In the analysis, students are to identify for each problem on the exam what concept(s) are being assessed, where in the book the concepts are covered, and whether or not the student got the problem correct or wrong. If the student got the problem wrong, they are to identify whether their error was a simple error (such as basic arithmetic errors), a notation error, or a representation of a significant misunderstanding. The quantitative impact of this analysis on student performance is inconclusive at this point due to a limited sample size. But the initial data does show improvement on the cumulative final exam compared to prior terms. The qualitative data does strongly show that this analysis does helps students identify their weaknesses earlier. Students self-reported using their analysis to identify their weak areas, as well as their stronger areas. Thus this post-exam analysis is appearing to accomplish its objective of helping students recognize their errors.



# Mathematics Stations

Dr. Christina M. Cobb, Middle Tennessee State University

Mathematics is one of those courses where students either hate it or love it. It is my goal to employ Active Learning activities, such as Mathematics Stations, to boost the outlook of students' perceptions of mathematics. Active learning, as defined by Prince (2004), includes instructional tools used during the educational development. My goal while their perceptions change is that the retention and passing rates of our mathematics courses will improve. Looking to the future, I see the need to enhance mathematics instruction in learning-support and college-level classes. The overarching objective is to include hands-on activities to keep the excitement going while learning mathematics.

## Purpose

The purpose of Mathematics Stations is to create a significant impact on student engagement with mathematics. Students usually say, "I hate math." I feel that it would be awesome to show students that mathematics can also be fun and engaging. With enhanced student engagement through Active Learning, it is hoped that students will become more involved in their daily mathematics lessons and be able to transfer gained content knowledge to their next mathematics courses.

## Objectives

- Students will be able to think critically.
- Students will be able to use the process of transforming knowledge.
- Students will be able to work cooperatively.
- Students will receive differentiated instruction.
- Students will be in a student-centered environment.

## Procedures

Mathematics Stations will be set-up in a circle with stations around the room. Each station will have a fun mathematics activity or game for students to be engage. Anderasen and Hunt (2012) describe mathematics station as a system of "differentiation where the class simultaneously works on different activities" connecting to the equivalent idea (p. 242). Each activity/game will also have real world applications for students to be able to notice the connections and make it relatable to something in their own lives. After the students finish the activity/game at each station, they will get their work checked by the teacher. The teacher will inform the students of any problem areas they may need to revisit. Once everyone has completed all stations, the teacher will go through the problem areas that most students had difficulty with. See below for a sample idea for Mathematics Stations.

| | |
|---|---|
| 1. $x^3 \bullet x^5 =$<br>2. $x^{-5} \bullet x^6 =$<br>3. $x^{\frac{1}{3}} \bullet x^{\frac{4}{3}} =$<br>4. $500^0 =$ | **Station 1**<br>Directions: Evaluate each exponential expression and determine what rule had to be used. |
| 1. $\left(b^2\right)^3 =$<br>2. $\left(x^{-5}\right)^{-10} =$<br>3. $\left(x^{\frac{1}{2}}\right)^{\frac{1}{4}} =$<br>4. $\left(\frac{4x}{y^4 z^9}\right)^3 =$ | **Station Two**<br>Directions: Evaluate each exponential expression and determine what rule had to be used. |
| 1. $\frac{x^9}{x^6} =$<br>2. $\frac{x^5}{x^6} =$<br>3. $\frac{x^5}{x^{-2}} =$ | **Station Three**<br>Directions: Evaluate each exponential expression and determine what rule had to be used. |
| 1. $x^{-6} =$<br>2. $2^{-3} =$<br>3. $y^{-10} =$<br>4. $\frac{1}{x^{-4}} =$ | **Station Four**<br>Directions: Evaluate each exponential expression and determine what rule had to be used. |

### Mathematics Stations for Properties of Exponents

*What rule is it anyway?*
Students will be placed in groups and asked to travel to each station. Students will then work on the problems at each station as a group. Each station will be timed according to the time frame of class. Students would be expected to complete all stations before the end of class.

