

COLLEGE ALGEBRA REFORM: WHY PROJECTS ARE WORTH THE EFFORT

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Background

In many other forums (see references), we have presented the practical side of using projects and applications in college algebra. In the pre-session presentation about College Algebra Reform at the ICTCM in Chicago, West tried to give a logical argument for why all teachers should use projects and applications in the college algebra classroom. Subsequent to the presentation participants were asked to discuss nine questions posed by West. This article will endeavor to answer these questions from our point of view at Francis Marion University. Hopefully this will guide others toward similar, logical conclusions.

Francis Marion University

First, we need to describe our point of view. Francis Marion is a small (3500), regional, liberal arts, public university. Each graduate, as part of their general education requirements, must satisfy a 6-credit-hour, two-course, mathematics requirement. There are many combinations that could be used involving courses such as College Algebra, Trigonometry, Precalculus, Probability & Statistics, Calculus for Business, Calculus, Elementary and Middle School Education Courses. An overwhelming majority of freshmen and transfer students start in some form of College Algebra. Further, about 90% of our entering students seek a Bachelor of Science degree that requires two laboratory sciences, and thus, some more mathematics. Depending on where a student starts in their mathematics sequence, other courses in mathematics might be required for business, education, computer science, physics, chemistry, engineering technology, and others.

Pre-session Questions

The nine questions from the pre-session are listed below:

- What are the goals of your College Algebra course(s)?
- How are your students placed in College Algebra?
- Can College Algebra students do some level of mathematical modeling?
- What are the advantages and disadvantages of contextual learning (use of applications)?

- What are the advantages and disadvantages of using projects as an assessment tool?
- What are the advantages and disadvantages of using groups (two's or three's) to submit projects?
- If reform is about changing the way we teach, does using projects and applications force us to change (reform)?
- Can projects enable us to accomplish our course goals?
- Is using projects and applications worth the time and effort?

Goals

Since many of our students start and end their mathematics general education requirements in College Algebra, the minimal general education goals are articulated with college algebra as the context. In the most general terms we want our students to:

- Represent, interpret, manipulate and interconnect different representations (numerical, symbolic, verbal, and graphical) of functions
- Understand and be able to use the concept of slope as a rate of change
- Communicate mathematics through reading and writing
- Use the computer and graphing calculator as tools for learning and problem solving
- Learn to be confident and aggressive problem solvers of real world problems

To accomplish these goals over two 42-lesson courses, we study data analysis, functions in general, linear functions, linear programming, linear systems of equations, linear regression, polynomial functions, logarithmic and exponential functions, and conic sections. In each course there are many applications used throughout the instruction. Further, there are a total of ten group projects in our two courses that are each required at the end of a topic. These projects are interdisciplinary in nature and require some form of technology use, significant time and effort, and a written report in a specified format.

Placement

At first student placement seems irrelevant and many schools handle this uniquely; however, most students are in college algebra not because they have not seen the material before but because they are placed there. Our freshmen are placed in College Algebra based on the judgment of one man, our department chair. He looks at individual Math SAT, high school background, their chosen major, and in many cases interviews the student. He is not totally satisfied with this process because it takes an enormous amount of effort on his part. But at the same time, his experience with placement tests has been unsatisfactory. So for many students we face two obstacles: (1) most of our students do not want to be in college algebra class, and (2) they think they are placed under their abilities. We are faced with a huge motivational problem. We feel that group projects provide the motivational edge and the uniqueness that can even intrigue the misplaced student. From a student's point of view, projects provide real world problems that motivate them to learn; projects cause students to synthesize their knowledge while

learning from their classmates; each student ends up with a valued product that becomes part of his or her portfolio (more on this later); projects broaden the students' contexts for problem solving; and projects and applications do improve knowledge retention.

Projects & Modeling

In general, our projects have a scenario that applies to some other common discipline relevant to all students such as biology, chemistry, physics, nourishment, population growth, business, social science, finance, and others. From the scenario we provide the student with a number of requirements and/or questions to answer. These questions can be answered by applying the mathematical analysis that they have just learned or should have retained from previous learning. Many questions are open ended with multiple answers depending on how the student models the problem. We usually pass the projects out a week in advance to allow time for open-ended thought and group discussion. We require a title page and executive summary in addition to all the supporting mathematics for the group submission. Usually on the day of submission or the next class there is an individual quiz on the project and/or a problem that is part of the test. Finally, near the end of the course, the student is required to submit a portfolio for grade which includes a copy of each project submission. In the portfolio, the student is required to write a reflective summary about all that they have learned in the course. Invariably, the projects are praised as the best learning experiences in the course.

In the authors' experiences, mathematical modeling as a separate topic has been reserved for the mathematically gifted. We think that is wrong. All students can solve problems at some level, because all college students should be asked to think critically. The problem solving that our school colleagues have been hounded about for years requires a certain level of mathematical modeling. We have found that in our experiences all students are capable of a certain level of problem solving and thus mathematical modeling. To define better what we mean by mathematical modeling, we require all of our students in their project submissions to restate the problem in their own words, to define all variables used, to articulate and justify any assumptions made, to write out the relationships of these variables, to solve the equations, and to verify that the results answer the problem. Further, in many cases we have the students investigate changing parameters or variables, in other words, sensitivity analysis. We have found that given these requirements all of our successful, and many of our unsuccessful, students are capable of mathematical modeling. It is not mathematical modeling that holds students back from successfully completing a project or solving a problem. These modeling experiences are the empowering parts of the projects, that cause them to think, that teach them to value their thoughts, and aide them in becoming confident, aggressive problem solvers.

