Inside New Life: A Grand Vision for Developmental Mathematics

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The traditional developmental mathematics model involves a sequence of algebra-based courses meant to provide content similar to that found in middle school and high school mathematics classes. As a curricular design, this methodology results in sequences of developmental mathematics courses for many students; evidence exists suggesting that our current remediation does not work well enough. Through the dedication of professionals across the country, the New Life model for pre-college mathematics seeks to create a positive alternative. Our basic design is based on the AMATYC standards (*Beyond Crossroads*), as well as previous work of MAA, NADE, and the Numeracy Network.

This article serves as a basic primer into the design of the New Life model. The New Life Project is a subcommittee of AMATYC's Developmental Mathematics Committee; our work represents professional judgment and collaboration, rather than official AMATYC actions.

Work on the New Life project began in late 2008; our initial work was completed by teams in 2009. These volunteers used a special wiki to share documents and resources, and to build consensus.

Three pillars: The Purposes of Pre-College Mathematics

The primary difficulty with the traditional model is that it represents a default remediation approach, presuming that college students should 'know' school mathematics. Further, the 'school mathematics' involved does not represent the progress made in K–12 education to incorporate a broader range of mathematics in terms of content and in terms of levels of learning outcomes. Instead of modifying this 'accidental' model, we designed a new model based on purposes for these courses combined with the best thinking in the profession.

The New Life project started with three goals of pre-college mathematics:

- Prepare students for a variety of college math courses.
- Prepare students for other courses with quantitative needs.
- Prepare students for academic and life success.

The first two goals resulted in back designing: looking at the mathematical needs in those courses to identify what learning outcomes are needed in pre-college courses. The third goal was more difficult as a basis for our design due to the broad nature of the goal; however, we did incorporate some of the available expertise on student success and numeracy.

We started our project by asking respected peers what they saw as the big problems in developmental mathematics. The major problems identified were

A. Isolation of our faculty from a community,

B. Excessively high use of adjunct faculty, and

C. Obsolete content.

Efficiency of design

In addition to these goals guiding content decisions, we established two design principles. The first principle states that each pre-college mathematics course should provide the broadest base of mathematics possible, so that each course supports multiple 'next course' targets.' In practice, this principle resulted in our first course

A 3-day meeting was held in Seattle (July 2009); participants:

- Kathleen Almy (IL)
- Rikki Blair (OH)
- Laura Bracken (ID)
- Sadie Bragg (NY)
- Connie Buller (NE)
- Rosemary Karr (TX)
- Rob Kimball (NC)
- Jeff Morford (MI)
- Julie Phelps (FL)
- Pat Rhodes (WA)
- Jack Rotman (MI)
- Myra Snell (CA)
- Jane Tanner (NY)
- Janet Teeguarden (IN)
- Linda Zientek (TX)

We did not have course names at this time, so they were called "the blue box" (MLCS) and "the green box" (AL).

including mathematics appropriate for all students—STEM and non-STEM. Since the traditional courses emphasize STEM needs, the New Life model is sometimes characterized as being for non-STEM students. However, our intent was to create a new model appropriate for all students. [Local implementations may initially target only non-STEM or only STEM students. We see this as being a transition phase in a reform.]

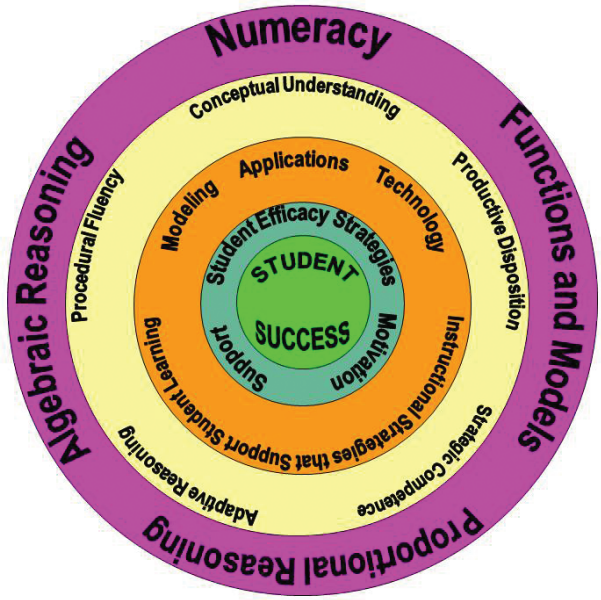
The second principle of design states that each pre-college mathematics course should enable students to consider additional academic goals, so that students will not be blocked from other mathematics goals – and may, perhaps, be inspired and empowered to accomplish loftier goals. In practice, this principle is reflected in each New Life course including more mathematics than a given student is likely to need for a narrow goal; instead of a traditional model where excess mathematics is a burden, our approach was to establish a positive experience with mathematics as a learning experience.

