

Cultivating Enthusiasm in Science and Orthopaedics in Middle School Students: Survey Data and Impact from the 2025 ORS Open Door Event

Jaimo Ahn^{1*}, Sydney M. Caparaso^{2*}, Carolyn Chlebek^{3*}, Sade W. Clayton^{4*}, Elena Della Bella^{5*}, John F. Drazan^{6*}, Rahul Gawri^{7*}, Hugo Giambini^{8*}, Mackenzie Hagan^{9*}, Paula A. Hernandez^{10*}, Chester Lowe^{9*}, Amy K. Loya^{11*}, Jason C. Marvin^{12*}, Joseph Roberts^{2*}, Christina Salas^{13*}, Shirley N. Tang^{4*}, Ryan E. Tomlinson^{14*}, Hope D. Welhaven^{15*}

¹Emory University, ²Arizona State University, ³MaineHealth Institute for Research, ⁴Washington University in St. Louis, ⁵AO Research Institute Davo, ⁶Fairfield University, ⁷McGill University, ⁸University of Texas at San Antonio, ⁹KUBTEC Medical Imaging, ¹⁰University of Texas Southwestern Medical Center, ¹¹Union College, ¹²American Institute for Medical and Biological Engineering, ¹³University of New Mexico, ¹⁴Thomas Jefferson University, ¹⁵University of California San Francisco

*All authors contributed equally to this work, †Corresponding Author: jason.marvin@aimbe.org

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INTRODUCTION: Early exposure to science is critical to cultivate the curiosity of secondary school students for STEM-based opportunities, particularly in orthopaedics where representation has historically lagged behind other biomedical specialties. The ORS Open Door Event was developed to address this gap in the field by providing students with hands-on workshops, career presentations, and direct engagement with musculoskeletal (MSK) researchers from different disciplines, career stages, and backgrounds. Building on the success of this event with middle school audiences in 2023 and 2024, we aimed to determine whether changes in students' attitudes towards diversity, STEM, and MSK research differ by grade level. Based on our previous survey observations, we hypothesized that 6th and 7th grade students would be more impressionable to this educational intervention compared with their 8th grade peers.

METHODS: This study was deemed exempt from review by the Human Subjects Review Committee at Union College as per 45 CFR 46.104(d)(2).

Educational Partner & Target Audience: The 2025 Open Door Event partnered with the Arizona Association for Middle Level Education (AzAMLE). Over 100 middle schoolers (Grades 6-8) from Rogers Ranch STEM Academy (58% Hispanic, 23% Black or African American, 4% Native American or Native Alaskan) and 72% economically disadvantaged students. **Early Career Outreach Travel Award (ECOTA) & Volunteers:** The ORS Planning Committee selected 10 ORS ECOTA awardees (\$300/award) to assist with organizing and executing this event. We solicited approximately 40 in-person volunteers via a general call to the ORS membership. **Career Speakers & Discussion Panel:** We hosted four trainee and faculty speakers (12-minute talk and 5-minute Q&A/speaker) who presented short research talks on bioengineering, biomechanics, biology, and orthopaedic medicine with insights from their personal and academic experiences. Following the speaker presentations, we held a 30-minute mentorship panel comprised of biomedical scientists across career stages and URM groups in STEM to answer science- and career-related questions.

Interactive Workshops: To conclude the event, students rotated through three interactive, 35-minute workshops on (1) Engineering Performance, (2) Cartilage and Bone, and (3) Spine led by ORS volunteers and industry professionals to learn about different MSK tissues and diseases. In small groups, workshop leaders instructed students to adopt an inquiry-based approach to problem-solving by making predictions, recording their observations, and analyzing data (e.g., measuring forces of physical movements, a competition for the highest loading required to fracture their sawbones) using a combination of low-cost household items and industry-sponsored equipment (e.g., a histology station). **Event Learning Outcomes:** We conducted pre- and post-event surveys of student attitudes toward diversity in science, the general importance of STEM and MSK research, and their career interests on a 5-point Likert scale (1, 3, and 5 denote strongly disagree, neutral, and strongly agree, respectively). Using self-reported personal identifiers to match pre- and post-survey responses, we analyzed the data on an aggregated and by grade level basis ($N=99$ total; $N=33$ /grade). **Statistics:** We assessed learning outcomes of the 2025 Open Door Event using Wilcoxon matched-pairs signed-rank tests for matched responses. Significance was set at $*P<0.05$ and trends at $\#P<0.1$. Data are shown as mean + SEM.

