The Mathematical Association of America

Renewal of College Algebra

Project Summary

The Mathematical Association of America’s College Algebra Renewal project will support pilot sections of modeling-based college algebra courses at eleven partner institutions and conduct a cross-institutional study to determine the success of the pilot courses.

Intellectual Merit

The need for mathematical and statistical understanding by students in disciplines traditionally considered non-quantitative has grown enormously, yet far too many students are unsuccessful in traditional college algebra courses, or are unable to apply skills learned in the course in the context of other fields. There is some preliminary evidence that modeling-oriented, application-based college algebra courses that take advantage of modern computational tools may better-serve students than the traditional college algebra course. With professional development support provided through this project, eleven colleges and universities will develop and offer pilot sections of modeling-based college algebra courses and support a national study determining the impact of these courses on students by comparing student performance and success rates in subsequent courses to those of students in traditional sections.

Broader Impact

Participating institutions have agreed to offer a total of 102 pilot sections over the two-semester implementation phase for this project, with at least as many control sections. Based on the evaluation of the pilot sections, successful practices will then be implemented in other college algebra sections. The MAA is committed to communicating the results of this project to the broader mathematical community, and encouraging all departments to review and make appropriate changes to their college algebra courses.
RENEWAL OF COLLEGE ALGEBRA

Eleven college and universities are seeking support to make use of newly developed course materials and texts to offer pilot sections of modeling based college algebra courses and to determine the effectiveness of these approaches. The mathematics department of each of these institutions has begun studying national recommendations and exemplary materials and has decided to offer, on a pilot basis, multiple sections of a college algebra course with modeling as the central theme and to design the course to include long-term projects, the use of technology and to de-emphasize algebraic and computational skills, focusing only on the skills their students will need in future work. The departments have also made a commitment to participate fully in a national research study to determine the effectiveness of this approach when compared to a traditional college algebra course that is currently offered by these departments and many others nationwide.

The college and university community of mathematics faculty know that college algebra needs to be changed. The importance of college algebra is clear, if for no other reason that it enrolls over 1,000,000 college students each year. [1] The need for mathematical and statistical understanding by students in disciplines traditionally considered non-quantitative has grown enormously, partially as a consequence of the integration of computers and other technology into almost every facet of our lives. These technological devices bring powerful computational tools to our desktops, but appropriate and effective application of these tools requires basic algebraic facility and a deep conceptual understanding.

Yet far too many students are unsuccessful in traditional college algebra courses (with “DFW” rates at many institutions at or above 50%), or find that, in subsequent courses where quantitative skills are called for, they are unable to apply skills learned in the course in the context of other fields. Many leaders of collegiate mathematics have discussed the potential for modeling/discovery-oriented, application-based college algebra courses that take advantage of modern computational tools to be much more valuable for students than a traditional, skill-based, pencil-and-paper college algebra course. Through the MAA’s Committee on Curriculum Renewal Across the First Two Years (CRAFTY) Curriculum Foundation Project, weekend “conversations” among mathematicians and groups of faculty from 18 different disciplines were convened to determine what faculty in the partner disciplines hoped students would learn in their lower division mathematics courses. As summarized in the 2004 MAA report, Voices of the Partner Disciplines,[2] the faculty in the other disciplines recommended that mathematics departments should “Replace traditional college algebra courses with courses stressing problem solving, mathematical modeling, descriptive statistics, and applications in the appropriate technical areas” and “de-emphasize intricate algebraic manipulations.”

Furthermore, the MAA Committee on the Undergraduate Program in Mathematics’ Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004 recommends that all departments should carefully “examine the effectiveness of college algebra, consult with colleagues in other disciplines to determine whether this course – as currently taught – meets the needs of their students” and design their courses so that they “engage students in a meaningful and positive intellectual experience.”[3]
That the college algebra course needs to be reviewed and renewed is a view shared by many departmental leaders as well:

- Many departments are working to revitalize their courses. For example, more than 20 individuals will present their reports on college algebra renewal efforts at the joint national mathematics meetings to be held in Atlanta in January 2005.
- As a part of the development of this proposal, MAA Department Liaisons were asked if their department would be interested in participating in this pilot/research proposal. Within six days, faculty from more than 210 departments indicated that they were interested in seriously considering this possibility.

The recommendations made earlier this year and the interest at the department level are important since a very large percentage of the students taking college algebra are still enrolled in courses that focus on intricate algebraic manipulations. Part of the reason that these courses have not been revised and renewed is inertia; however, another reason is that many faculty are concerned that students in modeling- and technology-based courses will have lessened skills and will be less successful in subsequent courses.

