# Assessing Changes in Attitudes toward Biomechanics Resulting from a High School Outreach Event

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## Abstract

A recent expo-style event celebrating National Biomechanics Day at North Carolina State University hosted over 200 students from local high schools to learn about the engineering discipline. Pre- and post-event surveys were administered to assess if the event impacted participants' attitudes toward biomechanics or their general understanding of the field. Student attitudes toward biomechanics improved post-intervention, as indicated by paired t-tests. Additionally, students were better able to see themselves as a scientist or an engineer following the event than before. These results indicate that our NBD event resulted in significant gains in engagement and excitement among high school students related to the field of biomechanics, which is a key first step for promoting enrollment in the field at the university level and stimulating curricular changes at the high-school level

## Keywords

Biomechanics, K-12, Outreach, Bioengineering

## Introduction

Attracting and retaining high quality undergraduate students to engineering is an ongoing priority in the United States[1]. Despite significant effort dedicated and money spent over the last quarter century to remedy the issue, and though enrollment has increased over the last decade[2], the number of graduates remains inadequate to fill the engineering positions available in the United States[1,3]. Furthermore, while efforts have focused on increasing enrollment and retention, little attention has been paid to diversification among engineering sub-disciplines, and the majority of degrees awarded in the last ten years at all levels have been in either mechanical engineering, computer science, civil engineering, or electrical engineering[4]. Clearly students need to be exposed students to a wider variety of engineering fields, beginning before they reach the university level.

One such 'up and coming' engineering discipline is that of biomechanics, which is critical to many fields, including orthopaedics, rehabilitation, and sports performance. Within the broad area of STEM (science, technology, engineering and math) and the narrower field of engineering, biomechanics is relatively new and suffers from a lack of exposure. For instance, it was not included in the list of engineering disciplines looked at by the American Society for Engineering Education in their 2017 yearly report[2]. It is not typically included among high school science curricula in the United States and is often overlooked among lists of science career paths due to a lack of awareness. The US government even failed to include it on their 2012 list of over 400 STEM career fields[5]. National Biomechanics Day was created in 2016 to address the issue. Its aim is to expand both the influence and the impact of biomechanics within the world of STEM and also to increase awareness of biomechanics among young people[6]. Our event sought to increase exposure to different aspects of biomechanics but also to engineering more broadly.

## Methods

**Participants:** Approximately 200 students from seven schools across Wake and surrounding counties enrolled in the event, identified via emails sent to high school biology, physics, and health science academy teachers. Five schools were public schools, one was a charter school, and one was a homeschooled group. Pre- and post-surveys were paired for 68 of the students. Of these 68, 38 identified as female and 25 as male. Five did not respond. Fifty identified as white, four as black or African American, ten as Asian, and one as Latino or Hispanic.

**Connections to Educational Theories:** We used Self-Determination Theory (SDT)[7,8] to inform our event design. Implications of SDT for education include that students will have higher quality learning when doing something self-motivated, as opposed to externally driven, and that contributing to a student's sense of competence and their own autonomy will increase intrinsic motivation, and thus engagement and learning[9]. By utilizing a self-guided, free-choice format for our event, we aimed to tap into the students' sense of autonomy. Feelings of relatedness were enhanced, because the students were interacting directly with scientists. Additionally, by using age-appropriate, inquiry-based activities and language, we aimed to contribute to students' feelings of competence.

**Event Design:** Because learning is more effective when it is self-motivated[10,11], the event was set up as an "engineering expo," like a small-scale science festival. The efficacy of science festivals on increasing engagement has been previously demonstrated[12–14]. Students were given unstructured time to engage in different biomechanics-based activities at their discretion. The activities were created and led by graduate students, faculty, and staff and focused on a wide-range of topics pertinent to biomechanics. They had varying degrees of interactivity and engagement time. Concepts highlighted include motion capture, 3D printing, biomechanical testing, bone fracture fixation, prosthesis design, use of 2D images to build 3D models, virtual reality and wearable sensors, nanofabrication techniques, and many others.

**Assessment and Survey Design:** The survey (administered both pre- and post-event) was submitted to the Institutional Review Board at North Carolina State University, and exemption status was obtained. We measured student attitudes toward science, math, and biomechanics using five-point semantic differential. Existing measures[15–17] were adapted to relate to biomechanics, as well as engineering more broadly. We assessed attitudes toward science, engineering generally and biomechanics specifically, as well as possible future careers in either field using a six-point Likert scale. To ensure validity, we included negatively-worded prompts where a lower rating indicates a more favorable attitude or response. We reverse-coded these items prior to analysis so that, like the other questions, a higher number reflected a more favorable response. Likert-type survey items were aggregated into three larger themes: scientist / engineer identity, engineering attitudes, and biomechanics attitudes (Table 1). We assessed internal consistency for each scale at both the pre-test and post-test level using Cronbach's alpha. Generally, a Cronbach's alpha of 0.7 to 0.8 is considered acceptable, and 0.8-0.9 is considered good. Therefore, it can be concluded that most of our scales were at least acceptable, and many were good. We then ran paired t-tests to evaluate gains resulting from the event.

