Title of Lesson Plan (Teaching Module):
Approaching Optimization with an Engineering Mindset

Personal information

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Name of School: _Evanston Township High School___________________________

Funding Amount Requested and School Information (Optional)

Dollar Amount of Funding Requested: ________________________________

Matching Amount by School (50% or more required): ______________________

Name of School: _Evanston Township High School__________________________

Address of School: _1600 Dodge Ave, Evanston, IL 60204__________________

Signature of Principal: ___________________________________  Date: __________

Signature Information

Signature of Principal Investigator: _Andrew Mauer-Oats_  Date: _12/02/09_
Teaching Module
Please prepare a formal written teaching module.

1. Abstract
In this lesson, students will examine how to best build a greenhouse onto the side of house, maximizing usable space while minimizing cost. The purpose of this lesson is twofold. First, these lessons will allow students to experience the engineering approach to solving a real-world problem. Students will learn to dissect all the pieces of the problem, properly label and account for all variables, and create a mathematical model to solve that problem. Second, students will examine the differences between a model-based approach to solving a problem and an abstract calculus-based approach to solving the problem. The students will then apply their calculus skills to find another solution to the problem. The students will then compare the two solutions to the problem and analyze any differences in outcomes. This activity will bring together mathematical and scientific models of problem solving, underscoring the necessity of building a deep understanding of the components of the problem and their connections to one another. This activity will take place over two weeks and will be a collaborative project just as most engineering projects are.

2. Objectives
There are three main objectives in this lesson. First, learn to build a good model of a problem by correctly identifying all variables and by developing an understanding of their relationships to one another. Second, students will learn to apply the engineering approach to problem solving: modeling, collaborating, and iteratively refining their work as they proceed. Third, students will learn to compare model-based solutions to calculus based solutions.

During my RET, I enjoyed experiencing mathematics in a laboratory setting, where we used computation and modeling to explore the validity of the methods that we were developing. This project allows me to bring that approach of validation and iterative refinement to the classroom. Students often struggle with story problems because they seem so abstract. I will explicitly teach my students an engineering approach to the problem, building up understanding piece by piece. I hope the students will develop an understanding that a careful approach, thinking about and validating one's steps before arriving at the final result, leads one to a good solution without the pain of starting from scratch every time a mistake is discovered. The fact that the students will actually construct a model of the situation will deepen their intuition for the problem, letting them see the question as a real-life situation rather than an abstraction. I hope it improves their understanding and also allows them to try out solutions to see if they are reasonable.

Alignment with Illinois State Learning Goals
7.A.4b Apply formulas in a wide variety of theoretical and practical real-world measurement applications involving perimeter, area, volume, angle, time, temperature, mass, speed, distance, density, and monetary values.

7.C.5b Determine how changes in one measure may affect other measures (e.g., what
happens to the volume and surface of a cube when the side of the cube is halved).

8.C.5 Use polynomial, exponential, logarithmic, and trigonometric functions to model situations.

11.A.4b Conduct controlled experiments or simulations to test hypotheses.

3. Methodology or Experimental Setup
Students will attempt to find the optimal solution to the greenhouse problem: Build a greenhouse on the side of the house with maximum usable space and minimal cost. The greenhouse is a triangular addition on the side of the house, and if the greenhouse roof isn't tall enough, the usable space that people can stand in will be quite small. On the other hand, costs can quickly spiral out of control. Students will work together in groups of 3-4 to solve the problem, mimicking the collaborative approach of research teams.

Abstract Solutions
In the second week, students will use the optimization methods learned in calculus class to solve the problem. They will need to work with the assumptions they came up with in the first week. This process will teach students how scientists make and refine models in their research. The students will then compare this solution to the model based solution and analyze any differences in the two solutions. They will present their conclusions to the rest of the class.

Resources

4. Expected Learning Outcome
Students will be able to
- Identify and define variables in a problem
- Build a model to explore the relationships between those variables
- Construct a model using conjectures for the unknowns
- Use the conjectured model to analytically compute a solution for the problem
- Explain differences between the conjectured model and the analytical solution

Students will be assessed on the detail and accuracy of their models, the quality of their analytical solution, and the organization and clarity of their presentations.

5. Budget Section
6. Acknowledgement Section

Acknowledgment is made to the National Science Foundation for their continued financial support of the RET Summer program and materials for classroom teaching modules NSF EEC-0743068 Grant.

Appendix

Andrew Mauer-Oats, Ph.D.  Mathematics Teacher
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CERTIFICATE:
• Type 09 Initial Alternative Secondary Certificate: August 2007
• Type 29 Transitional Bilingual Certificate: March 2009
• Considered “Highly Qualified” under No Child Left Behind Act

EDUCATION:
Alternative Teacher Certification, National-Louis University, 2007
Doctor of Philosophy – Mathematics, University of Illinois at Urbana-Champaign, 2002
Masters of Science – Mathematics, University of Illinois at Urbana-Champaign, 1996
Bachelor of Arts – Mathematics, Williams College, 1993

PROFESSIONAL EXPERIENCE

EVANSTON TOWNSHIP HIGH SCHOOL  August 2009 - Present
Mathematics Teacher
• Teach: Algebra 2 Honors, AP Calculus (AB), Topics in Mathematics.
• Assistant Coach: Matheletes (Math Team)

UNIVERSITY OF ILLINOIS AT CHICAGO  Summer 2009
Research Experience for Teachers
• Detection of localization in three dimensions, under Dr. Craig Foster.

CHICAGO PUBLIC SCHOOLS  October 2008 – June 2009
Curie Metro High School  Chicago, IL
Bilingual Mathematics Teacher: Algebra 1, Algebra 2, and Geometry
• Teach: Spanish and Sheltered English language mathematics classes.
• Take One: professional development creating one entry towards National Board certification.

CHICAGO PUBLIC SCHOOLS  September 2007 – August 2008
Kelvyn Park High School  Chicago, IL
Teacher: Geometry and ACT Preparation
• Teach: geometry and ACT preparation. Credit recovery algebra in night school and summer school.
• Tutor: during school AVID class and after school mathematics club.
• Confer in Spanish with parents.

CHICAGO PUBLIC SCHOOLS  August 2006 – August 2007
Manley Career Academy  
**Teacher: Algebra and Geometry**  
- Incorporate reading and writing into mathematics lessons.  
- Teach summer school: geometry.

**CHICAGO PUBLIC SCHOOLS**  
**Chicago Teaching Fellows**  
**Teacher in Training**  
- Teach a remedial geometry summer program for students at Hyde Park Academy.  
- Participate in intensive professional development workshops and discussions.

**EDUCATIONAL TESTING SERVICE**  
**AP Calculus Reader**  
- Graded Advanced Placement Calculus examinations.

**NORTHWESTERN UNIVERSITY**  
**Lecturer**  
- Taught mathematics courses for nonmajors: appreciate the beauty and power of mathematics.  
- Created and taught seminar on teaching mathematics, including high school observations.  
- Member of calculus teaching team.

**PURDUE UNIVERSITY**  
**Postdoctoral Research Assistant**  
- Taught mathematics courses for mathematics education majors: geometry.  
- Designed and taught new course in statistics.

**SKILLS**  
Spanish: proficient oral and written communication skills.