RESULTS: Supporting our hypothesis, overall student attitudes showed significant increases across nearly all learning outcomes, except for the statement “I am interested in becoming a MSK researcher.” (Fig. 1a; $P=0.12$; 4.05% increase for aggregated). Students reported the greatest increase for the statement “I know a lot about MSK research” ($P<0.0001$; 52.0% increase for aggregated). Contrary to our hypothesis, while all students demonstrated increases across all domains, 8th graders consistently displayed the greatest increases in diversity- and STEM-related learning outcomes compared with 6th and 7th graders (Fig. 1b). Importantly, we observed an isolated, non-significant decrease for the statement “I am interested in becoming a MSK researcher” for 6th graders ($P=0.69$; -4.40% decrease), indicating an overwhelming positive impact of their participation in the 2025 ORS Open Door Event.

DISCUSSION: Contrary to our hypothesis and our 2024 ORS Open Door Event data, older students demonstrated greater shifts in learning outcomes than younger students. With an expanded sample size relative to previous cohorts, our new data suggest that older students may be more responsive to program offerings, potentially due to increased maturity, broader exposure to science in school, or a stronger investment in future career planning. A limitation of this study is that ORS Open Door organizers and volunteers are substantially more experienced in running this event, which may explain these differing observations between the 2024 and 2025 student cohorts. Nevertheless, as the program continues to expand and evolve, our recent data highlight a potential need to further tailor our outreach activities to maximize engagement across a range of age groups.

SIGNIFICANCE: Our findings provide compelling evidence that the ORS Open Door Event, an immersive STEM outreach experience, positively influences middle school students' perceptions of science and orthopaedics. The consistency of these results across three consecutive years of survey data and the established program structure support expansion of this initiative as a model to broaden long-term participation in the scientific workforce.

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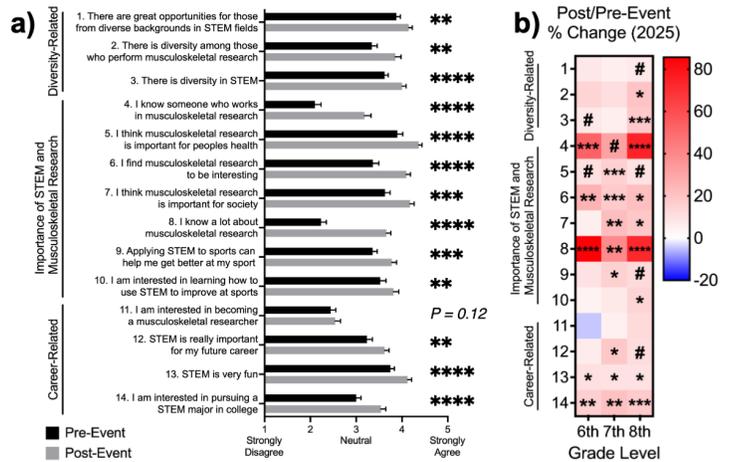


Figure 1. (a) Comparison of 99 matched pre- (black) and post-event (gray) survey responses illustrates near-universal increases in middle school students' attitudes and enthusiasm for STEM and MSK research after attending the 2025 ORS Open Door Event. **(b)** 8th graders reported the most significant changes in learning outcomes. Heat map denotes % changes in students' post/pre-event survey responses by grade level. Red & blue indicate increased and decreased scores. $\#P<0.1$, $*P<0.05$, $**P<0.01$, $***P<0.001$, $****P<0.0001$.