A number of examples of modeling-based materials have been developed with NSF support in recent years. For example, the texts *Functioning in the Real World: A PreCalculus Experience*, by Sheldon Gordon, et al, and *Contemporary College Algebra: Data, Functions, Modeling*, by Don Small, provide a whole-course modeling approach. Modules for use as supplements to existing texts have been developed through the “Earth Math” projects (earthmath.kennesaw.edu), led by Christopher Schaufele and Nancy Zumoff, and through Project INTERMATH (www.projectintermath.org), a consortium of eight schools and four additional associated schools led by the United States Military Academy at West Point. Many exemplary approaches for courses of this nature are described in the MAA Notes volume *A Fresh Start for Collegiate Mathematics* (an outcome of a NSF-funded conference), edited by Nancy Baxter Hastings and scheduled to appear in spring 2005.

Preliminary, and mostly undocumented, evidence does exist concerning renewed college algebra courses. This evidence indicates that skills do not decrease, that more students complete these courses and that these students go on to be successful in subsequent courses. However, this evidence is largely anecdotal and not confirmed by national studies.

This proposal was drafted by CRAFTY leadership, in conjunction with eleven colleges and universities. If funded, we will:

1. provide professional development support for eleven colleges and universities to offer pilot sections of modeling based college algebra courses, and

2. support a national study determining the impact of these courses on student learning by documenting: the success rate of students in the pilot courses; the performance of the students on skill-based as well as modeling-based final exam questions; the percentage of students who enroll in subsequent mathematics courses and their success in the courses; the students’ success in other courses for which college
algebra is a prerequisite. In all cases comparisons will be made with a control group of students enrolled in the prevalent skill-based college algebra courses.

The following eleven institutions have committed to participating in this proposed project. A letter expressing commitment to this project is included with the supporting documents. These institutions were selected from among those that expressed preliminary interest. The selection was based upon the commitment of these departments to participate fully in the faculty development component, their ability to offer pilot sections while also offering sections using their current approaches, and their willingness to participate fully in the research study. The eleven institutions that were selected were also chosen to provide a cross section of different institutions.¹

<table>
<thead>
<tr>
<th>Name of Institution and highest degree offered</th>
<th>Lead Faculty Member</th>
<th>Minimum Number of Pilot/Control Sections to be Offered each semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Arizona</td>
<td>Ted Laetsch</td>
<td>5/5</td>
</tr>
<tr>
<td>Essex Community College</td>
<td>Timothy Stafford</td>
<td>5/5</td>
</tr>
<tr>
<td>Florida Southern College</td>
<td>Kenneth Henderson</td>
<td>3/3</td>
</tr>
<tr>
<td>Harrisburg Area Community College</td>
<td>Linda Myers</td>
<td>4/4</td>
</tr>
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<td>Mesa State University</td>
<td>Theresa Friedman</td>
<td>3/3</td>
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<td>Southwest Missouri State University</td>
<td>Roseanne Killian</td>
<td>7/7</td>
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<td>North Carolina A&amp;T State University</td>
<td>Kathy Cousins-Cooper</td>
<td>4/4</td>
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<td>University of North Dakota</td>
<td>Richard Millspaugh</td>
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<td>Manfred Stoll</td>
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<td>South Dakota State University</td>
<td>Donna Flint</td>
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</tr>
<tr>
<td>Southeastern Louisiana University</td>
<td>Randall Wills</td>
<td>6/6</td>
</tr>
</tbody>
</table>

**Approaches to be Adopted/Adapted/Implemented**

The mathematics departments of the eleven participating institutions have agreed to pilot sections of a college algebra course with the following features: the central theme/organizing idea of the course will be mathematical modeling; students will be assigned long-term project(s); students will be assigned work to be completed in collaboration with other students; graphing calculators and/or computer utilities will be utilized throughout the course; the algebraic skills deemed by the institution as critical will be maintained in the course, but will be deemphasized. The goal is to enable students to use mathematics to quantify real-world situations – that is, to mathematically model physical phenomena. All participating institutions will be provided with the volume *A Fresh Start for Collegiate Mathematics* to provide an overview range of approaches to modifying their own courses in a way that is appropriate to their own missions and the needs of their students. While we recognize that other alternatives to the traditional college algebra course may also hold promise, we have chosen to restrict our attention to modeling-based materials in order to limit the scope of the project and to facilitate a meaningful evaluation of the outcomes of the renewed courses.