Additionally, a major constraint was recognized from the outset: one pre-college mathematics course is better than two, and students should not be faced with more than two pre-college mathematics courses. As we designed our first course, we did not assume that there was a mathematics course preceding it. More about this will be discussed later.

The Courses of New Life

Working from lists of learning outcomes, which were mostly drawn from existing references (such as MAA CRAFTY and the Numeracy Network), we spent time in 2009 in identifying outcomes (and their categories) organized into clusters that would become courses. Since we wanted to have one pre-college course when possible, learning outcomes that applied to all college students were organized in one cluster for a course to be called Mathematical Literacy for College Students (MLCS). Outcomes that were either for STEM-bound students or were clearly more advanced in basic ways were placed in another cluster for a course that we now call Algebraic Literacy (AL).

In addition to outcomes, we also discussed instruction and assessment. We created visualizations of a total course design for MLCS, which led to the "spinner models" seen at the 2009 AMATYC Annual Conference:



The outer band in this model represents the content goals of MLCS, and the band immediately within that is the assessment design; this assessment design was adapted from the book *Adding It Up* (Kilpatrick, Swafford, & Findell, 2001). The third band represents instructional strategies, which were seen as the interface between the outer bands (content and assessment) and inner bands (student support and success). The fourth band illustrated our interest in designing a course with direct applications of psychological and social dimensions of student success. Clearly, the student success 'target' in the middle illustrates the high expectations for very high student success levels; fewer pre-college courses will do little good if the typical 50% pass (as seems normal in traditional courses). Although we did not create a similar visual for Algebraic Literacy (AL), we would anticipate a similar design.

The 2009 AMATYC Annual Conference featured a Symposium which officially launched the New Life Model; Rosemary Karr and Jack Rotman were the presenters. This symposium was recorded; see http://www.amatyc.org/videos/NewLife/rotman.html.

Mathematical Literacy Course

Mathematical Literacy for College Students (MLCS) is a strong mathematics course, with benefits to students, without presuming students will take another mathematics course afterwards. MLCS serves these curricular purposes:

Prepare students for some college mathematics courses (some introductory statistics courses, quantitative reasoning, technical mathematics courses, etc.).

- Prepare students for some other college courses with quantitative needs (basic science and social science, some technology courses).
- Prepare students for success in college, based on the psychological and sociological components of the class.

Originally, the second course was called "Transitions"; the new name (Algebraic Literacy) was developed in 2012 for better communication.

MLCS seeks to provide this preparation by focusing on concepts and reasoning, more than on symbolic manipulation. We saw MLCS as a course with obvious value to students, based on learning in context and direct application.

Since we currently have a structure with an algebraic emphasis, we needed to clarify how MLCS dealt with algebra. You will see "algebraic reasoning" as a goal, with outcomes within that emphasized representations; in some outcomes, symbolic procedures are included – often to be done after application of the algebraic reasoning.

The major tool for the New Life project is our wiki, which serves as an online community: see http://dm-live.wikispaces.com.

The proportional reasoning goal was seen as a transition zone between the numeracy goal and the algebraic reasoning goal. Also, we did not envision the four goals as being chapters in a book; rather, we anticipated that courses would have a structure that blended the four goals throughout the course (with numeracy starting off strongest, and shifting towards algebraic reasoning and functions later). In addition, we expect that each MLCS course would include incidental work on other mathematics (such as statistics and geometry).

