MIDDLE SCHOOL WINNER

Bedroom Design
A Hybrid Modeling Activity for Middle School Engineering and Technology Education

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Overview of the Instructional Model

Bedroom Design is an engineering design activity developed by a partnership between middle school teachers in New York, and the Hofstra University Center for Technological Literacy for middle school Engineering and Technology Education (ETE). The curriculum is underpinned by a "hybrid" instructional model that has the potential to transform instruction in ETE. The model preserves the hands-on physical laboratory activity that has engaged generations of students, but incorporates an IT-based engineering design approach that will accelerate technology education's transition to a contemporary STEM-based discipline. The hybrid model integrates both screen-based 3D simulation and real-world physical modeling into middle school engineering and technology education programs.

The model expands the responsibility of engineering and technology educators to reinforce core disciplinary concepts (particularly middle school mathematics) within technological contexts and includes three components that can redefine the way engineering and technology education instruction is conceptualized:

1. Infusion of core disciplinary concepts (i.e., grade-related mathematics) into ETE instruction.
2. Use of STEM teacher teams to collaboratively plan, assess, and revise instructional approaches.
3. Use of an "informed design" approach to instruction that leads students to develop understanding before they engage in design activity.

Note: In this case, the hybrid model used Google SketchUp (GSU), a 3D modeling program available at no cost from Google, followed by hands-on physical modeling of the planned bedroom and reflection time.

A guide for instructors and workbook with student materials can be downloaded from the Hofstra CTL Web site at www.hofstra.edu/Academics/Colleges/SOEAHS/CTL/ITEA/index.html. For further information, contact Chris Malanga (Riverhead Middle School) at chris.malanga@riverhead.net or Michael Hacker (Hofstra University) at mhacker@nycap.rr.com.

Problem Situation

You are moving to a house that is being built for you. The architect who is working on the project needs information regarding your lifestyle to determine the best design for your bedroom. It can be a dream bedroom. The budget is $27,500 for a rectangular bedroom with a minimum area of 120 square feet. However, the budget increases to $30,000 for a nonrectangular bedroom with the same minimum area.

The Design Challenge

You and your teammates will design a furnished bedroom. You will build virtual and actual scale models of your bedroom, with furnishings.

Design Specifications and Constraints

To solve the problem, your design must meet the following specifications and constraints:

- The window area must be equal to at least 20% of the floor area.
- The minimum room size is 120 square feet. The minimum height of all ceilings is 8 feet and the maximum is 12 feet.
- The bedroom will have two outside walls and two interior walls. In both models one interior wall can be removed for easy visualization of the design.
- The budget is $27,500 for a rectangular bedroom and $30,000 for a nonrectangular bedroom.
- The cost of basic construction is estimated at $150 per square foot of floor area

Focus on Engineering

An issue commonly found in middle school design activities, is that students focus more on product design than on mathematics-based engineering design. The bedroom design challenge specifically integrates age-appropriate mathematical analysis and modeling with engineering thinking and engineering design methodologies into the student activity. The mathematics in this activity was explicitly related to middle school mathematics standards.

Additionally, it is quite often the case that trial-and-error problem solving (gadgetering) characterizes design activity in middle and high school classrooms. Trial-and-error problem solving uses up a great deal of class time and the focus is normally on the end result, rather than on the learning. A uniqueness of this project is that it uses an "informed design" approach that provides *just-in-time knowledge building* as a prelude to design.

Informed design is a validated design pedagogy developed through NSF projects conducted by the Hofstra CTL. It melds guided inquiry with moderately open-ended design and lead students to develop conceptual understanding **before** they begin designing, but after they have been introduced to the main challenge. In an informed design activity, students develop their STEM understanding (they will *inform* their STEM knowledge and skill base) by completing a series of short, focused tasks called *Knowledge and Skill Builders* (KSBs) before they start designing. Seven Knowledge and Skill Builders are provided within the Student Packet (the complete packet is available upon request). These include the following:

Math-related KSBs

KSB 1: Geometric Shapes

KSB 2: Factoring

KSB 3: Percentage

KSB 4: Mathematics of Scale

KSB 5: Mathematical Nets

KSB 6: Spreadsheets and Pricing Information

K-12 Role in Partnership

The Bedroom Design unit conveys important middle level ideas in mathematics and technology education. As the unit and embedded activities and lessons were developed by New York State teachers, key ideas are driven by the New York State Standards for Mathematics and Technology Education. These standards are highly correlated to the national (ITEA) Standards for Technological Literacy; and the NCTM Standards for School Mathematics.