**Table 1: Survey Aggregate Scale Summaries – Paired tests**

| Theme | Questions | α-pre | α-post |
|---|---|---|---|
| Scientist / Engineer Identity | I see myself as a scientist, I see myself as an engineer, I can be a scientist if I so choose, I could be a successful engineer. | 0.67 | 0.80 |
| Engineering Attitudes | Engineering is interesting, Engineers are creative, Engineers are helpful. | 0.85 | 0.75 |
| Biomechanics Attitudes | I understand what biomechanics is, I could explain to someone else what biomechanics is, Biomechanics is a good career option, Biomechanics is tedious and detail-oriented*, Biomechanics is interesting/fun. | 0.86 | 0.84 |

*Reverse-coded prompt

## Results

From the paired surveys, many of the semantic differential word pairs relating to biomechanics saw statistically significant improvements post- vs. pre-event (Table 2). For most questions, a lower value (or a negative difference) indicates more favorable views. For reverse-coded questions, the opposite is true: high values indicate more favorable impressions. The Likert-scale aggregate measures also demonstrated significant gains following the event. That is to say, students agreed more with statements regarding whether they saw themselves as scientists and engineers, they had improved attitudes toward engineering in general, and they had improved attitudes toward the field of biomechanics (Table 3).

**Table 2: Semantic Differentiation Scale for Biomechanics (1=first word, 5=second word)**

| Word Pair | Pre-Event | | Post-Event | | n | p-value |
|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | | |
| Important - Unimportant | 1.40 | 0.65 | 1.16 | 0.44 | 62 | 0.0014 |
| Interesting – Dull | 1.83 | 0.97 | 1.31 | 0.58 | 63 | <0.0001 |
| Valuable – Worthless | 1.68 | 0.77 | 1.24 | 0.61 | 63 | <0.0001 |
| Confusing – Understandable* | 2.67 | 0.86 | 2.77 | 0.97 | 63 | 0.2415 |
| Exciting – Boring | 2.27 | 0.93 | 1.81 | 0.94 | 63 | <0.0001 |
| Simple – Difficult | 3.41 | 0.84 | 3.39 | 0.91 | 63 | <0.0001 |
| Hard – Easy* | 2.67 | 0.72 | 2.45 | 0.85 | 63 | 0.1916 |

*Reverse-coded prompt. Means reported are those calculated on responses prior to applying reverse coding.

**Table 3: Results of Aggregate Measures (1=strongly disagree, 6=strongly agree)**

| Scale | Pre-Event | | Post-Event | | n | p-value |
|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | | |
| Scientist/Engineer Identity | 4.25 | 0.98 | 4.63 | 1.11 | 63 | 0.0004 |
| Engineering Attitudes | 4.93 | 1.01 | 5.29 | 0.74 | 63 | 0.0035 |
| Biomechanics Attitudes | 3.72 | 0.81 | 4.46 | 0.62 | 61 | <0.0001 |

## Discussion

The primary goal of this event was to increase excitement and engagement, which is more effective at altering attitudes toward science than teaching content [18–20]. Therefore, our assessment focused on changes in students' perceptions of biomechanics and engineering following the event and did not assess learning gains. Results indicate that we achieved this goal, as significant positive gains were found in several areas relating to biomechanics via the semantic differentiation measures and aggregate measures of Likert-type scales assessing scientist-engineer identity, attitudes toward engineering, and attitudes toward biomechanics. It is worth noting students who were already interested in STEM topics were more likely to attend than those who were not, so this undoubtedly affected the results. Additionally, factors other than specific event content or exposure to engineering could have played a role, as student perceptions could have been swayed by excitement from attending an event away from the classroom, from being on a college campus, or other similar effects. However, based on personal feedback from the students and teachers, we feel that exposure and engagement definitely had a positive impact. Future studies should focus on distinguishing between attitude changes resulting from the intervention itself and those resulting simply from the change in routine from the day-to-day habit of school.

In addition to increasing engagement, this event sought to change perceptions of engineering and engineers generally. Though engineering and technology design components are broadly included in most states' educational standards[21], students do not adequately understand what it means to be an engineer, and rectifying this should be a national priority[3]. The problem is two-fold: most students lack perception of the field, and among those who do indicate an awareness of engineering, most hold perceptions that are inaccurate. This problem persists across all grades, college-bound high school students[22–24]. Therefore, outreach should explicitly address engineering issues and content in order to increase awareness of engineering as a profession [25,26]. Furthermore, one shortcoming of many existing STEM outreach efforts is that they take place in the classroom rather than the laboratories where the engineers and scientists do their work. Exposure to authentic contexts has been shown to increase learning potential[27], and exposure to real-life engineers and the state-of-the-art technology is an important component of effectively changing perceptions[28]. Though this event included two tours of laboratories doing work in biomechanics, future event design should emphasize these lab tours and also include assessment as to whether these environments increase engagement in addition to learning potential.

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