

AC 2010-1715: TOYS AND MATHEMATICAL OPTIONS FOR RETENTION IN ENGINEERING (TOYS'N MORE) BROAD IMPACT -THE CAMPUSES

Janice Margle, Penn State Abington

Janice M. Margle, Associate Professor of Engineering at Penn State Abington, received her M.Sc. and B.Sc. degrees in Mechanical Engineering from The Pennsylvania State University. She is Co-PI on the NSF-Sponsored Toys'n MORE grant and currently teaches introductory thermodynamics and introductory engineering design courses. She is a licensed Professional Engineer and has worked for NASA, the Navy, IBM, PPL, and private industry. She is active in promoting activities to increase the number of women and minorities in engineering and is a member of Penn State's Women In Science and Engineering (WISE) executive committee.

Javier Gomez-Calderon, Penn State New Kensington

Dr. Javier Gomez-Calderon, Professor of Mathematics at Penn State New Kensington, received his Ph.D. from The University of Arizona. From 2002 to 2006, he served as Head of the Mathematics Division of the former Commonwealth College which, at the time, included 14 campuses in the Penn State system. He is currently Co-PI on the NSF-Sponsored Toys'n MORE grant. Dr. Gomez-Calderon is the author, or co-author, of twenty-nine articles, four elementary textbooks, and four in-house publications. In 2007, Dr. Gomez-Calderon received the Milton S. Eisenhower Award for Distinguished Teaching. Other awards include the 2002 Commonwealth College Outstanding Research Award, the 2001 Valley News Dispatch Coach of the Year Award, the 1997 New Kensington Excellence in Teaching Award, the 1996 Theresa Cohen Mathematics Service Award, and the 1989 New Kensington Excellence in Teaching Award.

Yu-Chang Hsu, Pennsylvania State University

Dr. Yu-Chang Hsu, Assessment Coordinator for the NSF-Sponsored Toys'n MORE grant, received his Ph.D. in Instructional Systems from The Pennsylvania State University. His research interests include learning environment design, impact of emerging technology on learning and instruction, cognitive processes of learning with multiple external representations, learning performance assessment, and program evaluation.

Amy Freeman, Pennsylvania State University

Dr. Amy L. Freeman, Assistant Dean of Engineering Diversity at Penn State, received her Ph.D. and M.Sc. from The Pennsylvania State University in Workforce Education and Architectural Engineering, respectively, and her B.Sc. in Construction Management from the University of Washington. She is Co-PI on the NSF-Sponsored Toys'n MORE grant and currently manages several retention programs targeting women and underrepresented technical students at all levels of the academic and career development pipeline. She is the current president of the National Association of Multicultural Engineering Program Advocates (NAMEPA) organization.

Dhushy Sathianathan, California State University, Long Beach

Dr. Sathianathan is Associate Dean for Academic Programs in the College of Engineering at California State University (CSULB), Long Beach. He earned his Ph.D. and B.S. in Mechanical Engineering from The Pennsylvania State University and Oklahoma State University, respectively. Prior to joining CSULB in 2009, Dr. Sathianathan was Head of the School of Engineering Design, Technology, and Professional Programs (SEDAPP) in the College of Engineering at Penn State from 2002-2009. Dr. Sathianathan is the founding PI of the NSF-Sponsored Toy's and MORE grant at Penn State and has led several NSF-funded initiatives to enhance engineering education, especially focused on retention. Dr. Sathianathan received the Boeing Outstanding Educator Award, the Boeing Welliver Faculty Fellow Award, and the ASEE-DOW Outstanding Faculty Award for work in engineering education.

Renata Engel, Pennsylvania State University

Dr. Renata S. Engel is Associate Dean for Academic Programs in the College of Engineering at Penn State. A member of the Penn State faculty since 1990, she is Professor of Engineering Design and Engineering Science and Mechanics and has served as Executive Director of the Schreyer Institute for Teaching Excellence. She earned her B.S. in Engineering Science from The Pennsylvania State University and a Ph.D. in Engineering Mechanics from the University of South Florida.