The Bedroom Design unit was pilot tested with 59 students during the period between 2007 and 2010. It was field tested by 35 teachers with over 700 students using an experimental and control group protocol. The national field test was cosponsored by the International Technology Education Association (ITEA).

University Role in Partnership

The Hofstra CTL is co-directed by David Burghardt and Michael Hacker. The mission of the Center is to promote and support the improvement of STEM literacy for K-16 students and faculty. Since 1992, the Center has conducted eight large-scale NSF projects largely focused on Engineering and Technology Education reform. This project resulted from an NSF Math/Science Partnership project (MSTP), Grant # 0314910.

Bedroom design was conceptualized by the CTL co-directors; the initial engineering design challenge and concept was developed by them and a set of preliminary KSBs were presented to the partner teachers during a professional development workshop. The teachers, particularly Mr. Chris Malanga from the Riverhead NY Schools (a technology teacher and a mechanical engineer) worked with university faculty to refine the materials. Teachers then field tested the materials with classes. During the entire process, faculty provided technical and pedagogical support to teachers in developing the final version of Bedroom Design. The formal research study was conducted Dr. David Crismond at the City University of New York Project evaluation was conducted by Drs. Bert Flugman and Deborah Hecht at the City University of New York.

Partnership Structure and Goals

During the summer of 2008, 15 New York State middle school Technology Education teachers attended an eight-day workshop for implementing a math-infused Bedroom Design activity co-developed by Hofstra faculty and lead teachers who participated in the NSF-funded Math Science Technology Education Partnership [MSTP] project. Teachers were introduced to the Bedroom Design curriculum, the program's "hybrid modeling" approach to design, and to ways of supporting middle school students' use of mathematics when designing model bedrooms, including those approaches that math teachers themselves use when introducing the mathematical concepts and problem-solving strategies to students.

The partnership was enhanced though collaboration with the International Technology and Engineering Educators Association (ITEEA), the professional association representing ETE teachers in the U.S. The ITEEA and Hofstra co-sponsored a professional development workshop at the March 2008 ITEA annual conference in Louisville, KY that introduced 20 additional teachers from 16 states to the program. All of the teachers field-tested the unit with middle school students during the spring 2008 semester.

The goals of the partnership were:

1. To develop a model that is driven by infusion of core disciplinary concepts into ETE instruction.
2. To encourage STEM teacher teams to collaboratively plan, assess, and revise instruction.
3. To use an "informed design" approach to instruction that leads students to develop understanding before they engage in design activity.
4. To establish a hybrid instructional model that integrates both screen-based 3D simulation and real-world physical modeling into middle school engineering and technology education programs.

Challenge Encountered	Strategies Used
Align ETE math pedagogy with that used in math classes.	Promoted collaboration as members of STEM teacher teams. Engaged math education specialists.
Embed a pedagogical design process instead of the more typical trial-and-error designing.	Developed an "informed design" pedagogy that relied on short "knowledge and skill builder" tasks to inform students of requisite knowledge prior to designing.
Enhancing Math Pedagogical Content Knowledge in ETE Teachers	Supported ETE teachers by facilitating regular conversations with math teacher-experts who modeled good math pedagogy.

Table 1. Challenges encountered and strategies used to overcome them

Explanation of Successes and Lessons Learned

After teaching the BD unit, TE teachers felt more confident and capable in using math KSBs with their classes. They described ways they were doing similar work with other design tasks they teach and were supporting other colleagues in similar endeavors with other classes. The data also suggest that programs should work harder to support and sustain math-ETE teacher relationships during unit implementation, a coordination effort that can be quite difficult. Finding included:

Exemplary materials themselves will not result in improved teaching and learning; professional development must accompany these materials.

