

Body-Based Approach to Teaching and Learning Statics

Keywords: interest theory, situational interest, engagement, persistence, statics, gateway courses

Background: Interest theory indicates that a person's interest has two components: personal and situational [1]. Situational interest, or an emotional state aroused by specific features of an activity or task, has been strongly related to indicators of learning and retention of knowledge in studies of text reading [1,2]. Novel approaches have been shown to increase situational interest while vivid and concrete teaching materials have also been positively related to situational interest and recall of information [3,4].

Lack of interest in and engagement with engineering subject matter have been noted as main factors affecting student persistence in engineering [5]. Students considering leaving engineering are on average not as excited about engineering [6]. Furthermore, a lack of interest in engineering can be a precursor to seeking out interests in other disciplines or subject areas [5,6].

Hypothesis: Situational interest in Engineering Statics can be increased through a body-based approach—using one's own body to directly experience and thereby understand fundamental concepts. By increasing situational interest, the following will result: a) an increase in student engagement, b) an increase in conceptual learning, and c) a strengthened commitment to persist in engineering.

Research Plan – Strategy: Statics is a course typically administered during the 2nd year of study in undergraduate engineering. A gateway course required for all mechanical, civil, and aerospace engineering majors, success in Statics is critical for students wishing to pursue engineering further. Statics is the first class young engineering majors take that requires true engineering problem solving and a high level of applying conceptual knowledge to real problems.

A review of a typical Statics textbook indicates a disconnect between the diversity of teaching examples used and the *desired* diversity of engineering student demographics. Cars and car-related problems dominate over one-quarter of the total examples and illustrations in the textbook. Furthermore, the remaining three-quarters of examples shown are largely airplanes, rockets, machine tools, mechanisms, and men: the ratio of men to women as pictured in the text is over 10:1, with only six women displayed over the entire 600 pages [7].

Recent studies have shown that Statics students have difficulty thinking and reasoning physically about the reactions and forces present at a given connection [8]. The proposed body-based intervention will provide a tangible means, through the human body, to experience and notice fundamental Statics concepts. The body-based intervention will introduce Statics concepts through interactive activities in which students experience muscular sensation and connect their internal feelings to technical concepts. This approach will prompt students to identify reaction forces and interaction within their own bodies. Additionally, the *novelty, concreteness, and vividness* of the body-based approach will catch the interest of students leading to active engagement and increased conceptual understanding. All students can participate in the body-based approach regardless of race, gender, or disability: it is fundamentally gender-neutral and does not bias based on prior knowledge and previous experience.

Research Plan – Methodology and Controls:

Year	Tasks	Control Group	Assessment Method
Y 1	Develop and pilot body-based activities to introduce fundamental Statics concepts (e.g. equilibrium, normal force, moment, torsion). Develop attitude survey.	N/A	Student Attitude Survey and Focus Groups. Begin longitudinal tracking.

Y 2	Implement body-based activities at large state university and small gender-balanced engineering college. Refinement of body-based activities.	Simultaneous recitation sections split into body-based and non-body-based groups at each site.	Pre-/post Statics Concept Inventory [9], Pre-/post Student Attitude Survey, Individual semi-structured interviews, longitudinal tracking.
Y 3	Implement body-based activities at multiple sites including addition of 3rd unique geographic location and demographics and/or expansion across college departments (civil engineering, physics).	Simultaneous recitation sections split into body-based and non-body-based groups at each site.	Pre-/post Statics Concept Inventory, Pre-/post Student Attitude Survey, Individual semi-structured interviews, longitudinal tracking.
Y 4	Analysis of results from surveys, concept inventory, interviews, longitudinal retention data.		

Anticipated Results: It is expected that increased situational interest will be observed in students enrolled in Statics and participating in the body-based interventions. This increase in situational interest will improve conceptual learning and encourage students to readily attempt physical reasoning during problem solving—regardless of gender or ethnicity. Enhanced student interest will help students pass through the gateway course of Statics into increasingly technical engineering classes, and will positively impact student persistence in engineering.

Institutional Effectiveness: The University of Colorado at Boulder is a nationally recognized leader in STEM Education. From the NSF-funded engineering GK-12 program to the National Academy of Engineering (NAE) award-winning Integrated Teaching & Learning Laboratory (ITLL), there are several opportunities for engineering education research. The university-wide NSF Integrating STEM (iSTEM) initiative aims to establish CU as a national hub of STEM education research and reform. The College of Engineering and Applied Science is demonstrating the iSTEM spirit by initiating a PhD program in Engineering Education and creating the Center for Engineering Education Research and Assessment (CEERA).

Intellectual Merit: The body-based intervention represents an opportunity to conduct groundbreaking engineering education research to fully understand the impacts of increased situational interest on student engagement and persistence in engineering. Through the use of the existing Statics Concept Inventory and survey instruments, the utility of this novel and potentially transformative approach can be well understood and assessed.

Broader Impacts: The implementation of a body-based approach to teaching Statics is a fantastic opportunity to discover how teaching examples relevant to all students regardless of gender, ethnicity, disability, and geographic region can impact persistence in engineering. As it relies primarily on the bodies of the students themselves, the body-based intervention requires no additional technology or resources and can be easily ported to any institution of any size. The body-based approach provides an innovative and unique learning situation for engineering students, and lays the framework for future large-scale engineering education research.

Citations: [1] Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annu Rev Psychol*, 109-133. [2] Schiefele, U. (1999). Interest and learning from text. *Sci Stud Read*, 3(3): 257-279. [3] Schraw, G. et al. (2001). Increasing situational interest in the classroom. *Educ Psychol Rev*, 13(3): 211-224. [4] Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students' recall of expository text. *Read Res Quart*, 23(4): 465-483. [5] Seymour, E. & Hewitt, N.M. (1997). *Thinking About Leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press. [6] Carter, R. L., et al. (2003). Factors Influencing Freshmen Retention in Engineering Programs. *ASEE Annual Conference & Exposition*. [7] Bedford, A.M. & Fowler, W. (2002) *Engineering Mechanics: Statics* (3th ed). Upper Saddle River, NJ: Prentice-Hall, Inc. [8] Litzinger, T. et al. (2010). A cognitive study of problem solving in statics. *J Eng Educ*, 99(4): 337-353. [9] Steif, P.S. & Hansen, M.A. (2007). New Practices for Administering and Analyzing the Results of Concept Inventories. *J Eng Educ*, 96(3): 205-212.