Dr. Engel is PI of the NSF-Sponsored Toys'n MORE grant at Penn State. Through various projects and initiatives, she has incorporated elements of design in fundamental engineering courses and has provided leadership to Penn State's efforts to assess student learning outcomes. For her individual and collaborative contributions to engineering education, she has received several awards including the University's George W. Atherton Award for Excellence in Teaching, the Dow Outstanding Young Faculty Award, and the Outstanding Alumna of the Fayette Campus, and Fellow of the American Society for Engineering Education. An active member in the American Society for Engineering Education (ASEE), Engel has held leadership positions in the Mechanics Division and Middle Atlantic Section and as the Vice President for Member Affairs. Currently, Dr. Engel serves as President-elect of ASEE.

Toys and Mathematical Options for Retention in Engineering (Toys'n MORE) **Broad Impact -The Campuses**

Toys and Mathematical Options for Retention in Engineering (Toys'n MORE) is a retention project under development at The Pennsylvania State University through an NSF-sponsored, Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP grant, DUE # 0756992). It is being conducted in collaboration with 15 Penn State campuses and the College of Engineering at University Park. Its goal is to increase retention of Science, Technology, Engineering, and Mathematics (STEM) students at Penn State.

The broad impact of the Toys'n MORE project is twofold: (1) the implementation of programs to enhance retention in STEM fields across a coalition of 15 Penn State campuses with more than 18,000 students at widely dispersed geographical locations throughout the state of Pennsylvania and (2) the ability to leverage resources and expertise to employ an interdisciplinary approach to improving student performance.

The 15 Penn State coalition campuses steadily attract close to 775 first-year students who declare engineering as their preferred major. On the average, 30 percent of the students head towards a baccalaureate degree in engineering and another 30 percent pursue other non-engineering STEM fields at any number of locations in the Penn State system. On the other hand, of the first-year students who declare engineering as their preferred major, approximately 35 percent drop out of college altogether without pursuing any other STEM fields.

Furthermore, examining 2001 data, the retention rate after two years for underrepresented (African American, Native or Hispanic) first-year students who declared engineering as their major during their freshman year was found to be approximately 13 percent. In other words, 87 percent did not pursue any STEM fields.

This paper focuses on the coalition of 15 Penn State campuses and their overall enrollments, their pre-calculus enrollments, targeted engineering numbers, and their retention projects. The information is summarized and presented in reference to the 15 campuses.

1. Pennsylvania and its Demographics

“Pennsylvania is a stable, prosperous market whose diverse population is eager to support new development and innovative business ideas¹.” Some statistics:

- More than 12 million people call the Keystone State home.
- 632,469 people own their own businesses; 26.4% are women-owned.
- The largest ethnic groups are:
 - White (85%),
 - African American (10%),
 - Hispanic (3%),
 - Asian (2%).
- Nearly 10% of households routinely speak a language other than English.

The 15 Penn State coalition campuses are as diverse as their settings with a mixture of ethnic backgrounds, educational levels, and socio-economic strata. On an educational level, 86% of the adults in Pennsylvania have at least a high school diploma and 24 % hold a Bachelor’s degree, or higher². Further, according to the National Center for Education Statistics, the Commonwealth of Pennsylvania ranks third in the nation in terms of total number of colleges and universities³. Moreover, of the top 50 universities in the U.S., four are located in the Commonwealth – the University of Pennsylvania, Carnegie Mellon University, Lehigh University, and Pennsylvania State University⁴. And, except for Penn State, all are private institutions of higher learning.

Programs offered at the 15 coalition Penn State campuses are important to the economic development of the Commonwealth. These campuses offer affordable, quality education to the local population.

2. One Program, 15 Campuses

The Toys’n MORE project covers 15 Penn State campus locations (Figure 1) throughout the state of Pennsylvania and the College of Engineering at the University Park campus in State College, PA. With more than 18,000 students at these widely dispersed geographical locations, the coalition of campuses comprises an integral part of Penn State.

