**Lesson Plan: MP3 Amplifier**

**Project Overview**

Accessories used with devices such as mobile phones or MP3 players are often designed for a specific audience or group of consumers in terms of aesthetics and functionality. In this project, an amplifier or speaker case is designed for a specific target audience. The design thinking process that underlies this project involves developing an understanding of the end users and the market for this type of device. Subsequent stages include the development of concepts which are transformed into virtual and physical prototypes utilizing rapid prototyping technologies that include 3D printing and/or laser cutting. These prototypes can subsequently be tested, refined and integrated into a final presentation.

**Software**: Autodesk® Inventor®  
**Time:** 11 to 15 hours  
**Difficulty:** 1 Brain  
**Subject(s):** Engineering, Art, Math, Science, Technology

**Concepts Addressed**

* User-centered research helps engineers and designers establish a solid foundation for the development of effective design solutions.
* Developing a profile of the intended user(s) of a product or service is essential to establishing the needed criteria to guide successful development.
* Specifications for the electronics to be housed by the casing are essential to the design process.
* The proliferation of consumer products, particularly in the tech and fashion sectors, creates opportunities for new product entries in the area of accessories that offer consumer personalization, increased product longevity, and enhanced performance.
* New automated design and manufacturing technologies allow for the low-volume production of products that meet specific criteria for individual users. This emerging trend is referred to as *mass customization*.
* Engineers and designers use a variety of tools and techniques ranging from freehand pencil sketches to sophisticated digital modeling to explore ideas and communicate concepts and technical directions to others.
* Parametric modeling software, such as Autodesk® Inventor®, has dramatically streamlined the process of product development from the identification of user needs to the production and distribution of finished goods.
* The Design Thinking Process is a work-flow path that promotes the development of a design.
* Low cost rapid prototyping technologies such as laser cutting and 3D printing have streamlined the product development process.

**Learning Objectives**

After completing this lesson, students will be able to demonstrate growth in the following areas.

**Process Skills and Knowledge**

Students will be able to:

* Use the design thinking process to successfully create a physical prototype.
* Explain how 2D sketches and digital models can be used as visualization tools for design ideation.
* Create a user profile of the intended consumer base in order to aid in design of a new product alternative.

**Academic Content**

Students will be able to:

* Explain the basic principles of user-centered research.
* Explain the significance of 2D and 3D visualization for the development of designs from concepts to finished production prototypes.
* Explain how writing, data acquisition and data analysis competencies are employed in the development of a product.
* Explain the role that material science plays in achieving the functional and aesthetic goals for a consumer product such as the one in the MP3 Amplifier project.
* Explain the role of environmental sustainability practices in a product development project.
* Explain the essential aspects of mass customization practices.

**Prerequisites**Have the students watch the technical learning videos included in the *MP3Amplifier\_Video\_Datasets* folder to prepare for the project.

**Key Terms**

***3D printing*** is a type of additive manufacturing, there are many different types of 3D printers, but most of the home and consumer 3D printers are specifically FDM printers (fused deposition modeling printers).

***Additive manufacturing*** is a process where material is added together to create an object, opposed to traditional subtractive manufacturing, where material is removed and cut away.

***CAD*** stands for *computer-aided design*.

***Constraints*** in Autodesk Inventor are used to determine how parts are attached to each other in an assembly and generally limit the degrees of freedom for a part.

***CNC*** stands for Computer Numerical Control, as such a CNC machine is a machine that is controlled by a computer; a 3D printer is a CNC tool.

***Design for disassembly*** is the use of assembly methods and configurations that allow for cost-effective separation and recovery of reusable components and materials.

***End users*** are the people who will be using the product.

***Ethnography*** is a [detailed](http://www.businessdictionary.com/definition/detailed.html) [study](http://www.businessdictionary.com/definition/study.html) of a group to describe its behavior, characteristics, cultural mores, and so on.