¹ Financial support is also being solicited from other sources to permit additional institutions to participate in a comparable pilot/research project.
Two leaders from each participating institution will attend the “Considering the Options Workshop” to take place August 1–3, 2005 in Albuquerque, N.M. in conjunction with MathFest, MAA’s annual summer meeting. During this workshop participants will be provided with information concerning a large collection of materials and approaches to consider to adopt/adapt/implement at their institutions. All of the texts and supplementary materials presented at the workshop will, of course, be modeling-based.

Authors of selected curriculum projects who have agreed to serve as consultants to departments that choose to implement their materials will serve as workshop presenters, and meet with individual teams to provide support through the decision process. Participants will be given an overview of the different approaches and have an opportunity to review all of the featured materials while having access to the authors when questions about a particular approach arise. Discussions will include samples of experiences of prior adopters of the materials, with special attention given to the pitfalls that may be faced when students are asked to consider mathematics in a modeling context. The workshop will deal with the full range of implementation issues including the provision of a sample document to use to obtain approval from institutional review boards and/or college and university curriculum committees.

Participating teams will be asked to consider two options. The first option will be to use a traditional text (perhaps the text the participants are currently using) and to modify the course incorporating supplementary materials from those featured in the workshop. A second option is to adopt and adapt one of the modeling-based texts that are offered for consideration. Departments that choose the option of adopting/adapting a new text for their course will also be able to supplement the chosen text with additional materials to meet specific needs of their students.

Overall direction for the workshop will be provided by Norma Auras, William Haver and Nancy Baxter Hastings. Co-PI Norma Auras, Chairperson of the Department of Mathematics at Miami Dade College, Wolfson Campus, is a collaborative author with the University of Massachusetts College Algebra Consortium, oversaw the implementation of a modeling-based college algebra course at her home institution, and has broad experience as a workshop leader at events connected with curriculum reform William Haver, Professor of Mathematics at Virginia Commonwealth University, has participated in efforts at his home institution to adapt a modeling-based text for their college algebra course, currently serves as the chair of CRAFTY, and is also one of the directors for the MAA project, Supporting Assessment in Undergraduate Mathematics. Nancy Baxter Hastings, Professor of Mathematics at Dickinson College, is a textbook author herself; has served as chair of the department, led prior workshops on reforming introductory mathematics courses and currently serves as chair of the MAA Committee on Professional Development.

The directors will develop the workshop schedule, and communicate the goals and requirements to the presenters to ensure that participating institutions receive enough information to reach an informed decision. Throughout the workshop, the directors will provide support to the individual teams and monitor/guide the discussions. After the workshop, the directors will continue to stay
in contact with participants via email, phone and video conferencing, as needed, to monitor implementation progress and coordinate site visits of both the author/consultants and the project evaluator.

The participating colleges have agreed to provide transportation to the Workshop for the two leaders. Support is sought for participant room and board and program expenses.

Making the Decision

At the conclusion of the workshop, the teams of two faculty members will return to their campus and discuss the options for offering pilot sections with their colleagues. Departments will be provided with copies of the CUPM Curriculum Guide 2004 to help guide the discussion. The mathematics faculty will then meet with faculty from user departments as part of the process of determining the materials and approaches that will be used for the pilot sections. Five copies of Voices of the Partner Disciplines will be provided by the MAA to each team as a tool to facilitate these discussions (during the Workshop the participants will learn about how this publication has been productively used in such settings at other institutions). Based upon these discussions the mathematics departments will decide which materials to use. A team of faculty will then develop the syllabus and supporting materials needed to adopt the course at this institution. Stipends of $5,000 per institution are proposed in the budget to partially support this development and the work required for each institution to participate fully in the research study. All other course development and implementation costs will be paid by the institution.

Campus Visit to Prepare Faculty

The appropriate consulting author will conduct a two-day visit to each campus to participate in the faculty development process. The details of the program will be developed jointly by the campus leaders, the consulting author, and the project leaders. Items discussed will include mathematics content, mathematical modeling, student projects, use of technology, student writing, and assessment of student work. All consultants will also provide follow-up support by email, phone and video conferencing as appropriate.

Offering the Pilot Sections

The first pilot sections will be offered in the spring 2006 semester and the second set during the fall 2006 semester. As described in the table on page 2 of this proposal, each participating institution has committed to offering pilot sections and control sections during these two semesters.

During each semester, faculty teaching the pilot sections will meet on a weekly basis to discuss the progress of the course. At least one video conference will be held each semester so that faculty can report on and share experiences with their colleagues at other participating institutions. An archived listserv will be maintained by the MAA throughout the project.

