STUDENTS' PERCEPTION ON TEACHING STYLE AND LEARNING OUTCOME

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The purpose of this study was to investigate the influence of active learning on students' learning outcomes in undergraduate introductory biomechanics and students' preference of teaching style. Five undergraduate biomechanics classes from four public universities in the United States were recruited (N = 204). Survey questions were administered over the internet. A total of 160 valid responses were analyzed. The students who rated their class was somewhat interactive and very interactive had significant learning improvement (p < 0.05). There was no significant learning improvement in groups that rated their classes either pure lecture (p = 0.09) or primarily interactive (p = 0.46). This indicated that moderate amounts of active learning enhance learning outcomes above lecture alone or primarily active learning. Students' preferred interactive style was hands-on activity.

KEYWORDS: active learning, biomechanics, BCI, engagement.

INTRODUCTION: Students' learning is the ultimate goal of teaching. Active learning (AL) has been proven to enhance student learning when compared to conventional lecture teaching style in many different disciplines (Freeman et al., 2014; Hake, 1998; Prince, 2004). AL encourages students' engagement in meaningful learning not only by listening in class but also reading, writing, discussing, and engaging in problem-solving actively (Chickering & Gamson, 1987). Any activity used during class time to engage these learning behaviours can be considered as an AL strategy. Some common and effective AL strategies are problem-based learning, think-pair-share, and hands-on activities. These strategies have been implemented from low-tech (Knudson & Wallace, 2019), to real-time clicker system (Armbruster, Patel, Johnson, & Weiss, 2009) and even augmented reality teaching strategies (Ibáñez & Delgado-Kloos, 2018). The mechanism of these aggregate learning benefits is unclear, as well as different responses of individual students to AL. Since students must ultimately learn, their perceptions of AL are important to be considered in developing effective instructional strategies.

Despite overwhelming positive evidence of AL over traditional lecture, there is limited evidence on individual students' perception of their engagement and effectiveness of AL pedagogies. A large study of science students reported 70% perceived the importance of AL, however, there was greater variation in student preference for AL (Welch, 2012). This generally positive but variable student perceptions of AL has also been reported in biomechanics classes (Knudson, 2019; Knudson & Wallace, 2019). Interestingly, a study of two biomechanics classes indicated that benefits of small amounts of low-tech AL over traditional lecture may be maintained whether students perceived group-based AL positively or negatively. It remains unclear if students' perception of AL meaningfully influences actual learning. Students' may perceive how the instructor implements teaching strategies differently that affecting their engagement and learning. Therefore, the purpose of this study was to investigate biomechanics students' perception of AL engagement implemented by their instructor, their preferred AL strategies and the effect of these preferences on learning biomechanical concepts. It was hypothesized that students who perceived their instructor used no AL activity in the class at all would have lower learning compared to students who perceived more AL activities during the class.

METHODS: A survey was administered to 204 students from five introductory biomechanics classes at four universities located in the middle and western portions of the United States. The class size ranged from 22 to 60 students. All participants were required to complete the online pre-test and a post-test survey. All students were enrolled in kinesiology/exercise science majors. The study was approved by the institutional review board and student consent for participation was obtained online. Students' learning in biomechanical concepts were measured with Biomechanics Concept Inventory version 3 (BCI v3; Knudson, 2006) presented online during the first and final two weeks of the semester (pre- and post-test). This BCI v3 consisted of 24 multiple choice questions based on biomechanical concepts and students were required to answer these questions with a time limit of 30 minutes. Studies showed that all versions of the BCI provide an unbiased measure of student learning of core concepts of the introductory biomechanics course (Knudson et al., 2003; Hsieh, Mache, & Knudson, 2012).

A questionnaire (Table 1) regarding students' perception of the instructor's teaching style was administered before the post-test online. There was no time limit for the questionnaire portion of the post-test. After exporting all the students' responses to spreadsheets according to classes, the data from students who did not complete the survey and had more than 4 points of decrease score from pre- to post-test were excluded (Knudson et al., 2003). A total of 44 students were excluded from data analysis due to non-compliance of pre- and post-test (n = 18, 8.82%) and incompletion of survey (n = 26, 12.75%). This non-compliance rate of 8.8% was much higher than previous studies (Henderson, 2002; Hsieh & Knudson, 2008; Hsieh, Smith, Bohne, & Knudson, 2012; Knudson et al., 2003) but lower than the 14% Knudson and Wallace (2019) reported. This could be due to eliminating the pressure to answer the online questions correctly.

Two additional items were related to the teaching style of their instructor. Students selected the percentage of time devoted to active learning strategies, ranging from traditional lecture only to AL being the largest single component of instruction. If students responded that AL was incorporated during instruction, the second item required students to identify the specific techniques utilized. An ANOVA was performed to examine the difference among the pre-tests from all four groups. Paired t-tests were performed to compare mean pre- and post-test scores on the BCI v3 in each of the four AL groups. Statistical significance for all tests was accepted at $p < 0.05$. Student learning of biomechanical concepts was defined by using the normalized gain score (g = (post-test score – pre-test score)/ (maximum possible score – pre-test score) proposed by Hake (1998).

