



BEAMworks' How to Train Your Dragon

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Field(s) of Interest: Biomedical Engineering

Brief Overview (1-3 sentences):

Students will explore the realm of disability engineering, learning what it means to be accessible/disability friendly, as well as why accessible engineering is necessary. We aim to put the mentees in the shoes of biomedical engineers in order to inspire inclusive thought whilst undermining negative stereotypes or stigma surrounding disability.

Agenda:

- Introduction (5 min)
- Module 0: Name Game (5-10 min)
- Module 1: Test Drive (5-10 min)
- Module 2: Give me A Hand (or a leg...or a tail)! (20-30 min)
- Module 3: Dragon Eggs! (0-5 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:

- Disability
- Assistive Device
- Biomedical Engineering
- Bone
- Joint
- Muscle
- Prosthetics
- Engineering Design Process
- Fidget Toy
- Non-visible Disabilities
- [Attention deficit hyperactivity disorder \(ADHD\)](#)

Background for Mentors

Module 1

- **Disability**
- **Assistive Device**
- **Biomedical Engineering**

A **disability** refers to a condition that hinders a person's physical, sensory, or mental abilities, limiting their ability to perform everyday activities. Disabilities can be developed or congenital (born with) and come in many different shapes and sizes. To help people with disabilities adapt to able-bodied society, **assistive devices** are developed. These devices are tools, equipment, or products developed to help individuals with disabilities perform tasks independently and without impairment. Typical examples would include wheelchairs, hearing aids, and prosthetics, but can also come to include things like live/closed captioning, voice recognition software, and braille displays. To make assistive devices, **biomedical engineering**, an interdisciplinary field that combines engineering principles and biological sciences, is applied. Biomedical engineers work to create innovative solutions to some of the world's most rampant biological/medical inhibitions, including disability.



Figure 1: The hearing aid and wheelchair, both examples of assistive devices.

Module 2

- Bone
- Joint
- Muscle
- Prosthetics
- Engineering Design Process

Bones, joints, and muscles provide the basic framework for the musculoskeletal system, responsible for allowing movement in the ways we know and observe it. **Bones** are the rigid, sturdy formations within the body that make up the skeleton, responsible for giving the body its shape, protecting organs, and storing important minerals like calcium. Fun fact – there are 206 bones in the adult human body, and inside of them are bone marrow, which is where blood cells are formed.

Joints are the locations throughout the body where two or more bones meet, allowing the body to move in several different ways. Some joints don't move at all, like the ones in your skull. Others are essential to facilitating smooth movement, such as your knee and shoulder.

Muscles are softer tissues that line your bones. They contract and relax to pull on your bones, creating explosive movement. You may commonly associate muscles to those like your biceps and abs, but your tongue and heart are also muscles.

A **prosthetic** is an artificial device that substitutes specifically for a missing body part. Prosthetic hands, legs, arms, and even eyes work to help an individual function without hindrance. Prosthetics can move in a variety of ways, including incorporating movement from a different joint to pull on cables or harnesses attached to the prosthetic (body-powered prosthetics), or via motors controlled by buttons/switches (motor-powered prosthetics) or electrodes placed on the skin detecting electrical signals from muscle contractions (myoelectric prosthetics). Biomedical engineers who create prosthetics often have to utilize the **engineering design process**, which is the trial-and-error process by which engineers test and refine the design of their invention repeatedly.

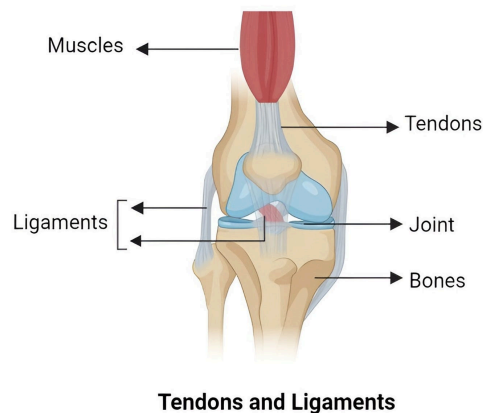


Figure 1 - the muscles, joints, and bones making up a physical and prosthetic knee.