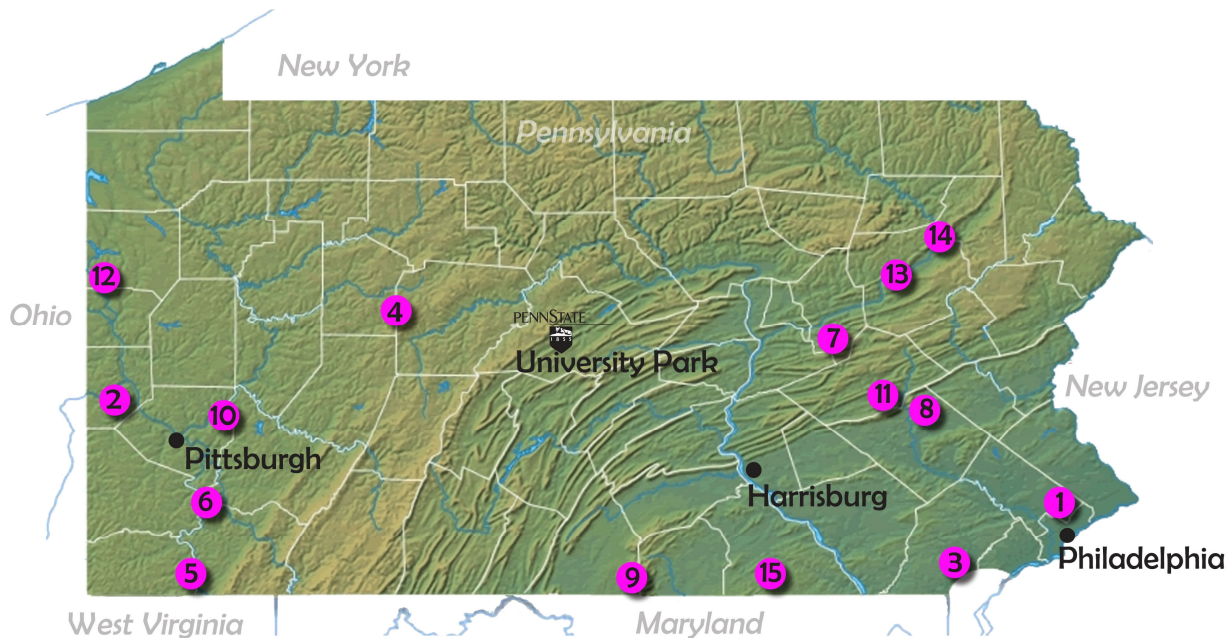


Figure 1: Coalition of Campus Locations across Pennsylvania.

Collectively, the coalition campuses offer more than 16 different baccalaureate degrees and 14 associate degrees (Table 1), including 9 programs in engineering and engineering technology and many more in various STEM fields. The coalition campuses also serve as feeder campuses for more than 100 STEM baccalaureate degree programs offered at University Park. As feeder campuses, in any one year, they provide instruction for more than 2,000 students in introductory

mathematics courses, of which close to 775 students will declare engineering as their preferred major.

Table 1: Coalition Campuses and Their Enrollment Profiles.

| | Coalition Campuses | STEM ^a Degrees Offered | Enrollments in Mathematics (2006-2007) | | Enrollments in Engineering (2006-2007) | Total Campus Enrollment (2006-2007) |
|--------------|-------------------------|---|--|-----------------------|--|---|
| | | | Pre- Calculus ^b | Calculus ^c | | |
| 1 | Abington | 4 BS degrees 1 Associate | 372 | 155 | 108 | 3141 |
| 2 | Beaver | 1 BS degree 2 Associate | 129 | 57 | 41 | 738 |
| 3 | Brandywine | 1 BS degree | 142 | 98 | 48 | 1631 |
| 4 | DuBois | 1 BS degree 4 Associate | 69 | 28 | 14 | 811 |
| 5 | Fayette | 5 Associate | 119 | 47 | 143 | 2467 |
| 6 | Greater Allegheny | 1 BS degree 2 Associate | 111 | 46 | 38 | 761 |
| 7 | Hazleton | 1 BS degree 5 Associate | 209 | 62 | 79 | 1143 |
| 8 | Lehigh Valley | 1 BS degree 1 Associate | 102 | 61 | 56 | 758 |
| 9 | Mont Alto | 2 Associate | 129 | 62 | 45 | 1032 |
| 10 | New Kensington | 2 BS degrees 6 Associate | 97 | 61 | 35 | 856 |
| 11 | Schuylkill | 1 BS degree 2 Associate | 111 | 35 | 25 | 911 |
| 12 | Shenango | 5 Associate | 44 | 28 | 7 | 893 |
| 13 | Wilkes-Barre | 3 BS degrees 5 Associate | 97 | 30 | 39 | 728 |
| 14 | Worthington Scranton | 1 BS degree 3 Associate | 177 | 50 | 46 | 1294 |
| 15 | York | 3 BS degrees 4 Associate | 119 | 57 | 50 | 1672 |
| Total | | | 2,027 | 877 | 774 | 18,836 |

^aSTEM degrees are defined as those in science (including biology, physics, chemistry, and other “classical” sciences), technology, engineering, and mathematics.