Research Component
The research component is an essential part of this project. We propose to design a national comparative study that will answer this question: In what ways is learning enhanced, qualitatively and quantitatively, when students participate in a modeling-based versus skills-based college algebra course? In particular we wish to compare

- the success rate of students in both classes (grades and retention),
- students’ and instructors’ attitudes about the courses,
- the performance of these students on common skills-based as well as modeling-based final examination question,
- the percentage of students who enroll in subsequent mathematics courses and their success in these courses, and
- the success rate of students in other courses for which college algebra is a prerequisite.

Barbara Edwards, Oregon State University, a respected mathematics education researcher, will design and coordinate this research. Each participating institution has agreed to provide information concerning students in the pilot sections and designated control section during each of the two semesters in which the courses are offered as well as two semesters of follow-up data. At the initial workshop in August 2005 one person from each team will be designated to facilitate the data collection.

The research design will take into account the fact that the courses will not be exactly alike. They will be tailored to each institution’s needs and goals as called for in the CUPM Curriculum Guide. To do this the research will identify the common threads in all projects. These threads will include student team work, long-term projects, and de-emphasis of algebraic skills, all in the context of a modeling-based course. Additional threads will be identified based on the decisions of the participating departments.

The data gathered for this study will consist of SAT math scores (to enable comparisons), grades, retention information and performance on common test items for participating students in both pilot and control sections. During the two semesters following each student’s participation in the college algebra course (experimental and control classes) the researcher will gather data on student retention and grades in subsequent mathematics courses and in other courses for which college algebra is a prerequisite.

The researcher will also make at least one 3-4 day visit to each participating institution for the purpose of observing pilot and control sections, interviewing instructors and conducting focus groups with students. The researcher will also participate as an observer in the initial workshop in August 2005 and the video conference in which participating institutions will share their experiences.

Results of the research will be reported in issues of Focus, the MAA Newsletter. They will also be submitted for publication in mathematics education journals and serve as the basis for proposals for sessions at MAA national meetings.

**Development of Proposed Plan**
In September of 2003, CRAFTY identified the need to support departments in renewing College Algebra as the committee’s highest priority. Susan Ganter, then chair of CRAFTY, and Shelly Gordon played leadership roles in developing CRAFTY’s thinking on this important course. This thinking, influenced by the findings of CRAFTY as published in *Voices of the Partner Disciplines*, included the following conclusions: departments need to first make a decision to renew their college algebra course in a manner that best meets the needs of students on their campuses; faculty then need to be aware of the exemplary supplementary materials and textbooks that have been developed in recent years; faculty need to open and maintain a dialogue with faculty in other disciplines on their own campuses concerning the needs of these disciplines and their students; instructors who will teach using new approaches and materials need extensive preparation and continual support; research needs to be conducted to determine the effectiveness of the renewed courses.

In the Fall of 2003, Bill Haver agreed to serve as the next chair of CRAFTY and, fortuitously, at the same time his department committed to working to renew its College Algebra course. With some support from another grant, Virginia Commonwealth University put in place a procedure very similar to the one in this proposal. Instructors from the department attended an MAA PREP Earth Algebra workshop, Don Small visited the campus and made presentations on modeling-based college algebra courses. Faculty from the department opened dialogue with the business school and other user departments, and, in the Fall of 2004, eight pilot sections of the renewed college algebra course, using Small’s text, are being offered. The faculty has met weekly to discuss the course. Initial results are very promising: attendance is much stronger than that in the control sections; the withdrawal rate is very much lower; and midterm grades are higher in the renewed sections. A portion of the final exam will be identical for students in the pilot and control sections, and the student success rate in the pilot and control sections will be tracked.

The response from our initial call to participate was overwhelming, and suggests that further efforts in this direction are wanted by the mathematics community. In addition to the consulting authors and workshop leaders named above, many CRAFTY (and other MAA) members, and faculty from institutions such as Virginia Commonwealth and Miami Dade, offer a network with a wealth of experience that can be called on to provide support to the project, and to suggest ways to pursue an expanded version of this project to allow additional institutions to participate. It is our existing structure and long experience in undergraduate mathematics issues that makes the MAA the ideal leader for this project.

**Conclusion**

If funded, the MAA, through CRAFTY, will share the results of the project, *positive and/or negative*, with the broader mathematics community. The MAA will encourage mathematics faculty to reexamine their department’s college algebra offerings and adopt those practices identified as successful. It is anticipated that the results of the proposed research will show that students completing renewed courses develop stronger mathematical abilities, have computational skills equal or better than those of students who complete traditional courses, and are more successful in subsequent courses. This evidence will make it more likely that we can begin to fundamentally renew the college algebra course nationwide in order to better serve our students.
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References