Module 3

- **Non-visible Disability**
- **Fidget Toys**
- **Attention Deficit Hyperactivity Disorder (ADHD)**

Fidget toys are small, handheld objects designed to be fiddled with and can nowadays be found just about anywhere, from fidget spinners to cubes to boards. Aside from being fun to play with, fidget toys can serve an important purpose in helping individuals with non-visible disabilities adapt to their surroundings by calming nervous energy and improving focus. As the name may suggest, **non-visible disabilities** are disabilities that may not be immediately apparent to others since they may not present with obvious physical signs. Individuals with non-visible disabilities may face unique challenges since others may not recognize their needs based on appearance or first impression alone. Some examples include chronic pain, dyslexia, depression, anxiety, and autism (according to the ADA).

ADHD, or **attention deficit hyperactivity disorder**, is a common non-visible, neurological disability that affects a person's ability to pay attention, control impulses, and regulate activity levels. People with ADHD may be easily distracted, restless, or impulsive, which can affect learning, work, and daily life. Fidget toys are often a perfect assistive device for individuals with ADHD to serve as an outlet for hyperactive behavior or impulses.



Figure 1: Different types of fidget toys. We will be using pop-its in this lesson.

Introduction

Though this lesson aims to emphasize the engineering design process and set up a framework for the rest of the semester as a whole, it also works to destigmatize and demystify disability and the reasons behind the significance of accessibility in infrastructure and everyday mechanics. Students should come away from this lesson with more than just a surface-level understanding of biomedical engineering.

Concepts to Introduce ● Disability as a concept ○ Disability ○ Assistive Device ● Physical disabilities ○ Prosthetics ● Non-visible (invisible) disabilities ○ Non-visible Disabilities ○ Attention Deficit Hyperactivity Disorder (ADHD) ○ Fidget Toy ● Basic human anatomy ○ Bone ○ Muscle ○ Joint ● Disability/Accessible Engineering ○ Biomedical Engineering ○ Engineering Design Process	Questions to Pique Interest ● Do you have a friend, family member, or someone close to you who has a disability? ● What kind of accessible engineering inventions have you seen in real life? ● Think of a disability. What kind of accessible engineering inventions could you come up with right now to help alleviate it?
Scientists, Current and Past Events ● Stephen Hawking - a world-renowned physicist with ALS. ● Temple Grandin - an autistic scientist and animal behavior expert ● Ralph Braun - an engineer born with muscular dystrophy. Credited with the invention of motorized scooters and wheelchair lifts. ● Toothless + Hiccup - both are amputees that utilize prosthetics.	Careers and Applications ● Biomedical Engineer ● UX Designer ● Accessibility Coordinator ● Disability Advocate ● Policy Analyst ● Physical Therapist

Module 0: Welcome to BEAM!

This is your mentees first time with mentors this semester, so this first module will serve as a chance to meet your mentees! Have fun with it and give them a good impression of BEAM, we want to get them excited about STEM from the beginning of the semester!

Teaching Goals 1. Names: Learn the names of your mentees	Materials • Paper • Markers
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Different Methods for Teaching

1. **Setting the Pace:** For some mentees, this may be their first interaction with BEAM! Ask questions on what they think BEAM stands for, who we are, and what we will be doing throughout the semester. Encourage different answers and ideas!
2. **Shy Mentees:** Mentees may be reluctant to introduce themselves at first! Have mentors go first as an example, and maybe even create your own name tags with the mentees!

Procedure

1. Organize mentees into a circle in the classroom
2. Go around the room and have everyone introduce themselves (say their name) and something from some category (animals, food, colors, science topics, etc.) that starts with the first letter of their name. (For example you could say Grace and Gekko if your site chose animals).
3. After this, have mentees return to their seats and pass out a piece of construction paper for each mentee, as well as some drawing materials for each table (if applicable).
4. Have mentees make themselves a name tag to keep on their desks throughout the semester! (they should put this somewhere safe to save it for the next site) – this way we can better remember everyone's names!

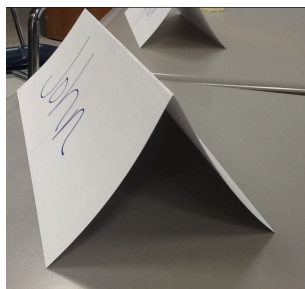


Figure 1: Name tag example (make it more festive!)

Classroom Notes

For learning names, try to set up a rule on this first day of site that anytime someone raises their hand, they should say their name. Along the same lines also during activities and builds mentors can walk around and talk to mentees, try to get to know your mentees!

