Engineering a Stronger Bone: A Biomaterials Design Challenge for Middle School Students.

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Statement of Purpose: Student interest in science, technology, engineering, and math (STEM) is not growing quickly enough to meet workforce needs [1,2]. Outreach programs for K–12 students increase interest in STEM, by providing early and informal exposure to foster STEM engagement. K-12 students who participate in STEM-related programs outside of class are more likely to develop a STEM identity and show greater interest in these fields than those without such experiences [3]. Providing students with opportunities to engage with STEM concepts is therefore critical for fostering both interest and confidence that leads to success as adults. To support early exposure to STEM concepts, this module introduces middle school students (grades 6–8) to biomaterials and their role in patient care through an interactive classroom activity. The module is designed for teachers or STEM outreach coordinators to use in a 45-minute period and aims to increase student knowledge of biomaterials while promoting interest in STEM-related fields. Knowledge of and interest in biomaterials will be assessed using surveys administered before and after the module.

Activity Methods: This learning module begins with a brief presentation (10 minutes) introducing biomaterials and how they improve human health. Students are then introduced to an activity in which they are tasked with *stabilizing a broken bone* using a variety of materials that are readily available at department stores, such as Walmart (Table 1). The activity is designed such that 10-15 groups of 2-3 students can complete the activity simultaneously in the classroom. Each group may select up to three stabilization materials from the available options and will have 15 minutes to stabilize the broken bone. Students may sketch their designs or experiment directly with the materials. After completing their designs, groups will have 10 minutes to test and record observations on how well their design stabilizes their broken bone by placing it between two supports and gradually adding pennies to a small container attached to the rod until the rod bends or fails. Students will record observations on which materials performed best, how combining materials affected stability, and will have 10min to discuss why some materials were more effective than others. This process allows students to explore material properties, design strategies, and the importance of combining materials to optimize performance, reflecting concepts used in real-world biomaterials design.

Table 1: Activity Materials and Estimated Cost for 15 Groups of 2-3 Students

Material	Purpose	Estimated Cost
Pre-cut 0.5-inch Dowel	Fractured bone	$25
Scotch Tape	Stabilization Material	$2
Straws	Stabilization Material	$3
Play-Doh	Stabilization Material	$10
Wooden Sticks	Stabilization Material	$3
Rubber Bands	Stabilization Material	$2
Total		**$45**

Assessment: Students will be evaluated on their knowledge of and interest in biomaterials using pre- and post-module surveys. Knowledge of biomaterials will assess the following learning objectives: (1) whether the student knows what a biomaterial is, and (2) whether the student understands how biomaterials can be used. Responses will be scored by instructors using the following rubric:

0 – Student does not understand the concept
1 – Student understanding is developing
2 – Student understanding meets expectations
3 – Student understanding exceeds expectations

Interest in biomaterials will utilize a 7-point Likert scale with response options ranging from strongly disagree to strongly agree, which will be assigned numerical values from 0–6. Pre- and post-module scores will be compared to evaluate student growth in understanding and developing interest.

References: [1] Paul, *et.al.* International Journal of STEM Education, 2020 [2] Amalina, *et.al.* Humanities and Social Sciences Communications, 2025 [3] Rodriquez-Devora, *et.al.* ASEE, 2022