Mathematics Games that can be used during the Mathematics Stations: Equations with BINGO, probability with M&Ms, Fundamental Counting Principle with Math Engage ID cards, Data collection activity (mean, median, mode, and histogram)

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Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, 93(3), 223-231.

# Creating a Classroom Environment that Encourages Student Success

Jennifer M. Cornett (Lee University)

I began teaching developmental math courses at our local university twelve years ago. Some of my students are prepared but lack the proper study skills to be successful. Other students enter the classroom on the first day already prepared to give up. Many have had a rocky relationship with math for as long as they can remember. Still others blame genetics for their inability to learn the subject at all. In my first few years of teaching, I spent hours creating lesson plans that laid out each math topic in a clear, methodical manner. At the end of my lesson preparation time, I felt satisfied and confident that all my students would be eager to solve the problems with me. It seemed like my students were soaking it all in as they copied examples from the whiteboard, but their assessments proved otherwise. In fact, their grades proved that many did not understand the lessons at all. However, as the semester progressed, I noticed how many students started to participate with my lessons. Some offered to help explain how to solve the problems to another student. They even began to drop by during my office hours to ask additional questions. Unfortunately, it took me a few semesters to realize that our classroom environment played a big part in the overall success of my students. In this article, I would like to share seven ideas that I have used to create a learning environment that promotes student success and retention.

1. **Seating Arrangement.** On the first day of the semester, I arrive early to the class to mark off areas of the classroom where I do not want students to sit. These areas generally include the back and far edges of the classroom. My goal is to get students to sit near each other which will in turn support collaborative learning efforts and student interaction throughout the semester. While my seating arrangement strategy is not always fail proof, it does seem to help the majority of student to sit in the front and center sections of the room. Katherine K. Perkins found that "seat location during the first half of the semester had a noticeable impact on student success in the course, particularly in the top and bottom parts of the grade distribution. Students sitting in the back of the room for the first half of the term were nearly six times as likely to receive an F as students who started in the front of the room" (Perkins, 2005).

2. **Course Syllabus.** The course syllabus is an essential key in promoting student success in my classroom. I spend the bulk of the first day (50-minute class periods) going over the course syllabus. My syllabus contains specific and

detailed information about course assignments as well as my expectation for each student. It also includes information regarding study habits and opportunities to receive help outside of the classroom (whether during my office hours or the math tutorial lab). Since I only see many of my students during class, the course syllabus serves as a line of communication between myself and them. Kathleen Gabriel, in her book Teaching Unprepared Students, states that "having a clear, well-written syllabus can help guide the way for at-risk students as they learn how to be academically successful" (pg 39).

3. **Roll Call.** At the end of the first day of class, I check attendance by calling roll. This may seem to be a trivial activity, but it helps me begin to associate faces with names. In addition to calling roll, I ask each student the same question. I will either ask them to tell the class the last movie they watched, their favorite TV show or another shared interest among college students. The purpose of this activity is for my students to realize that they do have some things in common with other students in the class. In her book, Successful *STEM Mentoring Initiatives for Underrepresented Students*, Kathleen Wai-Ling Packard describes this commonality with other students as belongingness. She says that "belongingness refers to a sense of shared identity (and) when students find connections to others who share similar interests, they are more likely to feel a sense of belongingness" (pg 16). In my experience, when a student feels that they belong, they are more likely to attend class and participate in class lectures and group activities.

4. **First Assignment.** My students write a short autobiography about themselves for their first homework assignment. Students are asked to include personal information about themselves (ie, hobbies, hometown, etc.) and their past experiences with math. Students are required to write this information in the body of an email, write their names in the message subject line and attach a picture of themselves. The purpose of this assignment is two-fold. First, it allows me to get to know my students' name and a little about their interests and background. Second, it ensures that they have my email address and they can easily find it by typing in the first few letters of my email address. I also respond to each email with comments and questions about the information shared in their email. I do my best to share something personal about myself that has some connection with what they have shared with me. Though replying to emails can be time consuming, I believe it helps initiate dialogue between myself and my student which we will build upon throughout the semester. Packard states that when "students perceive that faculty and staff are approachable, and they can ask questions, they are more apt to increase their capacity to learn as well as experience an increase in their (coursework)" (pg 19).

