I·D·E·A·S
Integrated Design + Education + Arts Studio

Rapid Prototyping with Simple and Compound Machines

Instructional Plan

OVERVIEW OF LESSON:

In this lesson, students will be introduced to the concept of using rapid prototyping when designing new products. Through investigation, students will understand prototyping as a means for designers to test products to make strong economic decisions. Students will begin by strengthening their understanding of two- and three-dimensional figures by working to translate from one form to the other. As students view a rapid prototyping machine in use, they will practice skills in identifying simple machines and describing the contribution of each machine toward the compound machine (rapid prototyper). Once students investigate the prototyping machine, they will work together to develop a product they would like to design, test, and produce. Through their design work, students will produce two-dimensional models of their product showing multiple viewpoints. They will then develop a rationale behind reasons for prototyping and plans for marketing.

SUBJECT MATTER:

Science
Math
English
History and Social Science

GRADE LEVEL:

3

CENTER FOR THE ARTS
AT VirginiaTech
Institute for Creativity, Arts, and Technology

Rapid Prototyping with Simple and Compound Machines

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TIME ALLOTMENT:

Time estimated to complete this lesson is five 50-minute class periods (or equivalent variation).

LEARNING OBJECTIVES:

- Students will be able to identify the simple machines that make up a compound machine.
- Students will be able to transfer two-dimensional objects to three dimensions.
- Students will be able to represent design ideas with drawings and writing.
- Students will be able to explain an economic choice.
- Students will be able to design a new object.

LEARNING STANDARDS:

Content
Standards listed below are not given in their entirety. Rather, the parts of the standards covered by this instruction are included. For complete text of the Virginia Standards of Learning, go to: http://www.doe.virginia.gov/testing/sol/standards_docs/index.shtml

- Science 3.2: The student will investigate and understand simple machines and their uses. Key concepts include:
  - types of simple machines (level, screw, pulley, wheel and axle, inclined plane, and wedge)
  - how simple machines function;
  - compound machines (scissors, wheelbarrow, and bicycle); and
  - examples of simple and compound machines found in the school, home, and work environment.

- Math 3.18: The student will analyze two-dimensional (plane) and three-dimensional (solid) geometric figures (circle, square, rectangle, triangle, cube, rectangular solid [prism], square pyramid, sphere, cone, and cylinder) and identify relevant properties, including the number of corners, square corners, edges, and the number and shape of faces, using concrete models.

- English 3.9 The student will write descriptive paragraphs.
  - Develop a plan for writing.
  - Focus on a central idea.
  - Group related ideas.
  - Include descriptive details that elaborate the central idea.
  - Revise writing for clarity.

- English 3.10: The student will write stories, letters, simple explanations, and short reports across all content areas.
    - Use a variety of planning strategies.
    - Organize information according to the type of writing.
    - Identify the intended audience.
    - Revise writing for specific vocabulary and information
    - Use available technology.

- History and Social Science 3.9: The student will identify examples of making an economic choice and will explain the idea of opportunity cost (what is given up when making a choice).

Technology

See complete Technology standards at http://www.iste.org/standards/nets-for-students/nets-student-standards-2007.aspx

- Creativity and Innovation
    - Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:
        a. apply existing knowledge to generate new ideas, products, or processes.
        b. create original works as a means of personal or group expression.
        c. use models and simulations to explore complex systems and issues.
        d. identify trends and forecast possibilities.

- Critical Thinking, Problem Solving, and Decision Making
    - Students use critical thinking to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students:
        a. identify and define authentic problems and significant questions for investigation.
        b. plan and manage activities to develop a solution or complete a project.
        c. collect and analyze data to identify solutions and/or make informed decisions.
        d. use multiple processes and diverse perspectives to explore alternative solutions.

Arts

See complete Arts standards at http://artsedge.kennedy-center.org/educators/standards.aspx

- Content Standard #1: Understanding and applying media, techniques, and processes
    Achievement Standard
        - Students know the differences between materials, techniques, and processes
        - Students describe how different materials, techniques, and processes cause different responses
        - Students use different media, techniques, and processes to communicate ideas, experiences, and stories

- Students use art materials and tools in a safe and responsible manner

• Content Standard #2: Using knowledge of structures and functions
  Achievement Standard
  - Students know the differences among visual characteristics and purposes of art in order to convey ideas
  - Students use visual structures and functions of art to communicate ideas

• Content Standard #6: Making connections between visual arts and other disciplines
  Achievement Standard
  - Students identify connections between the visual arts and other disciplines in the curriculum

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CRITICAL AND CREATIVE THINKING OBJECTIVES:

A complete listing and explanation of critical and creative thinking objectives can be found at www.ideas.soe.vt.edu.