Algebraic Literacy Course

Algebraic Literacy (AL) is designed to be a modern course that blends symbolic and numeric work with algebraic objects. To understand the model, it is critical that we see AL as fundamentally different from intermediate algebra; see the curricular purposes below. The outcomes in AL describe a course with intrinsic value to students, so that AL does not assume that students will be taking a course like precalculus; however, we did identify some additional outcomes that would provide the background for courses like pre-calculus (called 'STEM boosting outcomes). The AL course can serve these curricular purposes:

Our online community (http://dm-live.wikispaces.com) provides all of our references for the model, such as the MAA CRAFTY and client discipline reports.

- Prepare students for some college math courses (reform college algebra, finite math, math for elementary teachers, etc.).
- Prepare students for a pre-calculus course, by inclusion of the STEM boosting outcomes.
- Prepare students for general science and technology courses (those with a strong algebraic basis).
- Prepare students for general academic success.

AL seeks to provide this preparation by building understanding and application, along with specific symbol manipulations. We see AL as a strong mathematics course focusing on key concepts (such as rate of change, graphical interpretations, symbolic representations, etc.).

The AL content goals are:

- Numbers and Polynomials
- Functions
- Geometry and Trigonometry
- Modeling and Statistics

You can see the same trend here as for MLCS: The AL course includes more than algebra. Our inclusion of diverse mathematics in each course allows the model to have fewer courses.

To see learning outcomes for both MLCS and AL, go to the wiki listed above.

The 2009 meeting in Seattle was supported by the Gates Foundation, and the Monterey Institute of Technology in Education (MITE). Ruth Rominger from MITE facilitated the meeting.

Image of the curriculum

Overall, we see the reform of developmental mathematics within the context of reforming all mathematics in the first two years. However, we would be very unreasonable to expect the entire curriculum to be reformed simultaneously. Therefore, we provide an image of the reformed developmental math curriculum within a typical set of courses, as seen in the following figure.

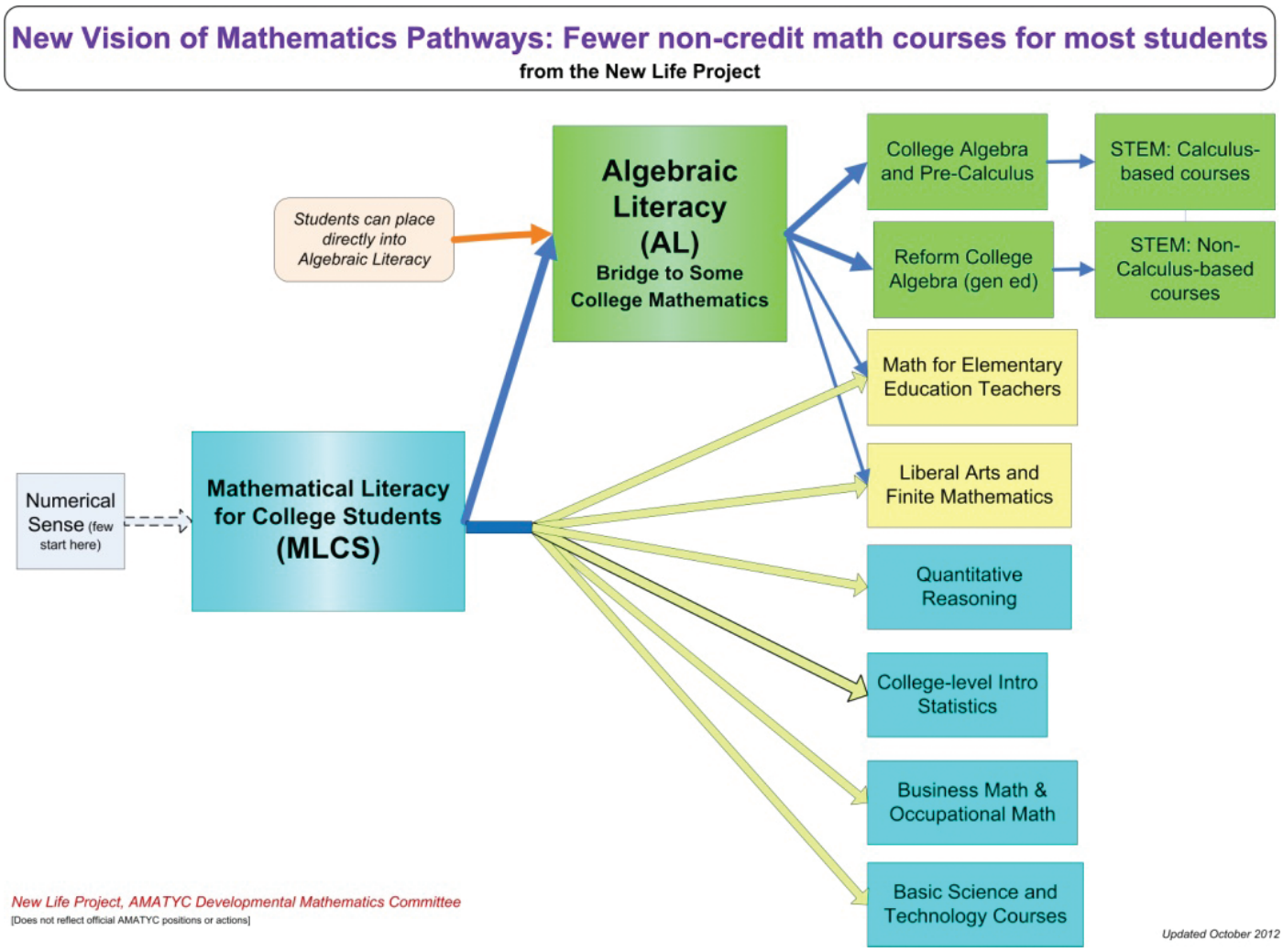
If we are to achieve the goal of one pre-college course for most students, we need to provide entry to the AL course without taking MLCS. The content of AL does not assume any further background than that provided in MLCS; we anticipate that this will allow a sizable portion of students to begin with AL (if needed for their goals). Placement concerns will be addressed below, as will the issue of 'students not ready for MLCS.'

