ACTIVE LEARNING AND STUDENT BELIEFS ABOUT LEARNING

Duane Knudson
Texas State University, San Marcos, TX, USA

This study documented the potential change in student epistemology of learning biomechanical concepts over a 5-week introductory biomechanics course implementing low-tech AL exercises. Twenty-five students agreed to participate and completed a pre- and post-test consisting of the Biomechanics Concept Inventory version 2 and two questions on their perceptions about the nature of learning. The active learning instruction increased mastery of biomechanical concepts over levels previously reported for lecture alone. Most students had positive perceptions of active learning experiences, however, some (4-12%) students had negative perceptions and decreased their interest in working with other students. Student epistemology did not change over the course and was not related to mastery of biomechanics concepts.

KEY WORDS: BCI2, engagement, epistemology, philosophy, responsibility.

INTRODUCTION: Active learning instructional techniques have consistently shown greater student mastery of course concepts than traditional lecture instruction in many disciplines (Beichner et al., 2007; Freeman et al. 2014; Hake, 1998), including biomechanics (Knudson & Wallace, 2019; Riskowski, 2015). These benefits appear to be related to student engagement and interaction, rather than electronic instructional technologies (Knudson & Wallace, 2019; Soneral & Wyse, 2017) that are often implemented in AL pedagogies.
A common observation in research on implementing AL pedagogies is initial resistance by some students (Brazeal & Couch, 2017; Sharma, Ahluwalia, & Sharma, 2013; Walker, Cotner, Baepler, & Decker, 2008) primarily based on their beliefs about learning (learning epistemology). Studies of kinesiology and biomechanics classes indicate that about 12 to 17 percent of students initially have a negative perception of AL experiences involving working in small groups with other students (Knudson & Meaney, 2018; Knudson & Wallace, 2019). Experts have recommended gradual introduction of AL or negotiation with students on use of AL exercises to potentially change epistemology of learning and reduce student resistance to group-based AL exercises. Successful implementation of AL may require instructors to effectively motivate some students to change learning epistemology to take more responsibility for their own and others learning (Lea et al., 2003; Welsh, 2012; White et al., 2015). There has been, however, inconsistent research results evaluating the change in student epistemology of learning in physics (Masden, McKagan, & Sayre, 2015). The purpose of this study was to document the potential change in student epistemology of learning biomechanical concepts over a 5-week introductory course implementing low-tech AL exercises. Understanding student epistemology and engagement in introductory biomechanics is important because of high levels of anxiety most students have for the subject (Wallace & Kernozek, 2017).

METHOD: Students in an introductory biomechanics course were invited to participate according to IRB approved procedures. Twenty-five participants from 37 enrolled students agreed to participate and completed both pre- and post-tests. Participants took a pre-test and a post-test that included the second version (Knudson, 2004) of the Biomechanics Concept Inventory (BCI2) and two questions on their current epistemology of learning in the course. These questions from a previous study (Knudson & Wallace, 2019), included an ordinal-level question focusing on perceptions of interaction with students and the instructor and an interval-level question on four major factors influencing their learning of biomechanical concepts (Table 1). Both study participants and students that declined participation in the study received extra credit in a quiz portion of their grade.
The investigator taught this 3-credit introduction to biomechanics course over a 5-week summer term. This class provided a focused, but limited amount of time to progressively implement several low-tech AL exercises in the 100 minutes class sessions. Low-tech AL exercises did not use electronic or computer technologies to facilitate searching and

interaction of the students and instructor. The class used four of the five low-tech exercises previously shown to significantly improve learning over learning previously reported for lecture alone (Knudson & Wallace, 2019). The instructor emphasized three primarily individual-based exercises (Quizzes/Projects, Hypothesize-Demo/Activity, Review/Self-Assessments) and gradually implemented one group-based exercise (Professional Issues Discussions). Hypothesize-Demo/Activity has students hypothesize results or mechanisms of biomechanical situations that were then demonstrated by the instructor or experienced by student physical activity. Review/Self-Assessments were short (3-5) practice assessment questions on recently covered biomechanical concepts. The number of these exercises used were 16, 9, 15, and 7, respectively. Assuming 5-minutes per exercise, the course had a minimum of 235 minutes of AL experiences. This 10-15% of class time is a low amount of AL, below the expectations of many students and university instructors for an active learning focused course (Miller & Metz, 2014).