***Intelligent Snapping*** allows a 2D or 3D primitive to be dragged onto any geometry and snap to the nearest face or edge.

**Kits** contains custom parts and pre-built kits.

***Laser cutting*** is a subtractive machining process that uses a CNC controlled machine to cut material using a laser. Laser cutters normally only cut flat materials such as plywood, plastic, and metal sheets.

***Mass customization*** in [marketing](http://en.wikipedia.org/wiki/Marketing), [manufacturing](http://en.wikipedia.org/wiki/Manufacturing), and [management](http://en.wikipedia.org/wiki/Management) is the use of flexible computer-aided manufacturing systems to produce custom output. Those systems combine the low unit costs of [mass production](http://en.wikipedia.org/wiki/Mass_production) processes with the flexibility of individual [customization](http://en.wikipedia.org/wiki/Customization).

***Mass production*** involves the manufacturing of large quantities of standardized products, frequently using assembly line [technology](http://www.answers.com/topic/mass-production). Mass production refers to the process of creating large numbers of similar products efficiently.

***Navigation Tools*** used to move around the scene. These include, pan, orbit, and zoom.

***Patterns*** create circular, rectangular, path, and mirrored patterns.

***PCB*** stands for Printed Circuit Board, this is the board onto which all other circuit components are affixed and wired to.

***Profiling*** is the process that is used to study individuals to assess their interests, preferences physical and cognitive abilities in relation to a proposed design development project.

***Prototype*** is a physical or virtual model used to evaluate the technical or manufacturing feasibility of a particular 3D design product concept, technology, process, end item, or system.

***Rapid prototyping*** is a term that refers to creating a prototyped part with a 3D printer, laser cutter, or another fast means of making a part; for example, with a CNC milling machine.

***Semiconductors*** are materials that are only partially conductive. By adding materials to semiconductors it’s possible to change their conductive properties. Semiconductors are integral to all modern electronics.

***Sketch model***refers to a model fabricated quickly with low cost, using easy-to-manipulate materials for the purposes of exploring multiple ideas.

***Undo*** is a command that allows the user to remove to 30 of the last actions taken in Autodesk 123D Design.

***User-centered design*** involves designing a product or system based on how the user interacts with it. The goal is to make a product that can be used intuitively.

***User-centered research*** or using observational methods to study and understand in both social and physical settings is a powerful and increasingly widespread technique for uncovering unmet user needs and desires.

***View Cube*** used to look at and orbit around the scene.

**Project Discussion Guide**

**Essential Project Conceptual Questions**

* Why is it critical to engage in market research at the outset of a product development project?
* What types of research strategies can be employed to develop insights regarding the users that may purchase the proposed product?
* What are the advantages and disadvantages of customized manufacturing in contrast to high volume mass production processes?
* How might the proliferation of affordable consumer grade rapid prototyping technologies such as 3D printing, and laser cutting impact the development and marketing of consumer products?
* In the past decade what changes have occurred in the area of portable speakers that might influence the design of the proposed product?

**Essential Project Design Questions**

* What person or group of people will represent your targeted market?
* What specific functional criteria and emotional needs or desires must be addressed in your proposed design?
* What are the practical reasons for having a portable amplifier or speaker for an MP3 player or smartphone?
* Will this MP3 amplifier ever need to be disassembled? What are some advantages and disadvantages to being able to disassemble it?
* How can dimensional specifications for the design of your MP3 amplifier accommodate tolerance errors that may occur during 3D printing or laser cutting?
* What are the budget constraints for your proposed product accessory?

**Day-to-Day Plans**

Review the individual lesson plans provided for this project, lesson 1-13, and the project scheme of work (SOW). Apply the design thinking process below as a reasoning practice to promote unique student outcomes and a deeper understanding of the project content.