^bPre-Calculus Courses include Trigonometry, Geometry, and Algebra (MATH 22 and MATH 26).

^cCalculus I is the first of the calculus sequence of courses (MATH 140).

A unique characteristic of the students at the 15 campuses is that approximately half are the first in their family to attend college. These campuses are twice as likely to enroll first-generation students as compared to the University Park campus. Noteworthy is the fact that high school graduation numbers in the regions served by the campuses have steadily declined over the past several years, and this trend is expected to continue for the next several years⁵. This reality clearly demonstrates the importance of the proposed effort to retain students in the STEM fields.

3. Applying the Strategies

Toys’n MORE is a collaborative effort to increase retention among the coalition of 15 Penn State University campuses throughout the Commonwealth of Pennsylvania and the College of Engineering at University Park. Through the auspices of the National Science Foundation, Toys’n MORE (STEP grant, DUE # 0756992) seeks to increase the retention of students pursuing STEM degree programs, particularly in engineering. Engineering and mathematics

faculty, in collaboration with respective Learning Center staff, Directors of Academic Affairs, and Deans at the 15 campuses and the College of Engineering at University Park, have joined forces with the diversity experts to reverse attrition and enhance retention.

Considering the number of campuses involved and the number of different STEM fields served, this effort is significant. Critical resources are being channeled into this broad network of campuses to trigger a change in the positive direction. Four strategies are being called to action. Each allows students the opportunity to apply several learning styles. At the same time, each campus is able to evaluate ways in which to enhance the curricular approach and educational resources for STEM field majors.

The four strategies called to action are:

- 1) supplementary tutoring to students in introductory mathematics courses,
- 2) hands-on design of functional toys for K-12 populations to engage STEM students in actual applications of science and mathematics,
- 3) math-intensive summer bridge programming for under-prepared students and students from underrepresented populations (minorities and women) including academic, social, and cultural activities, and
- 4) continuous assessment of strategies 1) through 3).

The first strategy to be implemented is the Math Tutoring Program. By fall 2009, the Math Tutoring Program was underway at all 15 coalition campuses (Table 2, below). The program, although slightly different at each campus, involved tutoring services for introductory mathematics courses.

Table 2: Coalition Campuses and Their Math Tutoring and Toy FUN-damentals Start Dates.

| | Coalition Campuses | Math Tutoring Program Started | | Toy FUN-damentals Program Started | | Campus College Connection- Bridge Programs Planned Summer 2010 |
|----|-------------------------|-------------------------------|-----------|-----------------------------------|------------------|---|
| | | Spring 2009 | Fall 2009 | Fall 2009 | Planned for 2010 | |
| 1 | Abington | | √ | √ | | |
| 2 | Beaver | √ | | √ | | |
| 3 | Brandywine | √ | | √ | | √ |
| 4 | DuBois | √ | | √ | | |
| 5 | Fayette | √ | | √ | | |
| 6 | Greater Allegheny | √ | | √ | | √ |
| 7 | Hazleton | √ | | √ | | |
| 8 | Lehigh Valley | | √ | √ | | |
| 9 | Mont Alto | √ | | | √ | |
| 10 | New Kensington | √ | | | √ | √ |
| 11 | Schuylkill | √ | | | √ | |
| 12 | Shenango | √ | | | √ | |
| 13 | Wilkes-Barre | √ | | √ | | |
| 14 | Worthington Scranton | √ | | | √ | |
| 15 | York | √ | | | √ | |

The second strategy developed is the Toy FUN-damentals Program. It was launched (Table 2, above) in the fall of 2009. The system-wide program is gradually being rolled-out and will extend to 14 of the 15 campuses by fall 2010. This program, which is delivered through a 1-credit, first-year seminar (FYS), or as part of an existing 3-credit engineering design course, focuses on enhancing retention through the deconstruction, creative design, and use of toys.

