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Technology and Mathematics Standards: An Integrated Approach

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TECHNOLOGY AND MATHEMATICS STANDARDS:
AN INTEGRATED APPROACH

Chris Merrill
Mark Comerford

Introduction
The use of standards-based teaching and learning has been gaining significant attention in the education world. State and national associations now base their specific subject area or discipline solely on standards, i.e., International Technology Education Association (ITEA), National Council of Teachers of Mathematics (NCTM), National Science Education Association (NSEA). Moreover, at the public school level, state boards of education are holding school districts accountable for teaching standards-based curricula. Standards-based instruction is not an educational fad, but a reality for public schools today and for the future (Reeves, 2002). In addition to a standards-based education initiative, integration of disciplines, especially within technology education, has gained attention throughout the years (Brusic, 1991; Childress, 1996; LaPorte & Sanders, 1995; Loepp, 1999; Merrill, 2002).

Technology and Mathematics
If you were to ask middle or high school students to define mathematics, they would probably tell you course titles or functions of mathematics that they have completed; i.e., ratios, proportions, algebra, geometry. However, a more open-ended and broader definition or meaning of mathematics is the study of patterns. It is with the latter definition in mind that the authors created a standards-based, integrated technology and mathematics lesson using the design and construction of stair systems as the hands-on activity—the catalyst to bridge theory and practice through an authentic, meaningful standards-based approach. Stair design offers teachers and students alike the opportunity to draw upon integrated learning while applying a standards-based approach. It should be noted that, while stair design may be a traditional type of activity, the authors consciously looked at developing this lesson and activity with a focus on Standards for Technological Literacy: Content for the Study of Technology (STL), using a backward design approach.

Standard 3 in STL states that, “Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study” (ITEA, 2000, 2002, p. 44). Likewise, Principles and Standards for School Mathematics lists two standards that are appropriate for this lesson: Connections and Measurement. One of the subparts of the connections standard reads that “Students will recognize and apply mathematics in contexts outside of mathematics” (NCTM, 2000).

Curriculum Design
To develop this lesson and activity, the backward design process, as presented by Wiggins and McTighe (1998), was utilized for eleventh and twelfth grade students. The backward design process is a three-stage process that teachers use to develop curriculum. More specifically, to start this process, teachers start by asking themselves: What is worthy and requiring of understanding? To answer this question, one must consider local, state, and national standards. Standards are the driving force behind today’s education and therefore need to be addressed and taken seriously. If the answer from this first question is not based on the standards, it is probably not worthy of teaching and learning (Reeves, 2002; Wiggins & McTighe, 1998).

The big picture of the backward design process is for teachers to teach for enduring understanding; for students to see the connections made between subject areas—to develop a cognitive bank of knowledge that is learned and internalized, not memorized. The backward design process draws upon what the students currently know and are able to do with cognitive and procedural constructs. The authors believe that, by using stair design and construction as the construct, students can make the connection for enduring understanding between what is currently being taught in mathematics and the hands-on approach of technology education.

The first question (What is worthy and requiring of understanding?) is translated into the first stage of this process—identifying desired results. The desired results, which are what the students should know and be able to do at the conclusion of the lesson or unit, were identified as:
1. Use mathematical formulas and functions such as slope, Pythagorean Theorem, addition, subtraction, multiplication, and division to design a new stairway.

2. Design two different stairways and draw them to prescribed scales.

3. Use tools to construct two different stair designs (with treads and risers) out of cardboard at half scale, based on a given total rise and total run.

4. Search various architectural magazines and the World Wide Web to identify various stair designs to assess their purposes for a given space.

5. Describe the historical influence of stair designs by writing a one-page paper on the history and application of stair designs.

The acceptable evidence (second stage), based on the mathematics and technology education standards that were identified in stage one, consists of the sketches (layout) of the stair design, mathematical formula usage, building/stair construction (finished stringers), pictorial display of work, and the written paper. The acceptable evidence is what the teacher will accept to show that, “yes, the students did understand, learn, and apply the content/constructs,” and here is the evidence or proof. The acceptable evidence stage should be thought of as a continuum. This continuum takes into account different levels of cognitive, affective, and psychomotor abilities. In fact, it may take weeks for the students to exhibit the “evidence” needed to prove to the teacher that they understand the material being presented.

The third stage of this curriculum design process is to plan the learning experiences and instruction. The authors created a “tear out” lesson plan (Lesson Plan Part 1) that could be utilized for this stage of the curriculum process. Lesson Plan Part 2 is a sample activity that could also be implemented for this stage in the design process, and is intended for the student. Figure 1 is an elevation view of a simple stair stringer that could be handed out to students. Figures 2 and 3 are examples of completed models.
that define the stair stringers, tread depth, riser height, and landing (if any) all constructed to a specific scale.

**Conclusion**

Integrating technology with other disciplines does not have to be a force-fit. The use of mathematics when designing stairs is appropriate and necessary. Technology education teachers basing their curriculum on standards and benchmarks will readily see the advantages of using multiple disciplines for students to develop enduring understanding. By integrating a relatively simple technology education activity with other disciplines, students will begin to see the "connections or linchpins" that connect different fields of learning.

**References**


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**Lesson Plan Part 1. Integrated lesson plan**

**Title:** Integrated Learning through Stair Construction

**Subtitle:** Stair Design and Construction: Mathematics and Technology in Action

**Standards:**
- **Technological Literacy**
  - Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
- **Mathematics**
  - Students will recognize and apply mathematics in contexts outside of mathematics.
  - Students will understand measurable attributes of objects and the units, systems, and processes of measurement.
  - Students will apply appropriate techniques, tools, and formulas to determine measurements.