**Understand: *Watch and Listen***   
To establish a solid foundation for the MP3 amplifier, students need to have a clear understanding of what they are being challenged to do. The best starting point is to carefully review the project design brief. Distribute the student pre-test and have students spend ten to twenty minutes developing their responses to the questions. Your next job is to facilitate a student discussion built around the pre-test questions. These can be conducted as a full class or small group discussions. As outlined in the project brief, the primary goal of this phase is for your students to establish an understanding of the purpose for the amplifier casing including the functional, emotional, and psychological needs of the identified end user(s). The

You may want to remind the students that Albert Einstein once said, “The mere formulation of a problem is far more essential than its solution.”

**Explore: *Develop a Knowledge Base***Through the Explore process you want students to develop a full understanding of the persona of the intended customer for the product accessory. This understanding helps students to fill in specific data on the design criteria matrix in the Define phase. A good place to start is to form teams in which students can discuss the essential project conceptual and design questions listed above.

The next step is for students to develop a game plan for filling in knowledge gaps. Depending on the time available, this inquiry can range from some brief online research to more formal research practices that may include interviewing potential consumers for the MP3 amplifier. An important first step in the Explore phase involves conducting a thorough analysis of the current range of mobile phone accessories on the market to determine what unique characteristics might be incorporated into a new design.

**Note**: It is critical that during this process students keep track of their findings in a notebook or journal. In some instances, digital photography and videotaping can serve as an excellent medium for capturing important insights.

**Define: *Clarify Requirements***

This critical stage in the design process involves establishing the criteria for the project. These factors include important variables such as the persona of the targeted customer. This requires identifying important aspects of who they are and how they want to be viewed in society; the functional, emotional and psychological needs they would want to be addressed by a product such as a portable amplifier or speaker. In this phase, it is also critical for students to identify criteria relative to the physical nature of a product accessory such as strength, durability, ease of use, comfort, and safety.

**Note**: *Open up the Design Criteria Worksheet, which will help you in completing the Define and Explore phases.*

**Ideate: *Creativity***this is the time for students to come up with as many ideas as possible for their product. While you want students to explore many concepts, remind them that it is good practice to keep some of the design criteria in the back of their minds as they explore ideas. Throughout the Ideate phase, a variety of techniques can be used to visualize a wide range of possibilities:

* 2D sketches on paper
* 2D orthographic and perspective sketches using Autodesk Sketchbook software.
* Quick-form studies or sketch models
* Virtual models using Autodesk software

The goal is to get students to visually communicate to themselves and others the essential direction you will take and refine in the next phase of prototyping.

**Prototype: *Test***In this phase, students use key concepts derived from the Ideate phase to create virtual and physical prototypes with the software. Students can watch the technical learning videos, explore the datasets from the example project, and refer back to the Digital Study Packets as they learn the skills that transform their concepts into reality. Encourage students to assist each other in learning the software.

**Refine: *Almost There***In this phase, you want your students to leverage the power of the software to refine aspects of the design. As students proceed through this phase, remind them to keep referring back the basic criteria that they previously established. Encourage students to engage in a mental practice of asking themselves if the details that they are incorporating help define a design that fulfills the functional and emotional needs and desires of the “clients.”

**Solution: Final Presentation**This phase is vital for preparing students for future success in school, careers, and life in general. The Solution phase is where you ask students to demonstrate how this project has helped them expand and enhance the *four Cs* of their learning and innovation skills: critical thinking, communication, collaboration, and creativity.

Instruct the students to prepare and conduct small group presentations that capture the important aspects of each of the previous phases. Ideally, students should be aware from the outset that the results of their efforts in design phases 1 – 7 will culminate in a final presentation.

**Note**: Emphasize that a successful presentation must clearly define the problem that guided the design and articulate the key criteria that are addressed in the solution.

Stress the importance ofusing software tools to visualize, animate, and present the same way real professionals do every day.Remind students that many colleges, universities, and employers place high value on digital portfolios that convey how a student thinks, how they work with others, how they can generate creative solutions, and how they communicate their ideas and knowledge through a variety of written, visual, and oral formats. By investing effort into this project your students will be one step closer to their goal for careers and/or college.