5. **Name Game.** By the second class, I take time out of the lesson to play a name game. I strongly believe that knowing each other by first name is critical to building a climate that encourages success and retention. Typically, I arrange the desks in a circle so that everyone is facing each other. I have each student, including myself, introduce themselves to the other class members. After giving us their name, students share three things about themselves using the letters ABC. Student tell the class their favorite activity (A), their bachelor's degree (B) and their hometown city (C). However, before the next student's turn, that student must re-introduce all the students that went before them. Yes, it seems like a daunting task at first, but the repetition of names proves to be helpful for all students including myself. I have found that my attendance remains high throughout the semester if I take time to include a name game activity such as this one. In her book, Gabriel states that "it is comforting and inviting for students to go to a class where they know other people, and they are able to talk to each other about the course material or just casually" (pg. 46).

6. **Collaborative Work.** During the first week of classes, I take time to teach students how to work together in small groups within a math classroom. I reiterate the importance of sharing your ideas as well as listening to other students' ideas. I typically use one of the following activities:

a) **Marshmallow Tower.** Groups are given a brown paper bag with dry spaghetti noodles and small marshmallows. Students are asked to build the tallest free-standing structure using only the materials in the bag and within a given time limit. I encourage group members to take time not only to think of a strategy themselves but be willing to share their ideas with the group. This activity does take some prep work and can get messy, but it is worth the effort to practice working together as a group.

b) **Einstein Logic Problem.** Educator Dan Van der Dieren has created a TED talk video to introduce the Einstein's Riddle to your students. After the short video, groups are given a list of clues to identify the man who stole a prized fish. Participation, sharing ideas, listening to others, and making mistakes are all part of this collaborative experiment. Students work together using critical thinking and deductive reasonings skills to decipher the clues and identify the thief. This activity is easy to prepare for and can be used as a last-minute filler activity as well.

I have found that students are more likely to participate in either of these two activities because they appear to have no connection to math. Packard noted that "investing in (collaborative learning activities) can have the added benefit of allowing learners to feel a greater sense of belongingness and ability to thrive" (pg 18).

7. **Meet and Greet.** For the first few weeks of the semester, I take five minutes at the beginning of class for students to stand up and introduce themselves to someone they are not currently sitting next to. I encourage my students to discuss their degree plans, their dream job, their hobbies, their weekend plans and whatever else they find to talk about. This small activity helps connect students who typically sit on the opposite side of the room from each other. I also find that after a few times of this "meet and greet" activity (as I call it in my classroom), students are more likely to ask questions during class because they have connected on some level with the other students in the class. I have seen many students' feelings of insecurity and timidity decrease as they make connections with other students. Gabriel says that "by setting aside a little classroom time so that students can meet each other, professors can start the cooperation process. Then when it comes to in-class activities… students who know each other by name will find it easier to work together" (p. 46). I also use this activity at the beginning of a class period when coming off a long weekend or break from school (i.e., fall break, spring break, etc.).

Despite all efforts to create an inviting classroom environment, some students will choose to remain on the fringes. In my experience those students who never fully engage in these activities typically have a high absentee record and often fail the course. On the other hand, some students who were fully engaged throughout the semester, still did not show enough competency to pass the course. However, when students are in a classroom environment, they can feel whether or not it is encouraging, warm and energetic. It is in such environments that students feel capable and supported to become successful learners (Packard, pg 115). These recommendations are not a fail-proof way to create successful learning environment, but they are examples that have worked for me in my classroom. I encourage you to start small. Try one strategy at a time and note if it made any impact on student success or retention in your courses. This list of strategies is far from complete and I would love to hear some of your ideas as well.