Descriptive data were calculated for the BCI2 scores and student perceptions of learning epistemology. To facilitate comparisons with previous studies, learning in the course was calculated using the normalized gain score (Hake, 1998). Potential change in student epistemology were examined with two Pearson Chi Square tests with a type I error rate of $p < 0.05$. Correlations were calculated between the interval- and ratio-level variables.

RESULTS AND DISCUSSION: BCI2 pre-test (M = 10.0) scores were consistent with other introductory biomechanics courses in kinesiology/exercise science (Knudson, 2004, 2006; Knudson et al., 2003). Mean post-test (M = 13.1) and learning scores (g = 21%) were qualitatively higher than previously reported national norms for 3-credit biomechanics classes (g=11%). Learning was also consistent (g=19%) with a previous study of low-tech AL (Knudson & Wallace, i2019), but qualitatively lower than 4-credit courses (g=25%) with labs (Knudson, Bauer, & Bahamonde, 2009) and more extensive AL instruction (g = 40-48%) in physics (Beichner et al., 2007; Hake, 1998). The improvement in learning with a small implementation of primarily individual-based AL exercises was consistent with the results reported by Knudson and Wallace (2019) and evidence of the efficacy of low-tech AL pedagogies (Soneral & Wyse, 2017). It appears faculty may be able to easily add low-tech, individual-based AL exercises to significantly improve mastery of biomechanics concepts above lecture alone. Biomechanics faculty interested in more detail on the efficacy of different AL pedagogies are referred to the review by McConnell et al. (2017).

Table 1
Additional Pre- and Post-Test Questions and Responses on Student Learning Epistemology

25. My learning of biomechanical concepts (will be/was) facilitated by interacting with other students and the instructor in class.

a. strongly agree b. moderately agree c. agree d. disagree e. moderately disagree f. strongly disagree

	SA	MA	A	D	MD	SD
Pre	61%,	15%,	19%,	4%,	0%,	0%
Post	32%,	36%,	20%,	8%,	0%,	4%

26. Estimate the percentage of each of the following four factors that you think (will) influence(d) your learning of the biomechanical concepts in this class. The four factors should total to 100%.

	Instructor	**You**	**Textbook**	**Working with Other Students**
Pre	34 ± 15%,	35 ± 17%,	15 ± 11%,	16 ± 15%
Post	36 ± 17%,	36 ± 13%,	13 ± 3%,	15 ± 14%

Note: $M \pm sd$ reported for question 26.

For most students their initial perception of epistemology of learning in biomechanics was positively inclined to interaction with other students and the instructor (Question 25, Table 1). This positive attitude was similar to that reported a previous study of four biomechanics classes (Knudson & Wallace, 2019) and other related fields (Knudson & Meaney, 2018).

Overall student perception did not significantly (p = 0.24) change over the course, however inspection of Table 1 indicates a few students may have even decreased their appreciation for interaction with students and the instructor over the terms. There were 4 to 12% of the biomechanics students participating, however, that consistently had negative perceptions of the active learning exercises and responsibility to support other student learning in group-based exercises. This was within the wide range of percentages (3 to 53%) previously reported for student resistance to active learning pedagogies overall (Cavanagh, 2011; Machemer & Crawford, 2007; Smith & Cardaciotto, 2011; Welsh, 2012; White et al. 2015) and previously reported (12-17%) in biomechanics (Knudson & Meaney, 2018; Knudson & Wallace, 2019). These students may be resistant to AL exercises, expecting the instructor to lecture on specific knowledge to be memorized for examinations and resisting efforts to engage them in discussions on different interpretations or contextual application of knowledge. Successful implementation of AL may require more instructor effort and time in AL that was used in the present study, in order to effectively motivate resistant students to take more responsibility for their own and other's learning (Lea et al., 2003; Welsh, 2012; White et al., 2015).

