BIOMECHANICS RESEARCH CONCEPT INVENTORY

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A pilot study of a test of biomechanics research concepts appropriate for advanced undergraduate and master's courses was conducted. Students in a master's biomechanics course (n = 14) took a 30 question Biomechanics Research Concept Inventory (BRCI) the first and last day of the course. The BRCI tested six research concepts areas and several prerequisites from introductory biomechanics. The students entered the class with 42% mastery of prerequisite concepts. Post-course scores significantly improved by a modest 50 percent from pre-course values. The BRCI indicated the largest apparent improvements were in the 2D kinematics, 2D kinetics, and in the reviewing and writing research reports concept areas. The BRCI has potential as a supplement to course grading for assessing learning of biomechanics research concepts.

KEY WORDS: Graduate, Improvement, Learning.

INTRODUCTION: Biomechanics faculty interested in the scholarship of teaching and learning (SoTL) have several standardized tests for undergraduate instruction from physics education (e.g., Halloun & Hestenes, 1985; Hestenes, Wells, & Swackhammer, 1992) and biomechanics education research (Knudson, 2004, 2006; Knudson et al., 2003). These tests given at the beginning and the end of course instruction have been effective in documenting typical learning gains (Coleman, 2001; Knudson et al., 2003), identifying factors related to learning (Hsieh & Knudson, 2008; Hsieh, Smith, Bohne, & Knudson, 2012; Knudson, Bauer, & Bahamonde, 2009), and active learning strategies that improve learning of mechanical concepts beyond traditional instruction (Hake, 1998; Riskowski, 2013). Active learning instruction utilizes activities with student interaction to and apply concepts previously presented in readings, mini-lectures, or online. Repeated testing of students is important in documenting the pattern of learning, and remembering of key course concepts since students tend to forget concepts that are not regularly revisited and applied over time in and beyond a course (Franklin, Sayre, & Clark, 2014).

While several versions of the biomechanics concept inventory (BCI) have been used in numerous studies of learning in introductory biomechanics (Knudson, 2013), to date there have been no SoTL studies of advanced or graduate-level biomechanics instruction. The purpose of this study was to develop and pilot a test of biomechanics research concepts that would be appropriate for advanced undergraduate and master's biomechanics courses.

METHODS: The author developed a 30 question test, with 12 questions of prerequisite concepts (anatomy, mathematics, and introductory biomechanics similar to the BCI reported by Knudson et al., 2003) and 18 questions on biomechanics research concepts commonly covered in an upper level or graduate biomechanics course. There were three questions from each of the following topical areas: Two-dimensional kinematics (2DKINE), dynamometry (DYN), errors/signal processing (ESP), electromyography (EMG), 2D kinetics (2DKINT), and reviewing and writing biomechanics research reports (RWR). A draft of this biomechanics research concept inventory (BRCI) was shared with two biomechanics faculty with graduate programs for feedback to improve the test. Contact the author (dknudson@txstate.edu) for a copy of the test.

The final BRCI was piloted in a study on a single master's biomechanics course and the study was approved by the institutional review board for the protection of human subjects. Students in the graduate class were not explicitly in a master's program focused on biomechanics, but general Exercise and Sports Sciences and Physical Education. Students in the course were given the test pre-course on the first day and the post-course test was

given on the final day of the course. One student from another graduate major and two students who missed the pre-course test were excluded from the study. Pre-course and post-course BRCI scores (n = 14) were compared with a dependent *t* test (alpha < 0.05). Learning was defined as the improvement in BRCI scores and was normalized to maximal possible improvement for each individual student base on their pre-test (g: Hake, 1989). Descriptive data were also compiled for the prerequisite questions (12 items) and six concepts area questions (18 items) of the BRCI. Correlations were performed between BRCI scores and the instructor's final grade in the course.

RESULTS: The mean (SD) pre-score score on the BRCI was 10.3 (2.6) questions correct for a mean prerequisite question mastery of 42%. All students improved on the second test, so mean post-course scores improved significantly (t = 7.0, p < 0.0001) to 15.5 (3.4) correct responses. This corresponded to mean improvement of 50% over pre-course scores and a gain (g) score of 26%. The specific mastery of the six biomechanics research concepts in the pre-test and post-test are listed in Table 1. Pre-course and post-course BRCI scores were significantly associated (r = 0.58, p < 0.03). Post-course BRCI scores were also significantly associated with final course grades (r = 0.66, p < 0.01).

Table 1
Percentage of Correct Responses in Six Biomechanics Reseach Concept Areas

n = 14	2DKINE	DYN	ESP	EMG	2DKINT	RWR
Pre-Course	12	67	33	36	31	19
Post-Course	43	76	55	55	64	48

Note: See methods for concept area abbreviations. Correct responses due to chance would be approximately 25%.

DISCUSSION: Pre-course testing with the BRCI indicated that these master's students entering this course retained only 42% of typical prerequiste knowledge from their introductory anatomy and biomechanics courses. Mean post-course mastery of prerequisite concepts were qualitatively similar (48%) to pre-course scores. This was consistent with faculty perceptions of students and recent research on student forgetting of course concepts not consistently reinforced over time (Franklin, Sayre, & Clark, 2014).

Post-course testing demonstrated significant improvement in BRCI scores, however the overall mean learning of biomechanics research concepts was not impressive. The mean normalized improvement (g) of 26% was similar in size to leaning gains for traditional instruction in undergraduate physics and biomechanics (Hake, 1989; Knudson, 2013). One might logically expect higher levels of improvement for graduate students than undergraduates, even with more rigorous questions. The modes mastery may be related to these graduate students not focusing on biomechanics.

Qualitative examination of correct responses in each of the six biomechanics research concept areas indicated there was apparent learning in all areas (Table 1). Mean correct scores for questions in these six areas following the course were between 43 and 76% of complete mastery. Students improved the most in the 2DKINE, 2DKINT, and RWR areas. The high rates of pre-course mastery of the DYN questions indicated that these questions may be too easy and should be revised in future versions of the BRCI.

The present study was limited by the single sample of 14 students from one graduate course, taught by one instructor at a state university. The BRCI has small number of questions for each prerequisite and research concept, representing a small subset of many graduate biomechanics course concepts. The reliability of the BRCI has also yet to be established.

The specific course in this study was a graduate-level overview of most biomechanics research methods and reports, designed around student-developed research projects typically using one kind of biomechanical data. The moderate correlation between the BRCI and course grades that were primarily based on independent research projects provided secondary construct validation of the BRCI.

Despite these limitations of the BRCI and the current pilot study, the BRCI shows promise as a test that faculty can use to supplement traditional measures of learning in advanced biomechanics research courses. Learning assessment information from the BRCI may be a useful supplement to traditional learning data (written project reports and essay test questions). Future research should consider expanding the number of BRCI questions, additional versions like the BCI (Knudson, 2004, 2006), so instructors can utilize more frequent and online testing to track learning and forgetting of key concepts (Franklin, Sayre, & Clark, 2014) that are essential to interpreting and conducting biomechanics research. It is hypothesized that improvements in graduate instruction in biomechanics might help reduce the number of future research reports with methodology and reporting errors. Knudson (2005) reported a majority of applied biomechanics research reports had multiple statistical and reporting errors.

CONCLUSIONS: The proposed BRCI shows promise as an instrument to document mastery of prerequisite and biomechanics research concepts in advanced undergraduate and master's biomechanics research courses. The research concept areas where the students in this graduate course had the most improvement were 2D kinematics, 2Dkinetics, and in reviewing and writing research reports.

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