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# The Evolution of Gateway Math Courses to Improve Student Learning and Success

Dr. Roberta (Bobbi) Parrino Cook, QEP Director, Indian River State College

The Quality Enhancement Plan (QEP) at Indian River State College (IRSC) is a five year action research project which ends spring 2019. The goal of the project is to improve student learning and success in gateway and subsequent math courses. The project started with one gateway math course (Intermediate Algebra) and two deliveries and has grown to two gateway math courses (Intermediate Algebra and Quantitative Reasoning) with multiple deliveries. The baseline success rate for gateway math in the academic year 2012-2013 was 54.8% (without summer) with a subsequent course success rate of 72.5%. For the academic year 2017-2018 (without summer), the gateway math course success was 67.4% and 2016-2017 having a subsequent MATH course success of 73.6% to date. The curriculum and pedagogy have undergone many iterations during this project and continue to do so. This article will attempt to summarize this evolution.

In 2013, just before the project started, the State of Florida passed Senate Bill 1720 which would eliminate the necessity to take developmental mathematics for any active military and all students graduating from a Florida High School since 2007. That means that students eligible under SB1720 who needed remediation could skip developmental math and go straight into the gateway math course. The path of the QEP was greatly affected by this law. The main question became "How do we serve an increasingly underprepared population while improving learning and success without lowering standards?" The QEP curriculum team which is comprised totally of math department faculty worked collaboratively for many hours over the past four years creating and redesigning curriculum and courses, while piloting various pedagogies and deliveries to promote learning and success for the students. At first, the math department only had to work with Intermediate Algebra. The team redesigned the curriculum – changing the order in which certain topics were addressed, modularizing the course and most importantly standardizing the course across the department in an effort to eliminate course shift. Since the beginning of the project the curriculum has been tweaked and redesigned twice after much research and discussion. The first deliveries that were piloted were variations on the emporium model. One of these models, the Supplemental Emporium (SE), has proven to be very helpful to some students especially those who are First Time in College students (FTIC).

The SE is a three credit course which meets four hours a week (a three credit course normally meets for two and a half hours). The student pays for three credits while the instructors get paid for four credits. The original SE model met for two hours twice a week with an instructor and a tutor. The first hour of each session was the focus hour where the instructor covered the content using active learning strategies. In the second hour, the students worked on their computer homework with the supervision and assistance of an instructor and a tutor. This format we call the SE2 still exists in the QEP and it has also evolved into the SE4 which meets one hour a day four days a week with the same combination of active learning strategies and computer work with an instructor and tutor present. More students seem to be successful in the SE4 model but not all students are able to be on campus four days each week.

Other delivery models that are being implemented for Intermediate Algebra courses at this time are the Flipped Emporium (FE), Virtual Mastery (VM) online mastery model, Hybrid Emporium (HY) and the Traditional (TR) lecture class. All of these, with the exception of the online course, meet for two and a half hours a week. All emporium models meet in a computer lab and have a tutor in addition to an instructor. Findings indicate that there is a population that is successful in each model. Once the project ends in spring 2019, the math department will decide which deliveries to retain based on evaluation of the data.

The success rates were slowly climbing with redesign, standardization and emporium treatments in Intermediate Algebra. The issue remained that many of the students who were not successful in Intermediate Algebra did not need to move on to College Algebra but rather to the liberal arts sequence and statistics. The QEP team researched the national trends to develop gateway math courses for Liberal Arts Pathway students. In the spring of 2015, the QEP piloted MAT 1100 Quantitative Reasoning. Quantitative Reasoning is a gateway math course using collaborative learning in face-to-face classes. The contents cover job skills, use of EXCEL and topics that will prepare students for success in the liberal arts sequence and eventually statistics. MAT1100 has been very successful with success rates hovering around 75-80%. Channeling students into this course in keeping with their guided pathways has helped them experience math success and improved math self-efficacy. A side benefit of the development of this course is the increased success for students in Intermediate Algebra because a greater percentage of students in the course actually need it to be successful in College Algebra.

With the end of the traditional developmental education model as we know it looming on the horizon in Florida, the QEP curriculum team, in an effort to be proactive, is piloting a one credit repeatable developmental modularized mastery course Elementary Algebra Modules during Fall 2018. The IRSC QEP will evolve and look a little different every term. We are constantly working to improve on how we serve our student population in the pursuit of a quality education.

