

GIVE STUDENTS A NEW “MINDSET”

OPERATIONS RESEARCH MATHEMATICS FOR HIGH SCHOOL

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OVERVIEW

- **Mathematics Instruction using Decision Science and Engineering Tools**
- A collaboration among math educators, engineers, and mathematicians at three universities
- To create, implement, and evaluate a new HS curriculum and textbook to teach standard mathematics concepts
- Curriculum intended for high school seniors who have completed two years of algebra and one year of geometry
- In year two of a five year program (ahead of schedule)
- NSF Funded

THE THREE MAJOR GOALS OF MINDSET

- The materials will enhance students' mathematical knowledge and skills, especially their ability to formulate and solve multi-step problems and to interpret the results
- The materials will improve student's attitude toward mathematics, especially those from underrepresented groups, and thereby motivate them to study mathematics
- The project will obtain adoption at the state level of the curriculum initially in North Carolina and Michigan, and then in other states

OUTLINE

- Current situation in the U.S.
- Problems addressing the situation
- Solution / MINDSET Project
- Course Content
- Teacher Support
- Project Assessment
- Summary

CURRENT DEMANDS IN THE U.S.

- “The need for a workforce that is skilled in science, technology, engineering, and mathematics areas is closely linked to the idea of American competitiveness in the global economy”
(Dr. Kemi Jona, Northwestern University, WRAL-TV May 30, 2008)
- High tech companies require high tech people
 - Highly skilled workers & managers
 - Engineers & scientists
- All jobs require more advanced mathematics

DEMANDS ARE NOT BEING MET

- U.S. is graduating the **same number** of engineers today as in 1980 (ASEE 2007) but **demand is 2x to 3x**
- U.S. students are not going into science, engineering & mathematics at the universities
 - Historical group going into engineering (male, white non-Hispanic) is not increasing
- Within engineering colleges students are (ASEE 2007):
 - 17.5% women
 - 11% historically underrepresented groups

STUDENTS ARE NOT MOTIVATED

- U.S. students do poorly in mathematics vs. students in other countries (TIMSS, 2005)
- U.S. students cannot solve (PISA, 2005):
 - Multi-step problems
 - Word problems
 - Nor interpret problem solution results
- Students believe mathematics is *not useful*

STATES ARE ADDRESSING THE CRISIS

- North Carolina and Michigan passed a bill requiring that all high school graduates **MUST** have 4 years of mathematics starting in 2011
- Alabama, Colorado, Texas, and Georgia have yet to set a start date but will enforce the requirement
- Other states are planning for the requirement

STATES ARE NOT ADDRESSING

- What should the new 4th year math course contain?
- How to improve problem solving ability?
- How to show usefulness of mathematics?
- How to improve attitudes toward mathematics?
- How to attract women and historically underrepresented groups to science, engineering & mathematics?

SOLUTION

- Design a course utilizing *production engineering tools*
- Tools are used by manufacturing, production, business, and service industries (including hospitals & healthcare, insurance companies, banking, finance, shipping & transportation companies, airlines, super markets, fast food stores, etc.)
- Production Engineering Tools
 - are primarily Operations Research & Statistics tools
 - are based upon contextual problems
 - are algorithm-based & thus require multi-step problem solving
 - have multiple solutions requiring interpretation


SOLUTION (CONTINUED)

- Problems draw from students' daily lives and demonstrate *relevance* for mathematics
- Problems require in-class *group activities* to solve problems
Examples: queuing, assembly, and quality control
- The hope is that *relevance* and *group activities* will attract women & minorities to science, engineering & mathematics

MINDSET PROJECT

- Create a new mathematics course based on Operations Research and Production Engineering tools to teach mathematics
- Designed for seniors in high school
- Algebra II pre-requisite only, no calculus
- Intended for all high school students

THREE MAJOR TASKS OF MINDSET

-  1. **Create a one year mathematics course with an Algebra II pre-requisite that uses Industrial Engineering and Operations Tools to teach mathematics**
2. Create a teacher training and support infrastructure to move the material from the project into the classroom
3. Organize and perform a statistically significant assessment to determine whether or not this improves mathematics education

1 YEAR MATH COURSE

Deterministic methods

(first draft complete)

- **Systems of Inequalities**
 - Linear Programming
 - Integer Programming
 - 0-1 Variables: Yes or No
 - Assignment Problem
- **Networks and Graphs**
 - CPM for project planning
 - Transportation networks
 - Location
 - Shortest path problems
- **Multiple Objective Tradeoffs: MAUT (Multiple Attribute Utility Theory)**

Probabilistic Methods


(in the design process)

- **Process Variability & Quality Control**
 - Frequency charts & probability
 - Distribution of the mean
 - Normal distribution
 - Graphical hypothesis testing
- **Simple Queuing Systems**
- **Decision Trees**
- **Simulation**

STRUCTURE OF CHAPTER

- 3 “real-life” situation problems
- First Problem - introduction
 - Purpose of a particular problem-solving technique
- Second Problem – context
 - Explains every step in process
 - Interprets solutions
- Third Problem – synthesis
 - Presents solution
 - Students are expected to interpret results in the context of problem
- Still learning how teachers are using the unconventional design of the textbook’s chapters

THREE MAJOR TASKS OF MINDSET

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-  2. **Create a teacher training and support infrastructure to move the material from the project into the classroom**
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CONSTRAINTS ON TEACHERS

- High school teachers are time constrained due to their heavy workload
- Teachers cannot be expected to take on a radically new course and material without significant assistance to learn and use the material
- Course adoption is directly dependent practicing teachers supporting the course


NEEDS OF TEACHERS

- Teachers must be able to immediately get answers to questions when they initially teach the material
- Some teachers may need expertise assistance in the classes they are teaching
- Teachers need access to course modules, supplemental material, in-class activity scripts, homework problems & solutions, sample quizzes and sample exams
- Project needs to capture their questions and comments to improve the course material (*continuous improvement*)

TEACHER SUPPORT INFRASTRUCTURE

- Goal: Support teachers using the course material & draw on their experience to improve the material
- Intensive two week summer course specifically tailored to practicing teachers
- On-site help
- Web-based support center
- Telephone help system (Skype)

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PROJECT ASSESSMENT

- Some assessment questions:
 - Is this a better way to teach mathematics?
 - Does this improve the students' multi-step problem solving capability?
 - Does this improve the students' attitude toward mathematics?
 - Does this attract historically disadvantaged groups and women to math or engineering?
- Study will be performed by outside Mathematical Education Statistician
- Study will be based upon a minimum of 1,500 students (50 classrooms of 30 students)

SUMMARY

- MINDSET's objective is to have high school students in the U.S. take an Production Engineering/Operations Research course
- Three primary tasks are necessary to make this happen
 - Course material development
 - Teacher support infrastructure development
 - Statistically significant assessment
- In year two of a five year project
- What sets MINDSET apart from other curricula besides the content is that teachers are providing input while it is still in its infancy

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