Enhancing STEM Education: Learning about Biomedical Engineering with 3D Pens (Resource Exchange)

Dr. Perihan Fidan, Tennessee Tech University

Perihan is a faculty member at the Curriculum and Instruction department at Tennessee Tech University. Her current research interests include STEM education, 3D printing, and incorporating literacy into STEM classrooms. She is a member of the American Educational Research Association, National Science Teaching Association, International Congress of Qualitative Inquiry, and the National Association of Multicultural Education.

Dr. Stephanie L. Wendt, Tennessee Tech University

Dr. Stephanie Wendt is an Associate Professor at Tennessee Tech University. She teaches undergraduate science methods and field experience courses to elementary pre-service teachers. She also teaches graduate courses in science methods, learning theory, grant writing, and educational technology. She is a member of the Tennessee Science Education Leadership Association (TNSELA) and Tennessee Science Teachers Association (TSTA), and is a former representative of the Board of Directors for TSTA. Dr. Wendt also serves as a reviewer for NSTA's peer-reviewed journal Science and Children. She participates in leading professional development for K-12 educators pertaining to science education at the state and national levels. Dr. Wendt focuses on helping pre-service teachers, in-service teachers, and elementary students develop a love for science and works to promote STEM in K-12 classrooms and the teacher preparation program at Tennessee Tech University.

Dr. Jeremy Wendt, Tennessee Tech University

Dr. Jeremy Wendt is the Chair for the Department of Curriculum & Instruction in the College of Education at Tennessee Tech University. He is also a Professor of Educational Technology. Since coming to TTU in 2003, Dr. Wendt has over 200 presentations at different local, regional, national, and international venues related to educational technology. Grant work for the department, college, and university has created many opportunities for collaboration in PreK-16 settings related to technologies such as iPads, Interactive Whiteboards, Virtual Reality and Assistive Technologies.

Dr. Ismail Fidan, Tennessee Tech University

Currently, Dr. Fidan serves as a Professor of the Department of Manufacturing and Engineering Technology at Tennessee Tech University. His research and teaching interests are in additive manufacturing, electronics manufacturing, distance learning, and STEM education. Dr. Fidan is a member and active participant of SME, ASEE, ABET, ASME, and IEEE. He is also the Associate Editor of IEEE Transactions on Components, Packaging, and Manufacturing Technology and International Journal of Rapid Manufacturing.

Enhancing STEM Education: Learning about Biomedical Engineering with 3D Pens

Introduction

3D Printing is clearly becoming a state-of-the-art production technology that is growing in many engineering and technology fields (Balletti, Ballarin, & Guerra, 2017). Today, this technology is especially popular due to its advantages. It is low cost, lightweight, and produces complex workpieces. Its utilization in healthcare, automotive, aerospace, and even in defense industries is growing sharply. This 3D printing technology is being introduced in classrooms across the United States with students of all ages, but sometimes using this technology can be challenging for younger students due to the complexity of designing, time management, and money constraints. 3D pens offer a lower cost alternative that provide immediate gratification for users. In this project, instructors demonstrate how 3D pens can be used to teach biomedical engineering in middle school classrooms.

This STEM lesson will use hands-on/minds-on materials while walking students through the Engineering Design Process: Ask, Imagine, Plan, Create, Improve (Museum of Science Boston, 2020). During the unit, the students integrate each of the STEM disciplines (Science, Technology, Engineering, and Math) in a fun and accessible way by using 3D pens to create models.

LEARNING GOALS:

Students will effectively design and construct a prototype prosthesis using a 3D pen.

STANDARDS:

MS.ETS1.1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS.ETS1.4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

MATERIALS:

Broken toys, graph paper, pencil, scissors, plastic lids, card stock paper, 3D pens, filaments, glue gun

Activity Time:

Five - 45 minute class periods
Grade Level: Middle School (4-8)

Lesson Overview:

Developing and using models is identified as an important Science and Engineering Practice of the Next Generation Science Standards (NGSS). The ideas shared in this unit demonstrate the effectiveness of using 3D pens to introduce biomedical engineering to middle school students. This activity provides a means to teach engineering concepts while creating models. At the beginning of the unit, students were introduced to 3D printing by reading the book *Beauty and the Beak* (Rose & Veltkamp, 2017) and watching YouTube videos about a bald eagle named Beauty that lost its beak in a hunting accident. The book and videos discussed how biomedical engineers improve the lives of animals and humans with prosthetics. The goal for the unit was for students to create prosthetic models with 3D pens for a variety of toys with missing limbs. In doing this, the students were given a chance to explore the features of 3D pens and then compare them to 3D printers. Similar to 3D printers, students saw how 3D pens use filament that goes through a heating process. Just like with 3D printers, the plastic filament in 3D pens is heated until melted and extruded from the tip of the pen.