# Tests Reviews and Corrections

Thomas Roybal, Assistant Professor, Utah Valley University

1. **Test Review with Signatures.** Students bring the test review to class (posted online) and work out the problems. There is space on the review for classmates to sign. Each student must explain two problems to two different classmates, and must have two problems explained to them by two different classmates. They must sign their classmates' reviews in blank provided. This prompts the students to explain math and help each other. I act as a traveling tutor, should a group of students not find anyone who can explain a problem to them. I do not sign any reviews—it is for students to help and sign.

2. **IF-ATs (Instant Feedback Assessment Technique).** Scantron sheets have one answer for each number marked with a star, then all answers are covered with silver scratch-off material. I write a multiple-choice review keyed to the IF-AT. Students in groups solve each problem and scratch off the corresponding spot on the IF-AT. If they are correct, they will find a star. This instantly shows them if they know the material, or if they need to rework the problem. This also differentiates what they need to study for the test. Additionally, I can look to see how many tries it took each group to find the correct answer. Students in my class earn credit for finding all the stars, and extra credit for finding 20 stars (or so) on their first attempt.

Alternatively, I write a multiple-choice review. On the board, I stick Sticky Notes with the letters A-E on each one, and a star under the correct sticky note. Students in groups solve each problem and lift up the corresponding Sticky Note. If they are correct, they will find a star. This instantly shows them if they know the material, or if they need to rework the problem. This also differentiates what they need to study for the test. Additionally, I can look to see how many tries it took each group to find the correct answer. Students in my class earn credit for finding all the stars.

3. **Treasure Hunt.** I write a multiple choice review with each answer corresponding to a different letter. The correct corresponding letters spell out a simple message. One spelled, "Find Yoda's note in the Math Lab." If students find Yoda, they earn extra credit. Only once have I had a group of students solve as a word puzzle, looking at just the letters instead of solving the math problems;

this group returned with Yoda's note and then solved the math problems.

4. **Problem Demonstrations.** Students choose a problem off the review and work it on the board. They must then explain the problem to the rest of class. Students get used to explaining math to classmates. If a student makes an error, that student will make the correction with my help.

5. **Email Address.** I write a multiple-choice review with each answer corresponding to a different letter. The correct corresponding letters spell out an email address. The group must send an email to that address, which I have access to in the classroom. I will reply with a confirmation email and the group earns extra credit.

6. **Escalating Extra Credit.** when a group earns extra credit, to make it a timed challenge, I have more extra credit available for those that complete the task sooner. The statement included is, "Each group that completes the task earns one point extra credit, plus one point for each group that completes it after you." This makes groups more competitive, as finishing earlier means more extra credit. Further, this had the added benefit that when a group completed a task, they will help slower groups finish. (More extra credit for the faster group, but also students helping students).

7. **Test Corrections.** Students must rework problems that they missed on tests. I provide a blank copy of the test, or they can do their reworks on their own separate paper. The students must also write what the error was and what the correct solution method is in complete sentences. The students must then paperclip these to their test and return them in by the next class. I regrade their reworked problems.

My motivation was for student to have an additional opportunity to master the material, in case they did not master it on the test. Additionally, the students can work on test corrections in groups, using books and tutors.

For one semester, I made test corrections earn back a portion of their points on the test. Students that missed this opportunity complained. I then made them extra credit, based on what portion of missed points the students corrected (so a student who missed many problems on the test and corrected lots of them would earn comparable extra credit to a student who did well on the test). Since this was not required, few students did the corrections, even though test showed many did not master the material.

This semester I have made test corrections worth 10% of the students' grade. The score is based on total number of points missed and what percent of those were then corrected. So far this semester, 20 of 26 students who took the first test did the corrections. 2 of the 6 who didn't do the corrections on the first test did not taken the second test.

I will continue to look for inventive methods to have my students prepare for tests. Additionally, I see that students learn material they may not have mastered when they took the test. I look forward to seeing further results in my classes.

# Easy Ways to Cultivate Student Engagement

Jason King

I still have nightmares about a few of my math classes. Everyone remembers The One Teacher They Had or The One Teacher They Heard About in math – the one that randomly called students up to the board to do problems, and let them sweat it out at the board while the other semi-panicked students, witnessing something more akin to a public shaming than to an educational lesson, said blessings of thanks under their breath that it wasn't their turn … today.