**Objectives:**
- At the conclusion of this lesson, students should be able to:
  - Design two different stairways and draw them to prescribed scales.
  - Define individual tread depth and riser height, stair slope, and stair stringer.
  - Use tools to construct two different stair designs (with treads and risers) out of cardboard at an appropriate scale, based on a given total rise and total run.
  - Search various architecture magazines and the World Wide Web to identify various stair designs to assess their purposes for a given space.
  - Describe the historical influence of stair designs by writing a one-page paper on the history and application of a stair design.

**Equipment/Materials List:**
- Pencil, paper, eraser, architect's scale, calculator, poster board, cardboard, x-acto knife, word-processing program, access to the World Wide Web,
- magazines depicting home design and construction technologies, local building code book (not required, but helpful).

**Introduction:**
Stairs are a common structure at home, school, and in our society. Stairs are of different shapes and styles, but the end result is always to provide a means for movement from one level to another in residential, commercial, or industrial structures. Stair designs are generally drawn by architects who follow building codes and requirements that dictate the stair geometry, including slope of stairway, minimum tread depth, maximum riser height, and required overhead clearances. Stairs are built on site by construction workers, prefabricated in a manufacturing facility and delivered on site, or are hand crafted by cabinetmakers. The design of stairs does not happen by chance, but by technological and mathematical problem solving, formulas, and theorems.

**Activity:**
In this activity, students will be using mathematical formulas, theorems, and technological tools to construct two different stair designs, using two different rise and run dimensions. In addition, students will have the opportunity to study the history of stairs and the various styles of stairs by creating a display of their work.

**Assessment:**
There are several assessments that are both formative and summative that deal with this lesson and can be found in the activity.

**Enrichment Activity:**
After completing the stair design and construction activities, turn your attention to roof design and construction. Roofs are mathematically figured the same way as stairs, but the construction process is different. Students should be instructed on roof designs and, in turn, can use previously learned knowledge and skills.

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**Lesson Plan Part 2. Integrated activity**

**Stair Construction: Mathematics and Technology in Action**

**Overview:**
Stairs are a common structure at home, school, and in our society. Stairs are of different shapes and styles, but the end result is always to provide a means for movement from one level to another in residential, commercial, or industrial structures. Stair designs are generally drawn by architects who follow building codes and requirements that dictate the stair geometry, including slope of stairway, minimum tread depth, and maximum riser height, and required overhead clearances. Stairs are built on site by construction workers, prefabricated in a manufacturing facility and delivered on site, or are hand crafted by cabinetmakers. The design of stairs does not happen by chance, but by technological and mathematical problem solving, formulas, and theorems.

**Introduction:**
In this activity, you will be using mathematical formulas, theorems, and technological tools to construct two different stair designs, using two different rise and run dimensions. In addition, you will have the opportunity to study the history of stairs and the various styles of stairs by creating a display of your work.

**Directions Part 1: #1 – Plain Stair Design**
After receiving the handout from your teacher, you should:
1. Calculate the slope and overall length of the stringer.

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**Bibliography:**
2. Identify how many risers and treads will be needed. **Note that in a straight-run stair there is always one more riser than treads.** 
3. Identify the size of the risers and treads. 
4. Use a piece of 8.5 x 11" paper to lay out and sketch the plan and elevation views of a plain stringer, which has a total rise of 3' 9½" and a total run of 4' 4½" using a scale of 1"=1' 0". 
5. Use tools to construct your design from pieces of cardboard at half scale. 
6. Turn in your sketches, calculations, and completed stair design. 

**#2 – L-Shaped Stair Design** 
After receiving the handout from your teacher, you should: 
1. Calculate the slope and overall length of each stringer. 
2. Identify how many risers and treads will be needed. 
3. Identify the size of the risers, treads, and landing. 
4. Use a piece of 11 x 17" paper to lay out and sketch the plan and elevation views of an L-shaped stair design, which has a total rise of 9' 1½", using a scale of 1"=1' 0". 
5. Use tools to construct your design from pieces of cardboard at the same scale. 

6. Turn in your sketches, calculations, stair design, and stair model. 

**Materials:** 
- Architect's scale, paper, pencil, calculator, eraser, cardboard, x-acto knife, glue gun and glue, and safety glasses 

**Directions Part 2:** 
Using the World Wide Web, your school library, or home/building magazines, search for information related to the history of stairs, different stair designs, construction techniques, architects and their influences, and technological advances of materials. Using a piece of poster board, create a pictorial display of your work. Your display should also contain the sketches and pictures of the stair designs you created during the first part of this activity. Be creative! 

**Directions Part 3:** 
Compose and format a one-page paper on the history of stairs and the different designs that are used in residential, commercial, or industrial structures. 

**Evaluation:** 
**Stair Designs #1 and #2 (each)** 
- Mathematical calculations 
- Sketches 
- Stair model 

**Poster Board Display** 
- Number and quality of pictures 
- Design and layout 
- Creativeness 

**Written Paper** 
- Overall
  - Readability 
  - Composition 
  - Spelling 
  - Grammar 

**Follow-up Questions:** 
1. What is the relationship between slope and the overall run and rise of a stair design? 
2. What materials are most commonly used to construct residential stairs? Why? 
3. What tools would be needed to build a complete set of stairs? 
4. Where else in construction-related processes would slope and Pythagorean Theorem be used? Why? 
5. List and name three different stair designs and describe their purposes.

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