Placement of Students

We are also aware that placement tests and placement systems will not change right away; the primary placement decisions will be based on existing tests, which emphasize algebraic procedures and concepts. Therefore, as an initial estimate, we provide these guidelines:

1. Students who are judged ready for beginning algebra can be placed into MLCS.
2. Students who are judged ready for intermediate algebra can be placed into AL.
3. Some students who are currently placed into pre-algebra or basic mathematics might be placed into MLCS.

As part of our collaboration, refining the learning outcomes for MLCS was supported by the Carnegie Foundation for the Advancement of Teaching (Stanford, CA) and the Dana Center at the University of Texas (Austin).



4. Some students who are currently placed into beginning algebra might be placed into AL.

The first two guidelines reflect how institutions initially start working with MLCS and AL. The last two guidelines suggest that some students could begin 'at a higher level' in the New Life model compared to the traditional curriculum. In the case of item 4, we believe that some students are sent to beginning algebra simply because they lack current symbolic manipulation skills, and will be ready for the more balanced approach of AL. For item 3, we note that MLCS has a very limited set of prerequisite skills (described below); most of the typical prealgebra or basic math class does not deal with these skills.

In the long term, the placement tests as well as our placement systems need reform as well. As our curricular needs shift, the tests and content will shift. We also need to refine our placement systems to reflect the best knowledge about factors that provide valid placement decisions.

What about Pre-algebra and Basic Math?

When our pre-college math courses are completely reformed, we believe that there will be no need to have any course prior to MLCS. Pre-algebra courses exist with a primary purpose to develop algebraic reasoning at a basic level; this need is addressed within the MLCS outcomes. Basic mathematics, and some pre-algebra

In 2009, Myra Snell shared an analysis of a sequence of math courses as nodes and connectors, like a network of edges and vertices. Sometimes stated as 'exponential attrition', the mathematics of a sequence might be better viewed as a product of independent probabilities to estimate the best case outcome. For three courses, the maximum theoretical value is between 0.2 and 0.3. Observed values are between 0.1 and 0.2.

courses, exist to develop procedural skills with decimals, fractions, and percents; we recognize that some students have a need for these skills beyond the very basic level required for MLCS. However, we believe that the real need (validated by external sources) is so limited that students would be served better by a different model, whether this is non-credit course work or just-in-time remediation.