And, all the while, the teacher probably thinks this is engaging their students. Perhaps this type of engagement is more like "we are engaging the enemy" than "my students are engaged in learning".

I'm not a natural math student, nor do I consider myself a natural math teacher, and math has never come easy to me. (It still doesn't!) The idea of bringing students up to the board brings up all kinds of weird anxiety issues within myself – because I remember how much stress that method brought to me.

Here are some very small things I do to cultivate engagement in the classroom. None of them are revolutionary or require a teacher to make … really any meaningful changes to the way they already do things:

1. **Learn their names, as quickly as you can, and pronounce them correctly.** If you don't know a student's name, you can't connect with them. Easier said than done, right? Here are the ways I do it as quickly as I can:

   On the first day of class, have students introduce themselves. If they say their names out loud, you're not mangling them. Write down the way they're pronounced.
   Pass out papers, in the beginning, every day. Probably in the beginning you won't have much to pass out, though, right? Oh, I've got the solution for you J

2. **On the first day, have students complete a simple piece of paper with two questions:** "What would you like me to know about you?" and "What would you like to know about me?" Sometimes students tell me about the things their hobbies, but far more often students tell me about their bad experiences with math and how much they're dreading taking this class. I consider a big part of my job, then, in helping them gain confidence and in fighting their dread of math. Without tackling this, it'll be an uphill battle all the way – math is hard enough without feeling like it's something that causes them pain.

When it comes to what students want to know about me – sometimes I tell students I can't answer their question, but often I get questions revolving around their mindset of math, like why would I ever want to be a math teacher. It's illuminating and helps me a great deal.
I answer their questions, and each time I hand back something I get to know their names better.

3. **After each class,** I ask students to complete a half-piece of paper asking them two questions: "How was class for you?" and "Do you have any questions, comments, or thoughts?" The expectation I have that students will ask me when they don't understand something is fictive. Some students will, but many students will feel awkward asking questions–for a variety of reasons. This way students know that their questions will be answered, that their feelings are valid, and, I hope, that I'm here to help them.

As a bonus, I hand these back, so every day I get reinforcement as to their names. Every bit helps!

4. **Build a classroom based around self-actualization.** I firmly believe that we learn from failure, not from success, and so in the past few years I have completely reevaluated the way that I evaluate. (See what I did there?) I now allow for unlimited exam retakes in class and unlimited homework retries in class. This is a lot more work on my part – especially the exams, since I use computerized homework – but I feel like this is a more organic – and far less adversarial – approach to assessment. From informal discussions I would say that the students feel the same way. Additionally, I have found that allowing for no test makeups is, in fact, a very unjust system – the students most hurt by this are those with children, those who are chronically sick, and those who work more than others.

5. **When students know you care about them, you can expect more from them.** When I have learned their names, when I reach out to students asking for their advice, when I take their interests and needs into account, and when I listen to them, I can ask more from my students. They have responded in kind. While some students, indeed, would prefer a blow-off class with less work, I have often been surprised by how much students appreciate struggling with material they know they will succeed at – if they know my expectations are just and if they know mistakes don't doom them. In the fullness of time, I expect to go further with this approach, offering less and less material to students, knowing that they will be able to learn more and more of it through making smaller and fewer mistakes through each iteration.

None of these ideas are revolutionary, but if you try them maybe they would help you with student engagement. What do you do to engage students?

# Problem-Based Learning in the Mathematics Classroom

Dr. Meredith Anne Higgs and Dr. Christina Cobb

U.S. higher education students are facing increasing pressure to compete in the global marketplace for employment opportunities. According to Duch, Groh, and Allen (2001), "Today, our students must be prepared to function in a very different working world than even existed ten years ago" (p. 4). To enhance their marketability and competitiveness, U.S. higher education students must be ensured of quality preparation for this workplace. STEM coursework (Science, Technology, Engineering, and Mathematics content) is particularly salient for success in a global economy. Indeed, concern for the mathematics, science, and engineering preparation of U.S. students has a rather substantial history. For example, the National Defense Education Act (NDEA) was passed in 1958 to help improve educational programs for STEM areas and offered funding to help with resources, equipment, and professional improvement for teachers (Jolly, 2009). In recent years, these concerns for student preparation have translated into a push to increase student retention and graduation rates. Specifically, one major area of concern is that higher education students that are not adequately prepared for college. Consequently, the national spotlight has been on focused developmental education for higher education students.