Brainstorming	Students will generate as many solutions or ideas related to a topic as possible within a given amount of time.
Exploring	Students will explore a challenge using a variety of raw materials, stimuli, and experiences.
Observing	Students will observe things related to the challenge closely to identify details, procedures, and methods.
Elaborating	Students will develop ideas and information that expands on what is explicitly given.
Extrapolating	Students will transfer knowledge of one topic to another.
Questioning	Students will identify missing or unclear information and ask questions to seek clarity.
Summarizing	Students will condense multiple ideas into a cohesive and comprehensive summary and restate it using personal connections and interpretations.
Composing	Students will use written, oral, and symbolic language to communicate a summary of thoughts, ideas, and solutions.
Embracing multiple points-of-view	Students will present ideas and arguments through the lens of multiple perspectives.
Remaining open-minded	Students will identify how ideas from multiple experiences (to include senses, fantasy, aesthetics, feelings, and actions of others) influenced their ideas.
Tolerating ambiguity	Students will be receptive to all ideas and perspectives regardless of degree of completeness or complexity.
Recognizing	Students will identify personal beliefs and values relating to the

relevance	context.
Risk-taking	Students will describe how the challenges faced in the process of meeting their goal encouraged them to work beyond their comfort level.

PREREQUISITE KNOWLEDGE:

- Understanding of the difference between two- and three-dimensional objects.
- Understanding of simple and compound machines. This lesson will serve as a follow-up or review to the concept of machines.
- Understanding of economic choices. This lesson will serve to apply student understanding of economic choices.

MEDIA/TECHNOLOGY COMPONENTS:

- Video footage of rapid prototype machine in operation.
- Still images of rapid prototype machine.
- Fab@Home website: http://fabathome.org/wiki/index.php?title=Main_Page

MATERIALS:

- Variety of materials to construct three-dimensional objects (such as tag board, foam board, cardboard, craft foam, etc.)
- Scissors
- Tape or glue
- Video of rapid prototype machine
- Still images of rapid prototype machine
- Computer with web access and display capabilities
- Images or physical objects that have resulted from the rapid prototype process
- Images of objects shown in both two- and three-dimensions

PREPARATION FOR TEACHERS:

- Preview video footage, images, and suggested website to identify components students will be directed to identify.
- Determine appropriate viewing method to allow for interaction with the video and image (for example, be prepared to write or annotate on the display surface).
- Gather items that have undergone the process of rapid prototyping, which could be any number of common household items.

INSTRUCTIONAL PLAN:

Constructing 3-D objects

1. Provide students with several different two-dimensional patterns to use to construct three-dimensional objects. An example would be a flat-pattern of a cube where students would use cutting and folding to translate the two-dimensional figure to a three-dimensional object.
2. Show students a variety of flat pattern drawings and have them work to identify and describe the type of three-dimensional object that will result when the flat pattern is assembled.
3. With students in groups of two or three, have each group create their own object by first drawing the two-dimensional sketch and then using materials of their choice to construct the three-dimensional object.

Introduction to the concept of prototyping:

4. Begin with a description and discussion of the concept of rapid prototyping. Show students a portion of the video containing footage of the machine working. Engage them in a discussion of how prototyping serves to help designers of products research in a more cost-effective manner and provides us with a more economically viable approach to developing new products; the prototype allows designers to test and evaluate effectiveness without incurring the cost of actual materials needed to make the finished product.
5. Discuss with students how prototyping contributes to making educated economic choices (i.e. before spending time and money producing the real product, we can test it first). Ask students questions about how a prototype design might help a company save money.

* For assessment, students should develop a group of written statements describing how rapid prototyping helps companies make strong economic choices along with an example of a situation when rapid prototyping would benefit a company.

Introduction to the prototype machine:

6. Following a brief discussion of simple and compound machines, run the video footage of the prototype machine working. Give students a few minutes to make a list of the simple and compound machines they identify being used in the prototype machine. After several minutes, reverse the video and have students work in groups of three to discuss their answers. Continue to run the footage of the machine working to allow for reference points. It may also help to provide students with a still image of the machine for them to reference as they talk.

7. Freeze the video or show a still image of the machine on either an interactive board or white board (a surface that can be marked). Have several students circle or otherwise indicate the types of machines they saw being used in the prototype machine. Once a piece is identified, ask students to explain how the machine is being used to help the prototype machine work (i.e. how does each piece contribute to the whole operation of the prototype machine)

* For assessment, students will submit their work done in groups to show their generated list of simple machines and statements about how each machine contributes to the compound machine.