Our conclusion is that courses at the current level of pre-algebra or basic mathematics do little to prepare students for further course work. The components of these courses that do offer student benefits are incorporated into MLCS, where they avoid the need for an additional mathematics course.

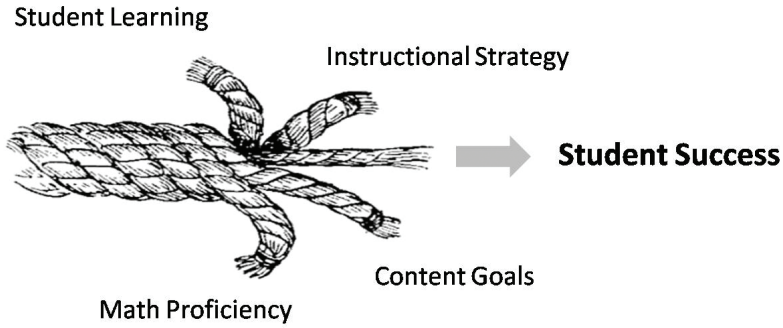
Prerequisite Skills for MLCS

Given the outcomes identified for MLCS, we made our best estimate concerning the prerequisites for this course. This initial estimate is the following short list:

- Use arithmetic operations to represent real-world operations, such as putting together, comparing, distributing equally, etc.
- Use real-number arithmetic to solve stated problems.
- Use graphical representations on a number line to demonstrate fluency in interpreting interval notation, ordering numbers, representing operations (i.e., addition, subtraction, doubling, halving, and averaging) and representing decimal numbers, including negative numbers.

We believe that students who can perform these "use" capacities are ready to take MLCS. This does not mean that we expect that all of these processes are done symbolically (the second item in particular). We also suspect that some students will discover gaps in these skills at a finer level of granularity as they proceed through MLCS, perhaps more than is currently seen in our courses. Rather than obsess over achieving a perfect preparation for MLCS, it seems more productive to focus on quick remediation – whether this is a boot-camp experience just before MLCS, or just-in-time remediation within the course.

In 2010, Robert Cantin (MA) created an alternative visual aid in place of the spinner model.



Students Not Ready for MLCS

Even with this short list of prerequisite skills to MLCS, we understand that we will have students who are really not ready to take MLCS. However, we believe that the profession needs to avoid the possibly false belief that we need to provide a course that prepares students for MLCS. If a group of students is not sufficiently served by a boot-camp experience, we need to design a system that balances 'better preparation' with the attrition arising from another course in a sequence. Larger institutions might offer a combination course which includes the needed remediation along with

an MLCS course for this population; smaller institutions might offer co-requisite modules attached to a regular MLCS course.

Because our profession is committed to student success, we have created longer and longer sequences of courses to get students ready – resulting in a system where the mean, median, and mode for students starting in the first course is "failure to complete." The New Life Project suggests that we avoid a third pre-college math course, and employ other methodologies instead.

Context of the Problems: If We Solve This, Will We Be Done?

Developmental mathematics is in the midst of major changes, accompanied and encouraged by external reports on the condition of developmental education. Faculty are trying various solutions, whether by choice or by directive. However, problems are not created, nor solved, in a vacuum isolated from other components.

In the case of mathematics, two major problems exist outside of developmental mathematics that impact students in a variety of programs. These problems can be identified by course titles "college algebra" and "pre-calculus." Many college algebra courses suffer from an identity crisis (Is it really pre-calculus? Does it prepare students for STEM-like courses? Is it general education?). Pre-calculus courses suffer from problems that are surprisingly similar to developmental mathematics: content historically driven and not systematically designed for preparation for calculus, along with instructional practices more based in the past than on student success.

In general, we believe that there is a need to have "New Life for Gateway College Math" as an extension of our work. We do not presume that our concepts and models are appropriate for this context, and expect a different group of faculty to become inspired to undertake the Gateway Math project.

Urgency exists for this type of work. The gateway to STEM is, far too often, the door closed on student aspirations. The good news is that we have information on the quantitative needs of client disciplines (economics, biology, and more), ground work has been done on college algebra reform, and various calculus reform efforts can inform our pre-calculus work. Mathematics departments cannot justify their existence by having an improved developmental program while continuing gateway courses that impede progress into STEM fields.