Developmental education has far-reaching consequences for higher education students. According to Boatman and Long (2010), students who have to complete more remedial courses during college are less likely to earn a degree. Asera (2011) asserts that developmental education is a pedagogical challenge, especially as students are reviewing information that should have been learned during the formative years of education. In terms of mathematics preparedness, this problem is, again, quite significant as mathematics readiness has a major impact on college achievement, workforce entitlement, and U. S. competitiveness in a worldwide economy (McCormick & Lucas, 2011). Taken together, the need to help U.S. higher education students successfully complete their prescribed mathematics course is truly important.

The question then stands, "What constitutes a successful higher education mathematics classroom?" Even a cursory review of relevant literature reveals a litany of high impact practices. One such possible practice is problem-based learning. In describing problem-based learning, Boud and Feletti in their 1991 work indicate that a suggested problem begins the learning process (as cited in Duch, Groh, & Allen, 2001, p. 6). While participating in small learning groups, the suggested problems are the vehicles "to motivate students to identify and research the concepts and principles they need to know to work through those problems" (Duch, et al., 2001, p. 6). Information acquisition, processing, and dissemination are keys in the problem-based learning classroom (Duch, et al., 2001). Creating problem-based learning activities does require more up-front preparation than other types of activities, but the learning outcomes can be substantial. There are various iterations of how problem-based learning looks in the classroom. In our classrooms, we prefer using 4-or 5-person student groups with the teacher acting as a facilitator. In larger classrooms, groups of 8 to 10 students may be a more practical model. (Duch, 2001, p. 40).

In utilizing the problem-based learning strategy in our classrooms, it is our goal to help create an atmosphere that promotes learning, allows students to think outside the mundane, and encourages active engagement with the lesson. This engagement requires that we create problem-based projects that allow students to relate required mathematics content to real-life situations. The following activity demonstrates these principles.

## Problem-based Learning Activity: Building a Theme Park to Teach Inequalities

### Objectives:

The learner will demonstrate mastery of inequality symbols and usage.

The learner will utilize problem solving skills when presented with safety guidelines, unequal situations, and project constraints.

### Question:

"It is finally summer and you and your classmates would like to create a business plan for a theme park in Nashville. The park must follow all safety guidelines set by governing federal and state governing entities. Therefore, the park will need to have a designated height requirement for each ride. Your task is to determine the minimum height requirement for each ride that you decide to create for the theme park. Remember that if the ride is required to have a minimum height requirement, you must consequently also determine what inequality to use."

### Presentation:

Faculty members will present a mini-lecture on symbols and use of basic inequalities, on how to solve inequalities, and on to graph inequalities. Faculty members will facilitate learners' explorations of inequalities, graphing, and the problem solving process.

### Activities Required:

1. Create a business plan for a theme park.
2. Determine appropriate safety guidelines.
3. Determine the minimum height requirement for each ride.
4. Determine what inequality symbol to use for each ride regulation.

### Benefits to Learners:

Students often ask, "When am I ever going to use this in real life?" By allowing students to use inequalities to figure out safety guidelines for an amusement park, students will make connections between academic mathematics content and real-life situations. Further, students may then be able to transfer that knowledge to other real-world problems.

### Problem Based Learning Summary

Using problem-based learning activities gave us insight into project development. Specifically, in order to be successful, problems must be constructed not only for the academic content but also with a solution space for the students. By creating a loosely defined problem that still has just enough boundaries and resources, students are able to think and create outside of their comfort zones. Therefore, the teacher must provide students with freedom to figure out the solution while the solution continues to lies within the instructor-provided resources. This loose boundary system fits well within the context of developing independent learners and STEM content.

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