Prototyping in the creative process:

8. Show students examples of several objects that have been created by a prototype machine, to range from functional, commercial products to more creative and hobby-oriented products (either physical objects or pictures). With students in groups of three, have each group pick one object. Guide them to work together to draw a two-dimensional version of the object as they view it from the front, two sides, and back. As a result, they should have four drawings, each showing a different perspective of the object.
9. Discuss with students how designers create product designs by first considering two-dimensional perspectives and translating those ideas into a three-dimensional object. This can include a discussion about the difference between two and three dimensions. Show translations of objects from two to three dimensions.
10. Allow students in groups of three to brainstorm a new product they would like to design and produce. As a group, they should draw their object, write a description of the product to include the proposed need and use of the item, and develop an advertisement to help sell their product. Also, have them include the reason why this item would benefit from a "prototype" before it is actually developed (i.e. the features that will be evaluated and functions that will be tested).
11. Engage students in a discussion comparing the work involved in "hand-crafting" the three-dimensional object they created at the beginning of the lesson versus creating using the rapid prototyping machine. Encourage students to talk about both difficulties and conveniences of using rapid prototyping to develop new products.

ASSESSMENTS:

Use the rubric at the end of this document to assess understanding of construction of the 3-D object, making economic choices, simple machines, perspective drawing, product design, and critical and creative thinking.

COMMUNITY EVENTS AND CONNECTIONS:

- Invite members from a local architecture or structural engineering firm to discuss their application of prototyping when designing structures or products.
- Have students visit local businesses (on their own, with guardians) to identify places where rapid prototyping may have been or has been applied.

ADDITIONAL RESOURCES

Information on Rube Goldberg (reversing the concept of simplifying tasks with machines):
http://www.rubegoldberg.com/
http://pbskids.org/zoom/games/goldburgertogo/rubegame.html

Videos on prototyping (you will need a Discovery Education account:

> Smash Lab: Train Crash (segment: Prototypes). Discovery Channel. (2007). Retrieved October 26, 2009, from Discovery Education: http://streaming.discoveryeducation.com/
>
> Rapid Prototyping and the Future: Aims and Mindsets for Making Repairs Practical (segment: Trash to Treasure). Exploration Production Inc. (2005). Retrieved October 26, 2009, from Discovery Education: http://streaming.discoveryeducation.com/

Images:
http://www.made-in-china.com/image/2f0j00PvlaQThWIicLM/Rapid-Prototype-HT20093-.jpg
http://img.alibaba.com/photo/251637720/SLA_rapid_prototype.jpg
http://img.alibaba.com/photo/11339467/Prototype_Maker_Resin_PU_Figurine_Mock_Up_Model.jpg

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CREDITS:

Rapid Prototyping Project Development

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ABOUT THE INTEGRATED DESIGN + EDUCATION + ARTS STUDIO:

The Integrated Design + Education + Arts Studio (IDEAS) is part of the Institute for Creativity, Arts, and Technology (ICAT) at Virginia Tech.

By merging the forces of art and technology into applicable prekindergarten through secondary school (PK-12) programs that strengthen student achievement, Virginia Tech is on the leading edge of a new paradigm in education. ICAT will reach beyond current educational models to fuse arts and technology with content. Our purpose is to strengthen critical and creative thinking skills that prepare students for future careers. ICAT will both generate research and produce learning modules and environments that address real needs identified by educators.

For more information, please see our website at www.ideas.soe.vt.edu.

WE VALUE YOUR FEEDBACK:

Please tell us about how you used the curriculum materials and/or arts project in your classroom. We welcome feedback, suggestions for improvement, and success stories. Find out more at www.ideas.soe.vt.edu.

Get the kit. The IDEAS team has available for loan a number of instructional kits for our various projects. Each kit includes a FlipCam, a small camera you can use to give us feedback. Because we can't be in the classroom with you, we turn to technology to help provide us a glimpse of the experience you and your students have with the program. That's where the FlipCam comes in.

All we ask is that you document your students engaged with the program and related activities. Feel free to make the filming an integrated part of your experience. Give the camera to the students, do the filming yourself, pass it around to multiple students - however you want to document. Once you are finished with the kit, simply return the camera with the other materials. The Institutional Review Board (IRB) of Virginia Tech requires parent, student, and school assent/consent for participation in this data collection. We provide you with all the necessary permission forms and information for your supervisors.