The AMATYC "Right Stuff" project has curriculum materials for college algebra courses which serve a general education purpose: http://www.therightstuff.amatyc.org/materials.htm.

Collaboration with Carnegie Pathways and the Dana Center Mathways

New Life is not the first reform model for developmental mathematics. However, we believe that there are three fundamental differences that will allow this model to develop stability in the profession:

1. The New Life model is built on a foundation of professional work (AMATYC Standards, MAA CRAFTY, NCTM, and Numeracy Network).
2. The New Life project is developed and supported by a large network of professionals, mostly faculty, from all parts of the country.
3. The New Life model is similar to other reform efforts, such as Carnegie Pathways and Dana Center Mathways.

The development of the New Life model coincided with the development of the Carnegie Foundation Pathways, and the two efforts collaborated in many ways. The content of MLCS is very similar to the developmental math content in the Pathways.

The Carnegie Foundation provided some funding to AMATYC to support two liaisons to their Pathways project during the start-up period (2010 to 2012); Julie Phelps and Jack Rotman served in these roles.

What's with the Name: New Life?

Occasionally, somebody will ask about the name chosen for the model. When we began our work, the profession of developmental mathematics involved significant levels of discouragement and some desperation. The name New Life was chosen to reflect our focus on working with faculty: We can bring a new vision and a new vitality to our critically important work with students, and we can develop new courses that emphasize important mathematics.

Where This Is Headed

We would not expect a major change to happen in a short period of time, although we could hope that inertia would build in a reasonable amount of time. Since first publicizing the New Life model in 2009, we continue to make improvements; most of these involve how ideas are communicated, rather than the ideas themselves. The New Life project will continue to be community based, rather than grant based.

Because the New Life model allows for local flexibility and compatibility with existing courses, faculty can move along the reform path at a pace that works in their college. At the time of this writing (late 2012), the MLCS course is being piloted or taught at about 20 colleges representing several states; indications of interest suggest a larger group planning on doing an MLCS course in 2013–2014. The AL course will generally be implemented after schools have done MLCS; this is not necessarily the case, but it appears that faculty see the 'MLCS first' strategy as a good plan.

Basic reform involves the entire profession over an extended period. Our hope is that we will achieve a majority reform condition within ten years or so, where a majority of colleges are emphasizing a New Life or comparable model. Through the committed work of professionals in a process that engages all of us, we can build something new which serves our students better.

To Begin Your Reform Process Using New Life

An initial step in the process would be to join the New Life online community (http://dm-live.wikispaces.com). In addition to resources, this site allows members to post items for discussion; help from others is available. One of our teams maintains this wiki, including a page dedicated to implementation issues. Another team works on professional development, and we may be able to connect your college with a qualified trainer.

Another step will be for you to talk with your local publisher representatives about materials. The companies are working on projects that will result in textbooks being available over the next year or two; in some cases, you will be able to class test a new textbook. We have a team that does some work on resources; if you have a question for them, post it on the wiki site.

In June 2012, an AMATYC webinar dealt with general reform issues in developmental and gateway mathematics courses, with presenters Uri Treisman and Jack Rotman. The recording of this webinar is available at http://amatyc.org.

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Jack Rotman has been at Lansing Community College since 1973, with a focus on "developmental" mathematics. He has an MA from Michigan State University. He has been active in the state professional organizations, with multiple presentations and offices. Nationally, Jack has contributed to the AMATYC Standards (both *Crossroads* and *Beyond Crossroads*), and has chaired the AMATYC Developmental Mathematics Committee twice for a total term of 9 years. Currently, he is leading a team working on a project to re-invent developmental mathematics – the AMATYC "New Life for Developmental Mathematics" group of the Developmental Mathematics Committee. Jack was involved as an AMATYC content liaison for the "Pathways Grants" of the Carnegie Foundations for the Advancement of Teaching, and has also been involved with the work on the Dana Center New Mathways Project. Jack seeks to combine an understanding of mathematicians, of college mathematics, and of cognitive psychology to bring a new perspective on mathematics in the first two years.