Figure 6.8: Designing a Prosthetic Hand Project Plan

<table>
<tr><td colspan="2">Project Title: Designing a Prosthetic Hand</td><td colspan="2">Topic: Identifying a specific client or end user, designing a prosthetic hand, and demonstrating its ability to execute one or two functions.</td></tr>
<tr><td colspan="3">Grade Level: 8–12
Varying levels of difficulty due to specified requirements, prototype testing requirements, and level of understanding of anatomy and physiology</td><td>Estimated Class Time:
Eight to fourteen classes, depending on grade level</td></tr>
<tr><td colspan="4">Challenge: Develop a prosthetic hand prototype that can do one or two functions most important to the end user.
Note: Students can choose or the teacher can specify the end user. Grade 10–12 students, particularly in anatomy courses, can develop a full case history of a hypothetical client.</td></tr>
<tr><th colspan="2">Curricular Connections</th><th colspan="2">Skills Focus</th></tr>
<tr><td colspan="2">Science—levers in the body; forces; anatomy and physiology of the hand
Social Studies—issues related to disabilities; worldwide incidence of amputation and subsequent support</td><td colspan="2">Critical Thinking—identifying key needs; analyzing effective designs; accessible materials and support if device implemented; developing prototype testing procedure
Creativity—aesthetics of design; possible modifications and superpowers
Spatial Reasoning—human interaction with designed environments and objects
Collaboration—working as a team; recognizing common human factors
Communication—listening to and acting on client feedback
Empathy—understanding and addressing a basic need to function in society and independence</td></tr>
<tr><th colspan="4">Overall Plan</th></tr>
<tr><td>Hook</td><td colspan="3">Share videos or articles about Hugh Herr (2014), Aimee Mullins (2009), or Alex Truesdell (Adaptive Design, 2018).</td></tr>
<tr><td>Engagement Activity or Quick Build</td><td colspan="3">Students spend a set amount of time at home (or in class) not using their dominant hand. They record and share experiences, challenges, and limitations.</td></tr>
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Overall Plan	
Background Instruction	Providing basic introduction about hand anatomy is important. Basic concepts include bones and joints, role of tendons, muscles that make the fingers move, and the value of an opposable thumb. Get students thinking about contraction and flexion, as these may also be helpful as students design their hand prototype. Your level of instruction depends on the curriculum and grade level. Teaching physics concepts relating to the function of fingers as levers is also important. Focus on concepts of effort force (input), load or resistance force (output), and the fulcrum or pivot point's location. Note: Most limbs in the body function as third-class levers, which have the effort (input) force located between the pivot point and the load. For example, when you lift your arm out straight, the pivot is at your shoulder, the effort is due to the biceps muscle in your upper arm, and the load is your lower arm. Third-class levers allow for speed and range of motion but, unlike first- and second-class levers, there is no multiplicative effect on the input force (mechanical advantage).
Background Research	Additional information on specific hand functions or anatomy concepts; investigation of simple prosthetic hand models in use; challenges in fit and use of prosthetics

Engineering Design Process	
Know Your Problem • Know your end user • Identify constraints • Define criteria	• Get to know (or create) the case history of your client. How did the client lose his or her hand? What does he or she like to do? What does he or she find most challenging? How would he or she like the hand to look? • Specify functions the prosthetic hand must accomplish. • Teacher-supplied materials and costs; end user further defines • Use end user research to develop a list of features related to functions; consider the appearance of the hand and other factors related to ease of use and maintenance.
Know Your Options • Research • Brainstorm	• Conduct additional research to understand specific required functions. • Use a variety of techniques to get students to consider innovative designs; remind students to consider reliability of function, appearance, and any additional (bonus) functions.
Develop a Solution—Part One • Choose a design • Identify needed materials	• Students settle on the best design; students discuss how the design meets constraints and criteria. • Encourage students to keep the design simple (see the following Possible Materials list) and then to troubleshoot and modify.

Engineering Design Process	
Develop a Solution—Part Two • Create a plan; make a sketch • Build the prototype	• Develop a sketch of both the overall prosthetic hand plus the following information: how it will attach to the client's arm and the key features that enable function. These are often the two most challenging parts of the design. • Obtain materials and build the hand; check function as you move forward, and make minor modifications on an ongoing basis; encourage students to record these modifications or develop a graphic organizer for documenting the process.
Develop a Solution—Part Three • Test the hand • Plan modifications to make the device better	• Test for function, comfort, and ease of use. + Work with students before they begin building to specify a testing procedure. Specify what they need to do and how many times they must repeat tests. For instance: pick up, hold, and put down a cup or object (grapes are challenging!) five times. Or pick up and throw a ball a certain distance, and so on. + After initial testing, have students choose someone who is not in their group test the hand. The group can help the tester put on the hand, but they cannot provide additional assistance. Note: Attaching the prosthetic hand over actual hand can be challenging; the key thing is not letting your actual hand assist the function of the prosthetic hand. + Encourage your students to take notes as they observe how the tester uses the hand and how well it functions. Students should also question the tester about comfort, overall appeal, and ease of use. • Modifications + Students must connect their modifications to their testing information (observations or testing data). Create a very simple modification form that asks what the modification is and why it is being done. + Limit modifications; two or three modifications are generally enough.
Develop a Solution—Part Four • Communicate your results	• The best way for students to present their design is for them to describe their client and then demonstrate their hand, highlighting their key goals for function and overall appeal. A brief discussion should include both their modifications and ideas for additions to their design. Limit time and have students consider using a pitch to the audience representing occupational therapists or medical personnel or agencies. • Anatomy teachers may want to request students identify connections between components of a prosthetic hand and an actual hand.

Group Size
Between three and five students works well. Students should begin to function effectively in teams; jobs are a must due to the number of aspects to the project. Suggested jobs are project manager, biomedical engineer, materials engineer, and physical or occupational therapist.
Assessment
Follow the general guidelines in chapter 3's Assessing section. The following are key considerations specific to this project. • This is very much a group project and the empathetic connection generally drives responsible involvement by all team members. Each individual's grade generally comes from some content connection work, background research, classroom performance, and final peer assessment. • Some teachers opt to include a short quiz based on key concepts important in understanding the anatomy and mechanics of the hand. Do not stress detailed vocabulary about anatomy at this point, but you can require it as part of the final presentation for students in grades 10–12.
Materials
• Foam core • Wire, string, twine, yarn • Springs • Velcro • J-hooks, eye hooks • Pins, tacks • Screws • Washers • Paper clips • Toothpicks • Rubber bands • Large dowels • Sheets of balsa • Small dowels and balsa scraps • Popsicle sticks • Straws and pipe cleaners • Hot glue and glue guns • Craft glue • Assorted tape • Scissors • Utility or craft knives (optional)