INTRODUCTORY BIOMECHANICS IN TAIWAN AND UNITED STATES

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The purpose of this paper was to share the experience of teaching and learning biomechanics in the United States and Taiwan. The challenge of learning biomechanics for students appears to be somewhat similar in both countries yet the difficulties result from different factors. Factors affecting learning outcomes can be separated into two major categories, instructor and students. The instructor is responsible for course materials and pedagogical approaches to deliver content. For students, there are different types of factors that impact their learning in biomechanics. This paper provides some approaches to promote the connection between instructor and students to further students' learning. The intent is to fuel the continuing discussion of engaging students' learning and application of biomechanics.

KEY WORDS: active learning, biomechanics, pedagogical strategies.

INTRODUCTION: Biomechanics is a useful tool and provides valuable knowledge for a variety of disciplines. This is why introductory biomechanics is often embedded into the curriculum for many departments in post-secondary schools worldwide. However, results from studies showed that biomechanics is a difficult subject for students to master, let alone apply (Knudson et al., 2003; Hsieh, Mache, & Knudson, 2014). William Thomson (or better known as Lord Kelvin) once said "*The life and soul of science is its practical application*" and promoted the idea of meaningful learning which is defined as the internalization of abstract ideas and the application of concepts to real-world situations. Unfortunately, for science teaching and learning, especially biomechanics, meaningful learning is not easily achieved. Challenges in learning fundamental biomechanics concepts can be attributed to multiple factors that are related to the instructor, student, and curriculum or system variables (Hamill, 2007). Each of these factors are explored and compared between two systems: the US and Taiwan.

In both Taiwan and the US, biomechanics instructors face the same issues for teaching. According to Huba and Freed (2000), "*Few of us have been formally trained to be effective as teachers. As ironic as it sounds, mastery of a discipline does not translate into mastery of teaching the subject*" (p. xvi). Most instructors who teach at a college or university resort to teaching the way they were taught and they become comfortable teaching in a traditional lecture format (Miller & Metz, 2014). Additionally, instructors stay in their comfort zone by using familiar material related to their specialized research interests in the classroom instead of meeting the needs or interests of students. This may result in biomechanical content that can be too narrow or quantitatively focused which is intimidating to students. Thus, curriculum discrepancies exist nationwide despite guidelines provided by the National Association of Sport and Physical Education provides (Garceau, Ebben, & Knudson, 2012; NASPE, 2003). While there are encouraging signs in both countries indicating a shift in the teaching paradigm toward an active learning approach, the majority of the teaching continues to rely on traditional methods.

Students who need to take introductory biomechanics are heterogeneous in background and training. This diversity in student backgrounds is similar in both Taiwan and the US. However, students from the two countries differ slightly in the learning of biomechanics. In the US, instructors reported several student challenges in teaching biomechanics. Students often lack prerequisite knowledge such as human anatomy, physiology, basic physics, and math (Garceau, Ebben, & Knudson, 2012). The diversity of the student backgrounds further compounds the issue of gaps in student knowledge and thus creates difficulty when presenting a universal curriculum. Thus, instructors are forced to spend even more class time familiarizing students with various basic concepts leaving little time, if any, to devote toward application of biomechanics. Between poor preparation to study biomechanics and the quantitative, computational nature of the material, students' motivation and interest in the subject matter may be lowered, which makes learning the material even more challenging. As a result, students may miss the true meaning behind the lessons due to feelings of intimidation from such complex course content.

Although Taiwanese students may exhibit deficits in foundational knowledge similar to their American counterparts, there is a distinct system and curriculum advantage. When students take introductory biomechanics, they are in relatively homogenous cohorts who share comparable background training and similar professional goals which makes instruction simpler. There is a combination of cultural and educational issues that impact student learning differently in Taiwan than in the US. Up until the last decade, the educational system strongly emphasized rote learning and procedural knowledge instead of higher order learning skills such as creative application and/or problem-solving. Memorization skills are repeatedly practiced in order to attain top scores on high-stakes testing and course grades. Learning becomes synonymous with automaticity of the material and it is typical for Taiwanese students to seek out short-term supplemental educational services known as cram schools or *buxiban* which provide additional drilling and practice to boost academic scores and performance (Ministry of Education, 2016). The consequence of this process is that Taiwanese students are good at mastery learning which is at the very costly price of meaningful learning (Wang & Huang, 2010). Additionally, Taiwanese students admitted to post-secondary institutions using the traditional method of high-stakes testing exhibited lower motivation and interest in all content areas (Wang & Huang, 2010). Lowered motivation and interest was found to negatively impact learning in biomechanics (e.g., Hsieh, Smith, Bohne, & Knudson, 2012).

TEACHING INTRODUCTORY BIOMECHANICS: Meaningful learning should be the goal of teaching introductory biomechanics. Chief complaints in achieving meaningful learning are limited amount of time as well as the lack of support, this portion of the article aims to provide ideas to address primarily the instructor and student concerns presented above. Three student-centered pedagogical practices are provided and can be applied in a variety of settings: 1) knowing students, 2) technology, and 3) promoting active learning.

