Dr. Green's Scholarship

My scholarship reflects my broad interests in mathematics, science, and the teaching and learning of these subjects, and it connects deeply to the courses I teach. I believe that this is appropriate for a professor at a teaching and learning institute such as St. John Fisher College. This deep connection between my teaching and my scholarship are demonstrated in my reflection on teaching. Each of my publications reflects a great deal of work on my part to develop a solid understanding of the related literature. And despite the serious time investment it has required to "dabble deeply" in several different (although related) areas of scholarship, my scholarly work after receiving tenure at Fisher has far exceeded my production before tenure (see table below) with an average of 3 publications per year since receiving tenure. This work also reflects my commitment to scholarship as a collaborative endeavor and has involved co-publication with six different faculty members at Fisher related to various aspects of teaching mathematics and science. Three of these colleagues have gone on to receive tenure and promotion after our work was published. I remain active, with several articles in various stages of production at present. Generally, my scholarship falls into one of five categories: teaching and learning mathematics, teaching and learning science, teaching and learning in general, mathematics in popular culture, and applied mathematics. These themes are discussed and expanded upon below. This work has resulted in a variety of peer-reviewed publications, book chapters and conference presentations. The article numbers refer to my C.V.

Type of Scholarship	Pre-Tenure	Post-Tenure
Peer-reviewed publications	2	15
As sole author	1	6
As first author	1	4
Invited Book Chapters	0	3
Presentations/Talks	5	7
Poster presentations	4	0
Workshops Presented	4	6
Local	4	4
National	0	2
Panel Discussions	1	2

Table. Comparison of pre- (Fall 1999 – Summer 2005) and post-tenure (Fall 2005 – Summer 2010) scholarship.

The majority of my scholarship is in the area of **teaching and learning mathematics**. These articles have dealt with a variety of issues in undergraduate mathematics. Article #2 analyzed reasons why students have difficulty with a particular problem in multivariable calculus (MATH 221). For this, I made use of cognitive science, in particular the revised version of Bloom's taxonomy of educational objectives. In another article about teaching MATH 221 I present a simple, inexpensive physical manipulative (clear blister packs for toys) as part of a classroom exercise to help students connect the contour diagram (level curves) of a function of two variables with the three-dimensional surface plot of the function (article #12). Article #5, written with Ryan Gantner, offered a general design for team-based mathematical modeling projects to ensure that both individual and group learning could occur effectively. This grew out of projects we developed and used in teaching MATH 170.

Article #4, written with Allen Emerson, compares a typical mathematics problem from a math service course for business students to the way we approach similar content in the MSTI 130 course we developed for the same audience. In general, our approach offers more chance for students to connect mathematics and the real world, more flexibility in solution approaches, and more realistic analysis and reasoning. In article #7, I show how the parameters of four commonly used pre-calculus models (linear, logarithmic, exponential and power) can be easily interpreted through an approach to interpreting change that unifies both amounts of change and relative (percent) changes. This unification comes through the use of transformations to construct nonlinear models of data, and it provides students in MSTI 130 a simpler way to think about such functions.

In articles #9 and #10, Allen Emerson and I discuss the approach we used in developing a new course to provide mathematical content in support of general business students. This previewed some of the work that was later expanded in article #4, showing how the use of authentic assessment strategies – like having students engage in the analysis of data within the context of a realistic business-type writing environment (the memo) – is a critical component to creating a learning experience that students find valuable. This theme of incorporating writing and communication is also an important part of two articles. Erica Johnson and I (articles #15, cited in a literature review of "best practices in distance education") looked at ways to incorporate elements of Web 2.0 (wikis and discussion boards) to support mathematics learning and encourage mathematical discussion. In article #17, I demonstrate two writing assignments appropriate for a calculus course (and adaptable to most other courses) that give students a different way to think about what they are learning.

Although I teach in the Mathematical and Computing Sciences Department, I have a strong background in physics and engineering, which explains some of my interest in **teaching and learning science**. Both the MST major and the GMST program have afforded me the chance to teach a variety of science content courses. One of these courses, now labeled MSTI 215 Dynamics of the Physical World, is a physics and earth science content courses for childhood education majors. One of the classroom activities I developed for this course offered an inexpensive way to visualize and experience (using kinesthetic approaches) a fairly abstract concept, the Doppler Effect, which predicts how a wave's frequency appears to change as the source of the wave moves (article #14). Tim Franz and I co-taught the Science Scholars Learning Community for three years. The LC was designed to explore scientific thinking by contrasting it with pseudo-scientific thinking and science fiction. In article #1, we show that this experience did result in a significant growth in students' ability to reason critically.