**Note**: If time is limited, you may opt to have students share their final presentation electronically. This provides an opportunity to generate feedback from peers and teacher.

**Differentiated Instruction**

* Encourage students to review the lesson and skills videos in small groups.
* Have small teams of students collaborate to complete one design criteria matrix by dividing up the work.
* Identify specific websites that students can use for the Define and Explore stages.
* Provide some students with a set of predefined design criteria and background content to modify the Define and Explore stages.
* Have small groups collaborate on the Ideate, Refine, Prototype, and Presentation stages. Have some students focus on the development of physical sketches and sketch models while collaborating with team members who focus on digital prototyping.
* Provide students with self and peer evaluation forms to be filled out at the completion of each phase.
* Provide students with models of successful student presentations with clear examples of each Design phase.

**Non-Native Speakers**

* Encourage students to tap into their own culture and life experience to discover prior knowledge of the project topic.
* Provide English/first language translation dictionaries and/or electronic translation devices.
* Allow the student to prepare materials in their primary language and have it translated later.
* Pair ELL students with native English speakers.
* Provide a translator for viewing of videos.

**Special Needs Students**

* Provide prefabricated modeling components.
* Engage the help of aides to assist in physical sketch modeling and prototypes.
* Accommodate students by allowing additional time and/or reducing the scope of project requirements.
* Provide any necessary accommodations for access to technology such as alternative input devices, larger font sizes, speech recognition, and so on.

**STEAM Connections**

**Background**

The design of a consumer electronic, such as an amplifier or speaker creates opportunities to dive into a deep inquiry regarding the components, materials, and mechanics related to consumer electronics accessories and the manufacturing processes required designing and producing them.

Science

* A key factor in the success of products, ranging from medical devices to consumer electronics, has been the innovative use of polymers. What are some of the significant characteristics of this class of materials that make them a preferred choice in product design? Consider factors such as strength, weight, cost, elasticity, ease of manufacturing, and aesthetic properties. What are some of the negative aspects associated with the use of polymers in the design of new products?
* Sound is a compressive wave that can bounce and reflect off of materials. This phenomenon is used in the creation of a speaker enclosure in order to make the speaker amplifies a specific frequency of sound. Investigate open and closed tube harmonics and assuming that the speaker is on the opening of the tube, calculate what frequencies of sound your case promotes. Consider how the speaker case could be modified if you wanted to boost the bass notes of your music.

Technology

* The successful design of a product or product component requires extensive knowledge of materials and manufacturing options. Manufacturing processes can be broken down into two key categories: material removal and material forming. Identify different production processes used for each category. Which process or combination of processes is most appropriate for your proposed design solution?  In what ways does the volume of parts that would be produced alter your choice of manufacturing processes?
* One of the biggest challenges in producing portable electronic devices centers on the development of efficient, economically viable battery systems. Investigate the development of batteries used in different portable electronics. What are the costs associated with producing batteries for products such as a portable amplifier or speaker? What are the environmental concerns related to the manufacturing and recycling these batteries? How much energy is required to produce them?

Engineering

* The volume control for the sample amplifier utilizing a knob. How does this device interface with the electronics to vary volume on the device? Volume control on devices such as smartphones utilize touch sensitive controls. Explore how this type of control might replace the mechanical knob used in the sample project.
* Manufacturing materials such as wood, plastic and metal exhibit different acoustical properties relative to absorbing or reflecting sound waves. Examine how the speaker design would change dependent on the materials selected for the housing. How might the thickness of a selected material impact the volume and fidelity of sound produced by a speaker?