Module 1: Test Drive

Mentees will be balling up their fist to represent the absence of a functional, anatomically complete hand. They will try and complete certain tasks to try and illustrate the difficulty in routine actions in disabled individuals without assistive devices

Teaching Goals 1. Disability - A condition that holds someone from performing tasks that other people do regularly. Disabilities can be something someone is born with, or they can develop later in life. 2. Assistive Device - A tool or piece of equipment that helps people with disabilities perform everyday tasks independently and effectively. May also include things like live/closed captioning, voice recognition software, and braille displays. 3. Biomedical Engineering - The branch of engineering that combines engineering and biology to create innovative solutions to medical conditions/problems.	Materials • 1 washable marker per student • Tape • 1 piece of paper per student
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Different Methods for Teaching

- 1. Introducing Disabilities:** People have different abilities, impairments, or needs. Some include visual, hearing, or mobility impairments, chronic conditions, or learning differences. These are called disabilities, but they don't mean that someone is "less than" or they can't do something— many just do them differently. Accessibility (support for your individual needs) is for everyone!
- 2. Addressing Problematic Behavior — Do's and Don'ts:**
 - a. Address It:** Make sure not to let problematic behavior slide! Pull the mentee(s) aside and ensure that you address the behavior to ensure that their classroom expectations are clear, which helps set the behavior for the rest of the semester.
 - b. Focus on positive behavior instead of negative:** Rather than focusing on getting the mentee to admit wrongdoing, it is often more productive to have the mentee acknowledge the importance of good behavior. For example, in addition to explaining why a mentee's joke about disabilities was disrespectful, it can be helpful to highlight that people have different abilities and that it's important to be respectful of their experiences
 - c. Don't "baby talk" to mentees:** Talking down to mentees or enforcing authority without giving the reason behind it can be frustrating to mentees. Be firm when talking to the mentee, but don't belittle them or be mean to them. **Remember:** The goal in addressing this behavior is to build a classroom environment where mentees are excited to participate and remain respectful of each other and the lesson.

Procedure

1. Have mentees ball up their hands into a fist, then try to pick up a marker (without unballing their fist) and write their name.
 - a. The mentees should quickly find this to be very difficult, if not impossible.
2. Next, give each mentee a single piece of tape, encouraging them to use the tape to help them write their name again.
 - a. The mentees should be able to use the tape in any way they can think of. Emphasize the fact that they themselves are being biomedical engineers trying to come up with an assistive device (albeit without the greatest solution).
 - b. The mentees should find that the writing process is easier, but still not seamless.

For younger sites/alternative activity

3. Have mentees ball up their hands into a fist and try to pick up a paper ball without any assistance/tape.
 - a. The mentees should quickly find this to be very difficult.
4. Next, give each mentee a single piece of tape, encouraging them to use the tape to help them pick the ball up again.
 - a. The mentees should be able to use the tape in any way they can think of. Emphasize the fact that they themselves are being biomedical engineers trying to come up with an assistive device (albeit without the greatest solution).
 - b. The mentees should find that this is easier, but still not seamless.



Figure 1: Mentee cannot pick up pen without assistive device

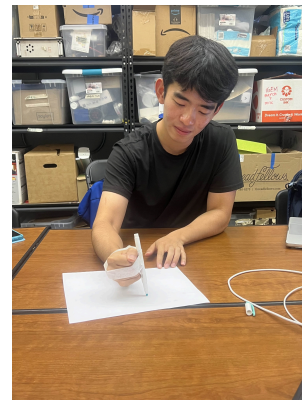


Figure 2: Mentee can write their names with assistive device

Classroom Notes

Proceed with caution to make sure that mentees are not gamifying disability.

Module 2: Give Me a Hand (or a leg...or a tail)!

Mentees will create their own prosthetic hand out of cardboard, string, tape, and straws, enabling them to potentially pick up a ping pong ball or write their name.

Teaching Goals 1. Bones - hard, dense tissue that form the rigid skeleton, responsible for giving the body its shape, protecting organs, and storing important minerals like calcium. 2. Joints - locations throughout the body where two or more bones meet, allowing the bone to move smoothly in several different ways. 3. Muscles - specialized tissue that line and pull bones by contracting and relaxing, enabling movement of the skeleton. 4. Prosthetic - an artificial device that substitutes for a missing body part. Can be body-powered, motor-powered, or myoelectric (among others). 5. Engineering Design Process - the trial-and-error process by which engineers test and refine the design of their invention repeatedly according to feedback.	Materials • Scissors • Tape • Plastic Straws (5 per student) • Cardboard • String (3 ft per student) • Ping pong ball (1 per group)
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Different Methods for Teaching 1. Learning Anatomy: Give visual representations when explaining each anatomical teaching goal. Encourage mentees to follow along and point to the various bones, joints, and muscles on their body! For example, when talking about bone → rib cage or fingers, joints → wrist or elbow, muscle → bicep. Ask interactive questions like: which parts do we use when we run or when we eat food! 2. Running the build: Mentors can split the mentees into smaller groups and guide mentees through the build. Younger sites may have trouble cutting out the cardboard or looping the strings, so mentors can help to save time. 3. Connecting the Engineering Design Process and Activity: During the build, if a mentee realizes that their robot arm doesn't work, you can ask them what they might have to change (ex. location of tape) to make all fingers unfold and grasp. They can then test their design to see if it produces desired results. You can also ask "How would you make the robot arm hold more weight/larger item/fragile item?" and relate it to how engineers use similar methods of thinking in order to design and improve their inventions as well!