Contextual Learning

The use of applications and projects assumes there are benefits to contextual learning. First, let us address the disadvantages. The use of applications and projects requires more open-ended time for the students. This means there must be fewer problems in class or on tests. To get around this on tests, we break our contextual problems into significant parts, so that time does not become an issue. In class if problem solutions are presented in class by students, they have the added benefit of learning from the same frame of reference and different problems can be attacked and presented by different groups. Most naysayers would say that student skills will suffer. Yet, most research that we are familiar with says that skill levels of students in contextual learning environments are at least as good as those students who are primarily drilled on skills. Finally, new and interesting applications are hard to find and require broadening of teacher's knowledge in other disciplines. We perceive this as an advantage by making the course interesting to the teacher and developing them professionally. The benefits to the student are listed in the next paragraph on advantages.

The chief advantage to contextual learning is motivation through relevance. Many of our students state that our course is the first time mathematics has been relevant to them. Further, contextual learning gives the students a better perspective of mathematics and how it fits in their education. Instilling confidence in their problem solving abilities supports their development as maturing students and citizens. The projects allow us to consolidate topic areas and generally give us opportunities to extend the curriculum into higher level areas of mathematics and other disciplines. Finally for faculty, the development of projects requires us to communicate with other disciplines to help us learn and make the projects more "real."

Assessment

We use projects as a significant part of our assessment plan. In each of our college algebra courses, we have five projects that are weighted the same as each of our six tests. These projects provide the opportunity for formative and summative assessment. In other words, they provide a vehicle for learning and require synthesis of the student's knowledge. They can be used as a form of a take-home test, saving on class time. Further, we have used old projects as significant graded homework and/or learning activities while a teacher might be missing a class. Finally, when time is not available in class, we can require students to research topics and learn on their own through a project. The chief disadvantages of projects as assessment tools are the time required for grading, assessment of individual effort, and the opportunity for plagiarism. Whereas time for grading is lessened by grading only group submissions, the other two disadvantages are inherent in using groups. We will address these next.

Groups

The industries and vocations we have communicated with or observed tell us that most problem solving is done in groups. We limit the size of our groups to two or three to ensure everyone is significantly involved and focused on the project. In addition, to get students used to working in groups, we force group activities in class. There are numerous disadvantages of groups, but most of them involve the idea of control. As teachers we are not in control of our students' learning. The student is in control of his or her learning. Group activities are great opportunities for learning. Student's peers have the same frame of reference and therefore communicate in terms they understand. Also, in group activities, the teacher assumes the role of guide on the side, much like accessing a reference or getting information from an expert. The problem remains the student's, and the group is working together to answer questions about the problem. So there is a student ownership in group projects. The only control we provide for our students in group projects is a format for submission and a due date. To address the concern about individual learning, there are a number of techniques such as peer weighting of effort and individual quizzes. We tend toward the latter. In all cases, projects are due before tests and tests contain questions about the projects. In most cases, an individual quiz worth half the project grade is administered after the project is turned in and discussed. This gets at individual learning and in many cases serves as a review before the test. Finally on plagiarism, we make our projects unique to the instructor and so disc copying and unreferenced outside help is usually obvious to the instructor to deal with as he or she deems appropriate.

Reform

In the 90's we were both involved in many calculus reform efforts, and West did some research in mathematics reform efforts at the college and school levels. We have come to the conclusion that in general, the purpose of mathematics reform is to change the way we teach to improve student learning. The use of interdisciplinary projects in all of our mathematics classes has indeed changed the way we teach. Further, we believe our students have benefited a great deal. Specifically in college algebra, we have designed two courses around the projects that the students do. In short, our student's learning has been enhanced because of our use of applications and interdisciplinary projects. At the same time we continue to have different faculty teach these courses so that they can experience what the reformed courses are like.

Goal Accomplishment

One might ask, "Are your goals accomplished?" The answer is yes in general. We did not set up the goals addressed at the beginning of this paper before we designed the courses. Instead, we approached our curriculum design like most mathematics faculty: our goal was to improve student learning. The goals came later, but they inform future design changes. In our experience, the projects enable us to assess goals such as "communicate mathematics through reading and writing" and "learn to be aggressive,

confident problem solvers of real world problems.” Without these projects, we would be hard pressed to state whether our goals had been accomplished.

Conclusion

The use of applications and projects in college algebra are definitely worth the effort. We have accomplished our goals for the courses, and at the same time, we believe our students’ learning has improved. Time and effort are the biggest obstacles to using projects in our courses. But since the early 90’s, we have been using interdisciplinary projects in all of our mathematics courses. As time goes on, the projects become less and less of an effort and more ingrained as our way of teaching. Our students definitely benefit from the experiences, making projects worth the effort.

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