The third strategy, the Campus College Connection, is geared towards retention of under-prepared students, minorities, and women through a math intensive summer bridge program. Students in this program prepare for their first semester during the summer in advance of freshmen who start in the fall. There are actually two successful residential summer bridge programs at the University Park campus, but only one focuses on students who are located at a coalition campus. Presently, 140 to 160 incoming engineering first-year students are African American, Native, or Hispanic. Over half begin their engineering degrees at one of the 15 coalition campuses. This math intensive summer bridge program has been successful at improving retention rates of underrepresented students at the campuses. The Toys'n MORE project extends duplication of the summer bridge strategy from University Park to 3 of the 15 campuses. The campuses will apply practices addressing situations unique to each of their campus cultures (for example, a commuter campus would not run a residential program). On the other hand, all will be math intensive and all will include professional student development, cohort interaction, and relationship building with faculty and mentors. Preparation for this strategy began in summer 2009 and is scheduled to get underway at the three campuses during the summer of 2010.

The fourth strategy, Assessment, examines the impact of the three aforementioned intervention strategies. For the Math Tutorial Program, the assessment involves a demographic survey, a diagnostic test, and a post-test for each of the introductory mathematics courses. The diagnostic tests are used to establish a baseline regarding students' prerequisite ability for pre-calculus and calculus courses. The post-tests are used to examine if significant learning gains are resulting from the intervention of the tutoring programs. In addition, the pattern of students' passing rates (i.e. grades of C, or better) is being tracked in introductory mathematics courses. For the 2009 cohort of students, we are pleased to see initial success compared to the 2004-2008 student cohorts in pre-calculus courses such as Math 22 and Math 26. However, we are also aware of the challenges revealed by the passing rate for the introductory calculus course, i.e. Math 140 (Table 3, below). We will continue to work with the coalition campuses to improve and examine the effectiveness of tutoring intervention.

Table 3: Passing Rates (%) for Baseline Years and Impact Year.

| | Pre-calculus | | Calculus |
|---------------------------|--------------|---------|----------|
| | MATH 22 | MATH 26 | MATH 140 |
| Baseline 2004-2008 | 68.03 | 67.62 | 76.10 |
| Impact 2009 | 70.25 | 70.66 | 75.51 |

For the Toy FUN-damentals Program, the assessment includes a demographic survey, a pre-survey and a post-survey on students' engineering self-efficacy and career interests in engineering disciplines. Findings of the surveys for Toy FUN-damentals program participants will provide valuable information regarding attitude change due to the intervention. For the Campus College Connection, the assessment involves a post-program survey with rating scales

and open-ended questions to solicit students' feedback about future improvement of the program. The purpose of this survey is to learn about students' learning and participation experiences, which will form continuous improvement of the mathematics intensive summer bridge program. Finally, we are also continuously tracking students' retention and academic pathways to examine the effect of intervention relative to the project goals and scope.

It is important to note, even though the coalition campuses are all Penn State campuses, each campus is administratively independent. The budget for each campus is directly driven by enrollments and state allocation. Hence, administratively, there are varying degrees of resources available to each of the 15 coalition campuses to address challenges associated with student retention. Even so, the proposed strategies are being implemented in a coordinated manner to ensure a broad impact across the 15 coalition campuses in order to reverse the declining retention of students pursuing STEM degree programs.

Bibliography

1. Commonwealth of Pennsylvania. (2009). *Demographics*. Retrieved December 31, 2009, from <http://www.newpa.com/build-your-business/locate/why-pa/demographics/index.aspx>.
2. Commonwealth of Pennsylvania. (2009). *Workforce*. Retrieved December 31, 2009, from <http://www.newpa.com/build-your-business/locate/why-pa/workforce/index.aspx>.
3. Commonwealth of Pennsylvania. (2009). *Education*. Retrieved December 31, 2009, from <http://www.newpa.com/build-your-business/locate/why-pa/education/index.aspx>.
4. Commonwealth of Pennsylvania. (2009). *Key-industries*. Retrieved December 31, 2009, from <http://www.newpa.com/build-your-business/key-industries/index.aspx>.
5. Pennsylvania Department of Education. (2007). *Report to the general assembly on public secondary school dropout rates 2005-06.pdf*. Retrieved September 9, 2007, from <http://www.portal.state.pa.us/portal/server.pt/community/dropouts/7396>.