Table 1: Questionnaire

Item	Choice
1. How would you describe your instructor's teaching style? (Active learning is when instructors engage your learning with any strategies other than traditional lecturing i.e. instructor talk through the whole period of class time)	**A.** Traditional lecture (lecture through the class period) **B.** Somewhat interactive (minimal active learning strategies such as hands-on activity, etc.; <10% of class time) **C.** Very interactive (moderate amount of active learning strategies embedded in the class; 10 – 40% of class time) **D.** Primarily interactive (> 40% of class time are active learning)
2. If you answer B, C, or D in the previous question, please indicate which active learning strategy helped you learn the biomechanical concepts best during the class time If more than one active learning strategy helped you (rank your choices from the most helpful (#1) to the less helpful strategies.)?	**A.** Hands-on activity **B.** Small group (2-3 people) discussion **C.** Quantitative problem solving **D.** Other; Please describe

RESULTS: Thirty-six percent of students rated class instruction as traditional lecture, 30% somewhat interactive, 24% very interactive, and 10% primarily interactive. There was no significant difference among the pre-tests (p = 0.76) of the four groups of the student ratings of instruction indicating equivalent initial ability across students' understanding of biomechanical concepts. The groups that reported their instructors used zero AL (p = 0.09; g = 0.01) and primarily interactive learning (p = 0.46; g = -0.01) showed no significant improvement in BCI v3 (learning biomechanics concepts). Students in both somewhat interactive ($p < 0.05$; $g = 0.04$) and very interactive groups ($p < 0.01$; g = 0.06) had significant learning of biomechanics concepts. Both standardized gains, however, were qualitatively lower than previous studies of lecture and AL introductory biomechanics instruction ($0.09 < g < 0.22$) using several versions of the BCI (Hsieh & Knudson, 2008; Hsieh et al., 2012; Knudson, Bauer, & Bahamonde, 2009; Knudson& Wallace, 2019).

The preferred active learning strategy reported in both very interactive and somewhat interactive groups was hands-on activity. Table 2 shows the ranking of the students' preferred active learning strategies. To validate students' perceptions regarding the instructors' teaching style, there were 63% to 89% of students in each category who were from the same institution. That said, more than half of the students had clear understating of their instructors' teaching style and the general percentage of AL engagement.

Table 2: Preferred active learning strategies

Groups	Preferred Active Learning Strategies
Somewhat Interactive (<10%; n = 48)	1. Hands-on activity (38%) 2. Small group discussion (31%) 3. Problem solving (21%)
Very Interactive (10-40%; n = 39)	1. Hands-on activity (42%) 2. Small group discussion (33%) 3. Problem solving (31%)
Primary Interactive (> 40%; n = 16)	1. Small group discussion (39%) 2. Hands-on activity (28%) 3. Problem solving (22%)

DISCUSSION: The findings of this current study confirm that the pure lecture teaching style was not an effective pedagogical strategy when compared to the AL strategy based on student perceptions and learning biomechanics concepts. The data of the current study indicated that the best-most learning in these students occurred with perceived implementation of AL between 10 and 40% of class time. This was consistent with moderate amounts of low-tech AL in biomechanics classes reported previously (Knudson, 2019; Knudson & Wallace, 2019). Surprisingly, students that reported their instructors spent more than 40% of class time implementing AL had no learning improvement. This is in contrast to extensive studies reporting larger learning gains with more extensive AL implementation (e.g. Freeman et al., 2014; Hake, 1998; Prince, 2004; Riskowski, 2015). The current students reported their preferred AL activity was hands-on activity. Stohr-Hunt (1996) showed that students who were engaged with at least one hands-on activity per week scored better on science achievement than students who only engaged in the hands-on activity once a month, less, or never. AL is designed to engage students in doing things and thinking about what they are doing (Bonwell & Eison, 1991). This combined with studies that identified students' interests and perceived application of the subject matter as important contributors to learning (Hsieh & Knudson, 2008; Hsieh et al., 2012), instructors may consider designing AL with hands-on activities based on students' interests and career goals to stimulate engagement and learning.

Against our hypothesis, when students perceived they were spending more than 40% of the class time on AL, it did not promote learning. This could due to several possible situations: 1) students were not prepared for the activity, 2) the instructor(s) did not implement the activity correctly and thoroughly, and 3) students did not fully engage in the activity. Biomechanical concepts can be complicated and counterintuitive for many students (Knudson, 2013). Implementing AL strategy when students have misconceptions about the concept and/or are not prepared for the activity may reduce the effectiveness of an activity. In other words, without the proper introduction of the concepts and understanding of students' readiness could result in time lost for meaningful learning. Additionally, Welsh (2012) and Knudson and Wallace (2019) found a small portion of students had a negative perception of AL. Although Knudson and Wallace (2019) found a small portion of the students had negative perceptions toward AL, this group of students still demonstrated significant learning of biomechanical concepts. There is a need to confirm the current results since the number of respondents who perceived the course as primarily interactive was small (10%, *n* = 16). Future research should also measure student attitude toward AL and actual AL times since the current students who perceived a larger amount of AL may be biased against the use of AL instruction.

The limitations of the current study are 1) the true amount of time that each instructor spent on AL strategies is unknown, 2) the types of AL strategies used by each instructor is unknown, and 3) the students' thoughts about AL and actual engagement are not known.

CONCLUSION: This study confirmed that a moderate amount of AL (students perceived as < 40% of class time) was associated with learning biomechanical concepts larger than lecture alone. Additionally, engaging some students in perceived 100% lecture and AL for more than 40% of the class time did not show significant learning of biomechanical concepts. Hands-on activity was the students' preferred AL strategy in these classes.

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