Toys & Mathematical Options for Retention in Engineering

3.0 STRATEGIES TO IMPROVE RETENTION

The objective of the Toys’n MORE program is to increase the retention of students in Science, Technology, Engineering, and Mathematics (STEM) by leveling the playing field through success in mathematics. The initiative involves four strategies:

**Strategy I: Math Tutoring**
The Math Success through Tutoring program proposes to increase retention of students in mathematics course sequences leading to calculus courses by combining instructor intervention and supplemental instruction (tutoring) through the Learning Centers located at the coalition campuses.

**Strategy II: Toy FUN-damentals**
Toy FUN-damentals is a 1-credit or equivalent toy design course highly successful in engaging students in engineering design and prototyping. This course has proven to increase retention of women in the College of Engineering. A modified version of the course is implemented at the 15 coalition campus locations to meet the needs of local STEM fields. This course is open to all STEM students.

**Strategy III: Campus College Connection**
This is a multi-step program designed to assist underrepresented minority students in transitioning from high school to college. This project supports the creation of locally customized summer bridge programs to be established at the 15 coalition campuses.

**Strategy IV: Assessment & Evaluation**
The research component is fundamental to determining the success of the change efforts. It provides a means to evaluate the impact of Toys’n MORE and to validate the process for wide dissemination. A combination of surveys, interviews, and analyses of a longitudinal database will address: 1) the extent to which Toys’n MORE improves students’ development of key mathematical competencies needed by STEM majors and 2) the extent to which the changes impact the retention rates of engineering and, in particular, the underrepresented students at the various locations.

Table 1: Assessment instruments and secondary data by math course and project strategies.

<table>
<thead>
<tr>
<th>Assessment Instruments</th>
<th>Pre-Calc</th>
<th>Calc I</th>
<th>Calc II</th>
<th>Calc III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>√</td>
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<td></td>
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<tr>
<td>Tutorial</td>
<td>√</td>
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<tr>
<td>Calculus</td>
<td>√</td>
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<tr>
<td>Project Strategies</td>
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<tr>
<td>Math Tutoring</td>
<td>√</td>
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<tr>
<td>Incremental</td>
<td>√</td>
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<tr>
<td>Connecting</td>
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</tbody>
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3.1 IMPLEMENTATION PROGRESS

- Project Teams at 15 campuses have been established (see map).
- Math Tutoring Program has been established at all 15 campuses (see map).
- A total of 1,502 students in pre-calculus courses are impacted by this effort.
- Toy FUN-damentals courses are established at 13 of the 15 campuses (see map).
- Internal Advisory Board has been established.

External Advisory Board:
- Ford Motor Company
- RR Donnelley
- Nucor Steel
- Ortho Clinical Diagnostics, a Johnson & Johnson company
- Applied Research Laboratories at Penn State

4.0 OPPORTUNITIES AND CHALLENGES

This project presents a unique opportunity to experiment and implement standardized (diagnostic and final) math exams across the coalition campuses for the purpose of establishing a learning outcome evaluation based on common ground.

However, challenges for this opportunity remain:
- Comparing to multiple choice exams, mathematics instructors prefer traditional evaluations that students show their work, thus allowing evaluation of the thinking process (i.e., calculation and reasoning).
- Mathematics instructors prefer to "write" their own exams and not use an exam prepared by others.

How challenges are being overcome:
- Final exams are made available to instructors two months in advance of being administered.
- Instructors are allowed to collect and evaluate student work (final exams, only).
- Instructors are permitted to "write" their own partial exams throughout the semester.
- A collection of sample problems and sample final exams are made available to students and instructors.
- Instructors have control in deciding the percentage the standardized final exams will play in the student's overall course grade.

Another challenge is to maintain the initial success of improving the passing rate, not only for the pre-calculus courses such as MATH 22 and MATH 26, but also for MATH 40 (the combination of MATH 22 and MATH 26) and the calculus course MATH 140. We will continue to work with coalition campuses and examine the effectiveness of tutoring interventions.

Also, we have begun tracking students’ success in pre-calculus courses to determine the foundation for their success in MATH 140, the first calculus course. Table 2 and Figure 1 present a snapshot of the passing rates and the initial impact of the project interventions with regard to the mathematics courses indicated.

Table 2. Passing rates (%) in numbers for the baseline years and the impact year.

<table>
<thead>
<tr>
<th>Course</th>
<th>Pre-Calc Pass Rate</th>
<th>Calc I Pass Rate</th>
<th>Calc II Pass Rate</th>
<th>Calc III Pass Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 22</td>
<td>67.83%</td>
<td>80.60%</td>
<td>78.60%</td>
<td>76.80%</td>
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<tr>
<td>MATH 26</td>
<td>67.80%</td>
<td>70.80%</td>
<td>72.60%</td>
<td>76.80%</td>
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<tr>
<td>MATH 40</td>
<td>80.60%</td>
<td>70.80%</td>
<td>72.60%</td>
<td>76.80%</td>
</tr>
<tr>
<td>MATH 140</td>
<td>67.80%</td>
<td>80.60%</td>
<td>78.60%</td>
<td>76.80%</td>
</tr>
</tbody>
</table>

Figure 1. A comparison between passing rates of the baseline years and the impact year.