The development of exemplary teaching materials requires not only significant teacher enhancement, but also the involvement and refinement of materials by curriculum and content experts.

To become exemplary, lessons must be revised after being informed by analysis of student work and evidence of student understanding.

Attention needs to be paid to the ways in which the content is being taught. Exemplary mathematics-infused design curricula require that pedagogical approaches similar to those used in mathematics classes should be cultivated to reinforce earlier math learning.

Strengths of all partners must be respected, where “status differential” is minimized. University faculty members are often perceived by school personnel as experts, even pedagogical experts, when in fact, their expertise may be limited to disciplinary knowledge and logistical leadership. Expertise in working with the realities of classroom teaching need to be acknowledged.

Research Results - Students’ Learning of Mathematics in Designing Model Bedrooms

While this paper’s main focus has been on key features of the Bedroom Design project and the impact of the program on teachers’ thinking and practice in the classroom, students’ learning of mathematics while doing the bedroom design unit was also studied. Teachers administered a pre- and post-test on targeted math ideas found on the high-stakes tests that students in New York state currently take every year from third to eighth grade. Identical items were used these two tests, but their sequence of presentation were altered to avoid order effects.

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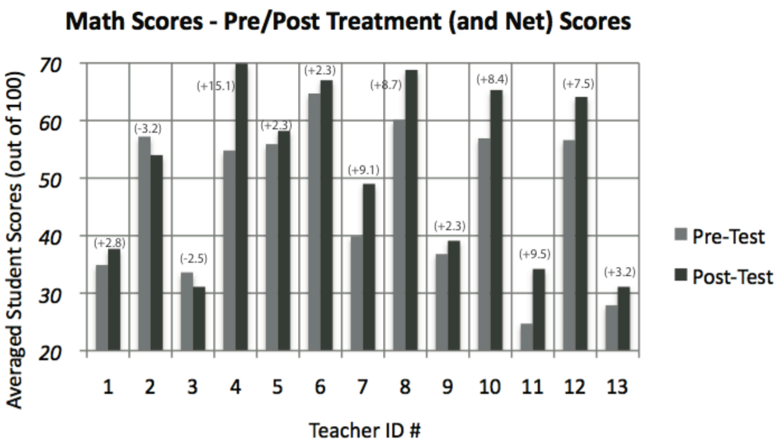

Classes for Teacher # ↓	*Math Pre-Test Score*	*Math Post-Test Score*	Change In Score
1	34.93	37.71	2.78
2	57.15	53.95	-3.2
3	33.61	31.1	-2.51
4	54.77	69.88	15.11
5	55.85	58.21	2.36
6	64.72	67	2.28
7	39.92	48.96	9.04
8	60.14	68.79	8.65
9	36.8	39.07	2.27
10	56.9	65.28	8.38
11	24.66	34.21	9.55
12	56.64	64.1	7.46
13	27.89	31.1	3.21
Average	**46.46**	**51.48**	**5.03**

Pre-test scores for students' mathematics knowledge showed a wide range of starting points: the mean pre-test score of 46.5 had a range of 40 points, while the post-tests averaged 51.5 points, and ranged just under 39 points (SE=15.16). There was thus a net improvement for all students of 5 points in the 100-point math test developed and administered by the project. A few positive correlations of statistical significance were noted between students' math scores and events noted in classroom teaching. Improvement in students post-test scores and teachers' self-reported confidence that students could do the mathematics was positively correlated [Pearson Correlation =+.711, Sig.(2-tailed)=.006]. Also, improvements in students' scores and the teachers' implementation of the bedroom design unit with high fidelity was also positively correlated [Pearson Correlation =+.588, Sig.(2-tailed)=.035]. Perhaps most importantly, a strong positive correlation was seen between teachers' own understanding of the math concepts and students' post-implementation math scores [Pearson Correlation =+.564, Sig.(2-tailed)=.014].

Examples of Student Work