Procedure 1. Have mentees trace their hand on the cardboard and cut out an outline of a	
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cardboard hand

2. Cut out pieces of straw and tape them onto the fingers and thumb (*make sure there are spaces in between the straws so the fingers can bend*)
3. Loop a piece of string through the straws and tape the end of the string to the tip of the cardboard fingers to secure it in place
4. Fold the finger between the straws to mimic joints
5. Pull the strings to use the robot arm/prosthetic.
6. Have the mentees try to either pick up a paper ball or write their names (or both!) again, this time with the prosthetic hand.

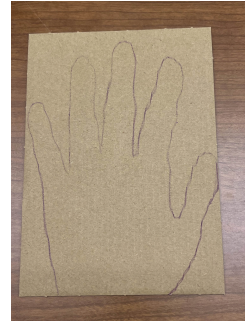


Figure 1: Traced out hand of mentee



Figure 2: Cut out hand with bended creases



Figure 3: Cut out hand with taped straws



Figure 4: Finished hand

Classroom Notes

If mentees want to have a hand with less finger (ex: more like a ball pit claw) encourage them to follow that design! A prosthetic hand should be customized to its user.

Module 3: Dragon Eggs!

The mentees will take home their own personal fidget toy. To account for time taken up by the first two modules, this module will serve as a conclusion with a discussion about non-visible disabilities.

Teaching Goals 1. Non-visible Disability - disabilities that may not be immediately apparent to others since they do not present with obvious physical signs. 2. Fidget Toys - Handheld objects designed to be repeatedly fiddled with, serving an important purpose in calming nervous energy and improving focus. 3. Attention Deficit Hyperactivity Disorder (ADHD) - a common non-visible neurological disability that affects a person's ability to pay attention, control impulses, and regulate activity levels.	Materials • 1 fidget toy (pop-it) per student
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Different Methods for Teaching [SCRIPT]

A **non-visible disability** is a type of disability that may not show on the outside, which means you can't always tell if someone has one just by looking at them. For example, someone might walk, talk, and play just like their friends, but they may still face challenges every day that other people don't notice. One common non-visible disability is **ADHD** (Attention Deficit Hyperactivity Disorder), which can make it harder for a person to sit still, pay attention, or control impulses. This doesn't mean they aren't smart or capable—it just means their brains work a little differently, and they may need extra tools or strategies to help them succeed. One helpful tool is a **fidget toy**. This is a small object designed to be fiddled with in your hands. Instead of being just a fun toy, it helps release extra energy, calm nerves, and improve focus, almost like a pair of glasses helps someone see clearly. By understanding non-visible disabilities, we can be more patient, kind, and supportive, remembering that everyone learns and experiences the world in their own unique way.

Procedure

1. Hold a classwide discussion about non-visible disabilities and fidget toys, aiming to allow mentees to understand that disabilities are not always purely physical. Be sure to talk about the importance of fidget toys beyond just being fun to play with.
2. Pass out 1 fidget toy per student.



Figure 1: Pop it used in this module.

Classroom Notes

Feel free to stick to the script when talking about this sensitive topic.

Conclusion

Wrap up with module 3 + class-wide discussion using MD-created script.

References

-  [1] Jumping into BEAM.pdf
 - (prosthetic hand lesson; Monica Cao, Sophia Wang; Fa21)

Summary Materials Table

Material	Amount per Site	Expected \$\$	Vendor (or online link)
Paper	1 per student		McL
Markers	1 per student		McL
Tape	3 rolls		McL
Scissors	5 per classroom		McL
Cardboard	1 per student	\$21.99	Amazon
String	3ft per student	\$5.99	Amazon
Plastic Straws	5 per student	\$6.97	Amazon
Ping Pong Balls	1 per group		McL
Fidget Toys	1 per student	~\$70	Amazon