An important part of helping students to experience the joy and thrill of mathematics is showing them the role of **mathematics in popular culture**. In article #8, I use the movie *The Matrix* to draw parallels with linear algebra (MATH 232) and provide multiple perspectives on the role that mathematical matrices play in the plot, special effects, and concept of the movie. This article was published in *Math Horizons*, a journal targeted at undergraduate mathematics majors and having a circulation of over 20,000. Jessica Sklar contacted me in 2009 about the possibility of expanding this article for inclusion in a collection of essays about mathematics and popular culture (B2a). This book is due out soon and will also include a second chapter by me (B2b) that contrasts the type of thinking required as an applied mathematician and the thinking required to be an effective role-player in a game like *Dungeons and Dragons*.

I have also remained active in **applied mathematics** research. Elements of my dissertation were published in article #16. This work looks at the possible gravitational signatures of a macroscopic collection of particles called tachyons. I have also done work with Munawar Karim on gravitation-related projects. In #18 we present a way to take advantage of a particular effect to create less expensive gravitational wave detectors (approximately $50,000 versus several million). To date, the expensive experiments have not conclusively detected such waves, so other approaches are needed. In article #19, I provided support for parameter fitting a nonlinear, integral-based equation to explain supernova data without appealing to the mysterious and yet-to-be-identified "dark matter" or "dark energy." Currently, I am engaged in several other applied mathematics projects connecting to climate modeling. I am also engaged in exploring a system of nonlinear differential equations that arose in my dissertation; there, I was able to solve the equations by finding an auxilliary equation that was integrable. I am attempting to generalize this approach so that it might be either clearly related to existing techniques for solution or added as a new "standard technique."

Finally, I have written on **general issues in teaching and learning**. Barney Ricca and I contributed a response to Mowat and Davis (*Complicity*, 7(1), 2010). This issue of *Complicity* consisted of a lead article by Mowat and Davis and a series of reactions to this article. The journal itself is dedicated to exploring the notions of complexity in education. Our response (article #3) looks at the conceptual web of mathematics that underlies the assumptions of Mowat and Davis' article and then considers what implications this would have for managing effective teaching and learning experiences. Diane Barrett and I illustrated how one could use the central concept of pedagogical content knowledge to organize a graduate program for math and science teacher preparation (article #6, citations in two articles). These ideas and my experiences in designing different courses and the MST major at Fisher culminated in an invitation to submit a chapter to the *Handbook of Curriculum Development*. This chapter, "Participating in the Hyperlinked Curriculum" (B1), surveys different approaches to designing a course or program. Viewing them all as variations on the mathematics of projecting a three-dimensional network of concepts into a linear (temporal) dimension through which the course unfolds, the chapter then previews a curriculum in which the students explore this three-dimensional web of concepts on their own, under the guidance of a teacher, incorporating their interests and strengths naturally.

New approaches to organizing and managing the learning environment necessitate new approaches to grading and evaluating students. This became critically apparent in designing and teaching MST 130, when Allen Emerson and I wanted to provide students with detailed feedback that would help them improve and rethink their work, rather than simply summarize the quality of their products. After an exhausting series of semesters we developed the Categorical Objective Grading System (COGS) that we reported in article #13 (cited in one article and one thesis). I have since adapted this approach to other courses. Once the curriculum is more open and allows students to choose a variety of ways to demonstrate understanding and ability, traditional record-keeping systems (imagine the standard grid of grades and students in a grade book) breaks down. In article #11 I demonstrate how to take advantage of a built-in tool in Microsoft Excel, pivot tables, to organize and report on student performance. This "how to" guide appeared in the *Mathematics Teacher*, one of the most widely read journals in mathematics education (approximate circulation of 50,000.)

Currently, Dr. Barney Ricca and I are studying student problem solving strategies. We are interested in learning about the cues that students use to shift strategies when solving problems. To support this work, we received a faculty development grant of $2,850. This will help compensate students for participating in the data collection process, which involves recording the students' activities on a computer in solving a variety of complex problems. This work will help inform a model we are constructing to help simulate student learning under different conditions in order to study how altering classroom conditions might influence student learning.

I also consider my work with mathematics majors, science scholars and GMST students as a form of scholarship. While these projects have not resulted in peer-reviewed publications (yet) each project is a piece of a larger project that could result in publication. Further, many of these students have been admitted to, and been successful in, Ph.D. programs, partly as a result of their research projects. The mathematics projects have dealt with advanced topics in differential equations (modeling, PDEs and numerical analysis), network theory, and cellular automata. Summaries of these projects may be found in section V of the dossier.

Finally, the work required to compile and analyze data on the GMST/Math Certification and undergraduate 7-12 Mathematics Certification Programs at Fisher to prepare the NCATE reports necessary for accreditation is considered a form of scholarship. It is peer-reviewed at a national level and is made public. It requires intense analysis and depth of understanding of the programs involved.