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Critical Perspectives

Self-efficacy theory applied to undergraduate biomechanics instruction

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ABSTRACT

Undergraduates are usually required to complete one or more biomechanics courses in a movement science curriculum. Students often avoid taking this course, perhaps because they have a reduced perception of success due to low self-efficacy with the perceived content, particularly related to mathematics. Student learning may be increased through the self-efficacy theory constructs of performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal. Within these, instructors may enhance student learning by: increasing students' perception of the content's application, reducing the use of technical equipment, utilizing modern presentation technologies, and emphasizing qualitative understanding. This paper will detail each of these.

1. Introduction

Nearly all universities in the United States require undergraduate movement science students to fulfill a biomechanics course requirement, and most only offer one such course within their curriculum (Hamill, 2007). Biomechanics is one of several sub-disciplines within the realm of sport, kinesiology, or exercise science, and involves the integration of human anatomy and Newtonian mechanics (Hatze, 1974; Knudson, 2010). The scientific literature related to biomechanics pedagogy has largely focused on courses taught within movement science or kinesiology departments. Commonly taught undergraduate biomechanics courses have increased the number of course objectives associated with mechanical concepts while reducing the objectives associated with functional anatomy (Garceau, Knudson, & Ebben, 2011). The greater emphasis on mechanical concepts requires students to have a firmer grasp of algebra, trigonometry, and sometimes elementary calculus depending on the instructional focus of the course.

It has been reported that many movement science undergraduates are fearful of math and physics (Garceau, Ebben, & Knudson, 2012). Hamill (2007) hypothesized that students often delay taking undergraduate biomechanics because they perceive it as an applied physics course rather than as a course that addresses the theory of biomechanical concepts. That undergraduate students have been shown to have difficulty learning Newtonian mechanics (Grayson, 2004; Hake, 1998), coupled with increased math and physics prerequisites for undergraduate biomechanics courses (Garceau et al., 2011), may add to students' apprehension. Self-Efficacy Theory (SET) may help to explain this behavior, as it aims to explain behaviors that result from an individual's beliefs about their perceived ability to perform a particular task (Bandura, 1986). These perceptions may lead to reduced effort and success when students do take biomechanics (Bandura, 1986). Students who enrolled in calculus had significantly higher self-efficacy compared to those who enrolled in intermediate algebra (Hall & Ponton, 2005). Since only 13% of introductory undergraduate biomechanics courses in North America require calculus as a prerequisite (Garceau et al., 2011), students' trepidation in taking biomechanics may

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stem from having low mathematics self-efficacy.

It has been suggested that the applied and quantitative aspects of biomechanics should be emphasized in an introductory undergraduate course (Hamill, 2007; Knudson, 2010; 2013). Riskowski (2015) reported that an emphasis on conceptual rather than mathematics based Just-in-Time-Teaching increases student learning in biomechanics. However, it is difficult to appropriately teach an undergraduate biomechanics course without incorporating some physics and mathematics. For example, to comprehend how ground reaction forces influence human movement, students need to understand the concepts associated with vector composition. And to grasp how vectors are used, students need to have a basic understanding of trigonometry. So while it is important that physics and mathematics remain a component of undergraduate biomechanics courses, there are pedagogical and course design strategies based on self-efficacy that instructors may use to reduce their students' apprehension and enhance student learning outcomes.

Recent reviews have summarized the research related to both course characteristics and some instructional strategies that enhance student learning of biomechanical concepts (Knudson, 2010; 2013). Within the literature there has been some discussion of students' math and physics ability on learning outcomes. However, no manuscripts have coupled this concept with student perceptions of their ability, or SET, and the application to biomechanics instruction. Therefore, we reviewed the SET and biomechanics teaching and learning literature for the purpose of developing a theoretical framework for which student learning in biomechanics may be improved by increasing students' self-efficacy about the subject. Specifically, this paper will: 1) briefly discuss SET, 2) discuss factors related to student learning in biomechanics, and 3) discuss how biomechanics course self-efficacy and learning may be enhanced through both course design and instructional strategies.

2. Self-efficacy theory

In his seminal paper on this topic, Bandura (1977) postulated that one's self-efficacy affects their choice of activities, effort, and persistence. It is what individuals infer from information obtained from the constructs of: performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal (Bandura, 1977) (Fig. 1). These constructs will each be briefly discussed.

2.1. Performance accomplishments

These are both the individual's accomplishments and failures at a given task. This component provides the most direct, personal evidence of one's ability to succeed (Artino, 2006; Schunk, 1991). Not surprisingly, past success raises one's self-efficacy for a given task, while past failures lower it (Bandura, 1977). Occasional failures are overcome more easily after repeated success (Bandura, 1977).

2.2. Vicarious experiences

Observing someone perform a threatening task can make an individual believe that they can improve, or even be successful, at the task if they are persistent (Bandura, 1977). Seeing a clear positive outcome is the most effective way of increasing self-efficacy through this construct, particularly when the situation is perceived as hazardous but is successfully achieved (Bandura, 1977).

2.3. Verbal persuasion

According to Bandura (1977), people may be led to believe that they can successfully perform a task when they have not been successful during previous attempts simply because they have been told that they can succeed. An important consideration with this construct is how much the individual believes in what they are being told. If they do not believe that they can be successful, it is unlikely that someone else telling them that they can be successful will change their self-efficacy in a meaningful way.

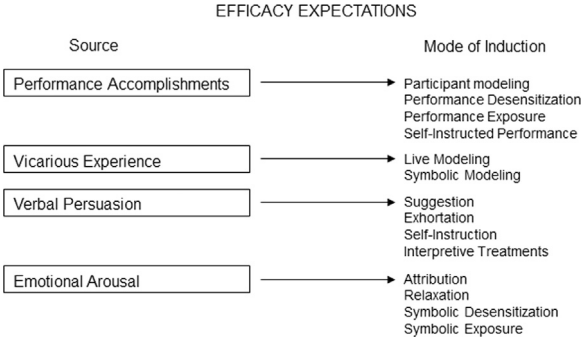

Fig. 1. The four main constructs of self-efficacy information.
Adapted with permission from Bandura (1977).