Knowing Students

Chickering and Gamson (1987) described that a crucial factor in student motivation and involvement is related to consistent and geniune contact between faculty and students both in and out of classes. In this section, the focus is on contact outside of the classroom. Instructors typically hold office hours in an effort to support students; however, a recent study showed that 66% of students had never seen their professor outside of class and the remainder of the students visited the professor only once during the course (Griffin et al., 2014). Students can be easily intimidated by faculty and/or find it difficult to request assistance. Instructors should consider using office hours to connect with students and comprehend their unique situations. For example, each student must have an individual meeting with the instructor to discuss class and lab performance using a semi-structured interview method. This strengthens faculty connections with students in several ways. First, the faculty can provide immediate feedback for learning regarding the student's specific concerns. Understanding students' backgrounds provide clues to assist faculty in designing and providing a variety of examples for quantitative and qualitative analysis used in lecture. When examples of applied biomechanics are supplied from students' recreational or professional interests, students may be more willing to ask how to apply biomechanical concepts apply to various situations. Finally, instructors can identify students with similar backgrounds or needs and group them together for further instruction and/or support.

Technology

Technology in and of itself cannot promote active learning in students. It is how the instructor utilizes it in class that makes a difference. In comparison to a decade ago, students now consider technology to be a necessity. The current generation of students is bringing a variety of mobile devices into the educational settings and is expecting that faculty embed technology to enhance the overall learning experience (Dahlstrom & Bichsel, 2014).

Technology can be utilized both inside and outside of the classroom to promote students' participation in learning and assess their learning progress. Outside of class, the majority of students and faculty reported using a learning management system (LMS) hosted by the univeristy in at least one course (Dahlstrom & Bichsel, 2014) indicating the value of implementing a technological platform for teaching and learning purposes. An LMS provides an online platform to deliver course materials such as handouts, media, and examples. However, relatively few faculty use these systems to their full capacity to assist in active learning (e.g., online quizzes, assignments, and practice problems).

A traditional lecture format is employed in many classrooms (Miller & Metz, 2014). Thus, in an effort to increase student participation and active learning inside the classroom, instructors are adopting audience response (AR) system technology (i.e., iClicker) in which each student responds to an instructor-posed question with a specific hand-held remote device (Caldwell, 2007). The system automatically compiles student responses and instructors can use this system as a formative learning assessment tool to determine comprehension of content and adjust instruction accordingly. This approach also avoids domination of a handful of students answering questions. However, it is an additional and expensive learning tool for many students which also requires a bit of learning for a new device. A cheaper alternative, Socrative, is a program which is able to provide all the functions of the AR system listed above, but only requires students to utilize their own mobile device (i.e., computer or cellphone). The Socrative app allows students to answer questions individually, collaboratively, and/or anonymously without being overly cumbersome.

Active Learning

Felder and Brent (2009) defined active learning as "anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes" (p. 2). These strategies can be integrated into any classroom setting beyond the traditional lecture format to enhance student learning outcomes. Some can be simple and straightforward lasting only a few minutes, while others are complex exercises that could require the entire class period. There is mounting data from studies across the science and education displines establishing that active learning techniques result in substantial learning improvements when compared to traditional instruction (Felder & Brent). Recently, meta-analyses comparing student learning outcomes have found increased student retention of content, improved ability to apply knowledge, stronger performance on exams, and decreased course failure rates as positive indicators of active learning (Freeman et al., 2014). Two examples of active learning for biomechanics are provided.

The first example to promote students' active learning involves pairing a progressive version of the think-pair-share strategy and a real-time feedback system such as Socrative. Students independently answer a question and then discuss differing answers with a partner in an attempt to come up with a final correct response. This process utilizes cooperative and collaborative learning to provide informal assessment of student learning to determine if more direct instruction is needed as well as provide an opportunity for interaction among students. To take it one step further, a small group (3-4 students) competition can be introduced to answer a series of practice problems. The instructor should provide a few basic knowledge questions as "warm-up," but integrative and application questions should be emphasized. In this manner, responses cannot simply be stumbled upon in the provided course material (e.g., book, lecture notes), but rather, the solution must be discovered or constructed through discussion, analysis, integration, and/or application of concepts. For those students who arrive at the correct answer, they have been reinforced for active learning. For those answer incorrectly, they remember and learn from their mistakes for the future.

The National Research Council (NRC; 1997) recommended discovery-based and/or problem-based learning as strategies to promote learning in science. These strategies have been commonly utilized in the biomechanics lab setting. In addition, an abbreviated version of discovery- or problem-based learning that allows students to engage in a kinesthetic learning can be integrated into the lecture. For example, when introducing the concept of balance, students can engage in a modified sumo wrestling activity. The goal is for students to determine which combination of variables (e.g., location of center of mass, base of support) that will result in the greatest mobility and maximum stability for a wrestler. The instructor can support and guide student learning through scaffolding and direct instruction, if needed, according to the learning performance of the students in the class through the use of technology (Hmelo-Silver, Duncan, & Chinn, 2007).

SUMMARY: Students in both Taiwan and US all face similar challenges with meaningful learning in biomechanics for PE or Kinesiology majors. Variables involving the instructor, students, and/or curriculum may impede the learning of introductory biomechanical content at the undergraduate level. Thus, this paper recommends promoting meaningful learning through: 1) instructors getting to know students, 2) utilizing technology, and 3) embedding active learning strategies to engage students' learning.

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