Throughout the unit students were placed in groups to promote collaboration during the engineering design process (Museum of Science Boston, 2020). Students began with asking questions about what biomedical engineers do, and then worked together to imagine how to create prosthetic limbs for their toys.

While planning, students drew models on graph paper using the toys' unaffected parts. They traced limbs in order to achieve symmetry through measurement. Next, students created prototypes of the broken parts from recycled plastic materials to scale their models. Last, students improved their models by using the 3D pens to create prosthetics that were similar to the size and shape of their toys' missing parts. During this final stage, students attached the prosthetic limbs for their toys and tested for function.

Lesson Outline:

ASK

✓Students brainstorm reasons about why beaks are important to birds.
✓Students discuss different food sources for birds by beak type
✓Read Aloud- Beauty and the Beak (Rose & Veltkamp, 2017)
✓View video clip that tells Beauty's story https://www.youtube.com/watch?v=3qz9EvjtV7k
✓Following the read aloud, students brainstorm ways to help the eagle fix his beak

IMAGINE

✓Provide students with other examples of prosthetics to help them imagine how they are used in our world
✓Watch Derby the Dog Video https://www.youtube.com/watch?v=uRmoowIN8aY
✓Watch Giving the World a Helping Hand Video https://vimeo.com/152492035

PLAN

✓Read Aloud- excerpts from the book *Biomedical Engineering* (Sjonger, 2015)
✓Students explain biomedical engineering in their own words
✓Students use their own toys or are given wind-up toys
✓Students trace the missing limbs onto graph paper and transfer to plastic materials to cut out

CREATE

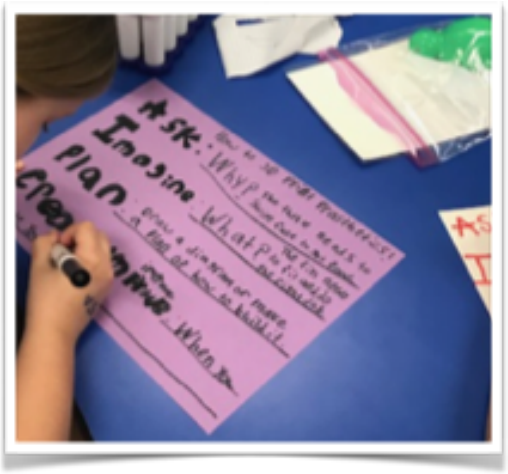
✓Students create prosthetics for broken toys from plastic recycled materials
✓Teachers hot-glue the plastic pieces onto the toys as a first prototype

IMPROVE

✓Students draw on card stock to make 2D templates for using with 3D pens
✓Give students the opportunity to use the 3D pens with adult supervision
✓Students complete 3D models of their prosthetic limbs
✓Students test the functionality of their toy's improved prosthetic limb

Assessment:

✓Students create engineering design posters
✓Students create a video with the iPads that allow each person at the table to tell how they engineered a prosthetic part for their toy and how it will improve its structure and function.



Advantages

- Easy to use
- Lightweight
- Various color options
- Durable and long-lasting
- Affordable
- Convenient

Limitations

- Requires access to power
- Takes practice
- Device can jam

Resources

- 3Doodler.com
- scribbler3dpen.com
- OfficialRainbowGirl.com

Citations

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education*, *5*(6), 66-70.

Balletti, C., Ballarin, M., & Guerra, F. (2017). 3D printing: State of the art and future perspectives. *Journal of Cultural Heritage*, *26*, 172-182.

n.d. (2020). *The engineering design process*. Museum of Science Boston. Retrieved from: https://www.eie.org/

Rose, D. L.& Veltkamp, J. (2017). *Beauty and the beak*. Persnickety Press. Apex, NC.

Sjonger, R. (2015). *Biomedical engineering and human body systems*. Crabtree Publishing Company.