Art

* As presented in the learning videos, the overall aesthetic is quite mechanical with hard-edge surfaces and plain geometric forms. What modifications can be made to this amplifier case to make it more visually intriguing?  What color schemes might be used to increase the visual appeal of the design?
* The same virtual modeling and rapid-prototyping technologies that are used by an engineer can empower artists to visualize and create new forms and artistic expressions. Investigate how artists are using virtual modeling and rapid prototyping in their work. What sorts of artistic creations are they developing? How have these technologies altered their creative process?

Math

* Overhead costs (such as power and rent for the building) end up making a large difference in the way a manufacturing plant is run. Create a mathematical model with a constant overhead, machine operation cost, machine operation time per day, payments for workers, and initial loans for the machines and building. Use this model to study how operating the machines for longer periods affects the price per product.
* The volume and fidelity of sounds produced by a particular speaker can be mathematically represented. Compare two or more types of speakers and describe the differences in a visual format that can be used to evaluate the respective quality of each speaker.

**Science and Math Matrices**

Projects in the Digital STEAM workshop create opportunities for teachers and students to connect concepts in Math and Science to real world projects. For example with the MP3 amplifier students could develop algebra projects around variables such as units sold, production costs and profit margins. The design of the product entails calculations related to the geometric form of the flash drive.

**Math Matrix**

|  |  |  |
| --- | --- | --- |
| **Grade 7** | **Grade 8** | **Algebra I** |
| Area | Ratios and proportions | Systems of linear equations |
| Volume | Area | Ratios and proportions |
| Ratios and proportions | Volume | Area |
| Modeling | Transformations | Volume |
| Graphing | Tessellations | Transformations |
|  | Systems of linear equations | Tessellations |
|  |  | Quadratic equations |

|  |  |  |
| --- | --- | --- |
| **Geometry** | **Algebra II** | **Trigonometry** |
| Area | Systems of linear equations | Use of vectors |
| Volume | Modeling | Determine forces acting on materials and objects |
| Transformations | Linear inequalities | Determine distances, speed, acceleration |
| Calculating measurements indirectly | Right triangle trigonometry | Triangle trigonometry for indirect measurement |
| Cartesian coordinates | Cartesian coordinates | Coordinates: Cartesian, polar |
| Right triangle trigonometry | Production costs of modular parts |  |

|  |  |
| --- | --- |
| **Pre-Calculus** | **Calculus** |
| Linear equations | Area of complex shapes |
| Inequalities | Volume of complex shapes |
| Multivariable equations | Forces |
| Trigonometry | Vectors |
| Calculating indirect measurements | Optimization |

**Science Matrix**

|  |  |
| --- | --- |
| **Chemistry** | **Physics** |
| Materials and material finishes | Forces on objects |
| Resistance to corrosion | Simple machines |
| Adhesives | Energy conservation |
| Interchangeable materials | Ergonomics |
| Makeup of molecules | Electronics systems |
| Chemical composition of recycled content | Micro-electronics |
| Strength and weight of materials | Electrical conductivity |
| Chemistry of phone accessory production | Radio waves |

**Build It**  
When you ask an adult what they remember most about school, the answer often refers to something they produced―something they built, wrote, performed, or generated through some form of visual media. Such activities can take extra time, but the benefits are worth it. And don’t stop with just one MP3 amplifier; try designing an entire line, with each new design using a different persona of the end user.

**Extension Ideas**

* Use Autodesk® Maya® to create a short commercial or advertisement featuring your MP3 Amplifier.

**Assessment Processes**  
The assessment process for all of the projects in this curriculum will provide students with formative feedback for each of the seven essential phases. The rubrics that are included as a separate document will guide students in knowing what is expected for each phase and the criteria used to evaluate the quality of the work. For each project, students complete a self and peer evaluation. These include a reflective narration for each phase, accompanied by a point score derived from the rubric. These evaluations are accompanied by a teacher evaluation that also includes a narrative and numerical score for each phase along with a cumulative score. The STEAM questions, Extension Ideas, and the optional Build It activity offer students an opportunity to take what they learn in the assessment process and apply that knowledge to enhance the quality of their work and increase their scores.