STUDENT NAME _____

RAPID PROTYPING WITH SIMPLE AND COMPOUND MACHINES ASSESSMENT RUBRIC:

Construction of 3-D object	**3**	**2**	**1**	**0**
Object design uniqueness	All elements of object design are unique from those presented in class.	Most elements of object design are unique from those presented in class.	Few elements of object design are unique from those presented in class.	No elements of object design are unique from those presented in class.
Accuracy of two-dimensional representation	All aspects of two-dimensional representation are accurate.	Most aspects of two-dimensional representation are accurate.	Few elements of two-dimensional representation are accurate.	No elements of two-dimensional representations are accurate.
Accuracy of translation from two- to three-dimensions	All aspects of two- to three-dimensional translation are accurate.	Most aspects of two- to three-dimensional translation are accurate.	Few aspects of two- to three-dimensional translation are accurate.	No aspects of two- to three-dimensional translation are accurate.

Making economic choices	**3**	**2**	**1**	**0**
Validity of argument	All aspects of content of argument are valid.	Most aspects of content of argument are valid.	Few aspects of content of argument are valid.	No aspects of content of argument are valid.
Validity of application of rapid prototyping	All aspects of proposed application of rapid prototyping are valid.	Most aspects of proposed application of rapid prototyping are valid.	Few aspects of proposed application of rapid prototyping are valid.	No aspects of proposed application of rapid prototyping are valid.

STUDENT NAME _____

Simple machines	**3**	**2**	**1**	**0**
Accuracy of list of simple machines	All identified simple machines are accurate.	Most of the identified simple machines are accurate.	Few of the identified simple machines are accurate.	None of the identified simple machines are accurate.
Accuracy of description of simple machines	All descriptions of simple machines are accurate.	Most of the descriptions of simple machines are accurate.	Few of the descriptions of simple machines are accurate.	None of the descriptions of simple machines are accurate.
Accuracy of understanding of contribution of simple machines to compound machine	All statements describing contribution of each simple machine to the compound machine are accurate.	Most of the statements describing contribution of each simple machine to the compound machine are accurate.	Few of the statements describing contribution of each simple machine to the compound machine are accurate.	None of the statements describing contribution of each simple machine to the compound machine are accurate.

Perspective drawing	**3**	**2**	**1**	**0**
Accuracy of two-dimensional drawing of three-dimensional object	All aspects of two-dimensional drawing of three-dimensional object are accurate.	Most of the aspects of two-dimensional drawing of three-dimensional object are accurate.	Few of the aspects of two-dimensional drawing of three-dimensional object are accurate.	None of the aspects of two-dimensional drawing of three-dimensional object are accurate.
Perspectives of the three-dimensional object	All four perspectives of the three-dimensional object are presented.	Three of the four perspectives of the three-dimensional object are presented.	Two of the four perspectives of the three-dimensional object are presented.	One or none of the four perspectives of the three-dimensional object are presented.

STUDENT NAME _____

Product design	**3**	**2**	**1**	**0**
Uniqueness of product design	All aspects of product design are unique from those presented in class.	Most of the aspects of product design are unique from those presented in class.	Few of the aspects of product design are unique from those presented in class.	None of the aspects of product design are unique from those presented in class.
Usefulness of product idea and design	All aspects of product design are valid as a useful product.	Most aspects of product design are valid as a useful product.	Few aspects of product design are valid as a useful product.	No aspects of product design are valid as a useful product.
Development of drawing and description of product	All aspects of presentation of product design are thorough and well-developed.	Most aspects of presentation of product design are thorough and well-developed.	Few aspects of presentation of product design are thorough and well-developed.	No aspects of presentation of product design are thorough and well-developed.
Development of marketing plan	All aspects of marketing plan are thorough and well-developed.	Most aspects of marketing plan are thorough and well-developed.	Few aspects of marketing plan are thorough and well-developed.	No aspects of marketing plan are thorough and well-developed.

STUDENT NAME _____

Critical and Creative Thinking	**3**	**2**	**1**	**0**
Elaborating	Student develops ideas that greatly expand on what is explicitly given.	Student develops ideas that somewhat expand on what is explicitly given.	Student develops ideas that do not expand on what is explicitly given.	Student does not develop ideas.
Observing	By observing resources, student identifies all types of simple machines present.	By observing resources, student identifies most types of simple machines present.	By observing resources, student identifies few types of simple machines present.	Student does not observe resources to identify types of simple machines.
Questioning	Student consistently identifies missing information and asks questions for clarity.	Student usually identifies missing information and asks questions for clarity.	Student rarely identifies missing information and asks questions for clarity.	Student does not ask questions.
Composing	Student uses all three of written, oral, and symbolic language to communicate ideas.	Student uses two of three of written, oral, and symbolic language to communicate ideas.	Student uses one of three of written, oral, and symbolic language to communicate ideas.	Student does not communicate ideas.
Extrapolating	Student makes many connections across topics.	Student makes some connections across topics.	Student makes some connections across topics.	Student makes few connections across topics.
Column Total				
Rubric Total			_____ out of 54	