Student epistemology of their attribution of influence on their learning biomechanical concepts also did not change (p = 0.74) over the course (Question 26, Table 1). These perceptions were also consistent with previously reported student perceptions about learning biomechanics (Knudson & Wallace, 2019), where students considered their learning most influenced by the instructor (34 – 36%) and themselves (26-35%). Students generally considered reading the textbook and working with other students as having less influence (13-16%) on their learning. There were significant negative associations (r = -0.47 and -0.58) between student ratings of learning variance related to the instructor and themselves for both pre- and post-test perceptions. These associations were slightly stronger than the association (r = -0.39) between these two perceptions reported by Knudson and Wallace (2019). This study also observed a significant negative association (r = -0.51 and -0.41) between working with other students and students themselves. Previous research has reported differences in instructor and student perceptions of responsibility for learning (Knudson & Wallace, 2019; Patrick, Howell, & Wischusen, 2016). Student learning epistemology ratings were also not correlated with learning (g).

Limitations of the study include a small sample of volunteers from a single biomechanics course taught over a short (5 week) term. Student beliefs about learning biomechanics may not have been completely documented with the two questions used. The accuracy of self-report instruments on beliefs about learning is controversial (DeBacker et al., 2008). The instructor also did not systematically attempt to communicate specific expectations for learning epistemology or advocate for the AL exercises used in the course. It is possible that the results of the study may not be representative of other biomechanics students in other kinesiology/exercise science programs, however the qualitatively greater learning with active learning experiences over lecture alone was consistent with previous studies of hundreds of biomechanics students (Knudson, 2004; Knudson et al., 2009; Knudson & Wallace, 2019). Future research should extend these results with larger samples of students, random assignment to instruction mode, systematic efforts to promote change in learning epistemology, and more extensive use of AL exercises.

CONCLUSION: Implementation of a small amount of low-tech active learning exercises in a 5-week introductory biomechanics course improved student learning above levels previously reported for lecture-only courses. Most students had positive perceptions of active learning experiences, however, some (12-16%) students had negative perceptions and decreased their interest in working with other students. Student epistemology of learning did not change over the course and was not related to mastery of biomechanics concepts.

REFERENCES:

Beichner, R.J., Saul, J.M., Abbott, D.S. et al., (2007). The student-centered activities for large enrollment programs (SCALE-UP) project. *Reviews in Physics Education Research*, 1, Retrieved from https://www.compadre.org/per/per_reviews/volume1.cfm?#Cite

Brazeal, K.R., & Couch, B.A. (2017). Student buy-in toward formative assessments: The influence of student factors and importance for course success. *Journal of Microbiology & Biology Education, 18*, 1-10.
Cavanagh, M. (2011). Students' experience of active engagement through cooperative learning activities in lectures. *Active Learning in Higher Education, 12*, 23-33. doi:10.1177/1469787410387724
DeBacker T.K., Crowson, H.M., Beesley A.D., Thoma, S.J., & Hestevold, N.L. (2008). The challenge of measuring epistemic beliefs: An analysis of three self-report instruments. *Journal of Experimental Education, 76*, 281-312.
Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., & Wenderoth, M.P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*, 8319-8320.
Hake, R. R. (1998). Interactive-engagement versus traditional methods: a six thousand student survey of mechanics test data for introductory physics. *American Journal of Physics*, 66, 64-74.
Hsieh, C., & Knudson, D. (2008). Student factors related to learning in biomechanics. *Sports Biomechanics, 7*, 398-402.
Knudson, D. (2004). Biomechanics concept inventory: version two. In M. Lamontagne, D.G.E. Robertson, & H. Sveistrup (Eds.) *Proceedings of XXIInd International Symposium on Biomechanics in Sports* (pp. 378-380). Ottawa: University of Ottawa.
Knudson, D., Bauer, J., & Bahamonde, R. (2009). Correlates of student learning in introductory biomechanics. *Perceptual and Motor Skills*, *108*, 499-504.
Knudson, D., & Meaney, K. (2018). Promoting active learning instruction and research (PALIR) in kinesiology departments. *Kinesiology Review*, *7*, 328-331.
Knudson, D., & Wallace, B. (2019). Student perceptions of low-tech active learning and mastery of introductory biomechanics concepts. *Sports Biomechanics*, doi:10.1080/14763141.2019.1570322
Lea, S. J., Stephenson, D., & Troy, J. (2003). Higher education students' attitudes to student-centered learning: Beyond 'educational bulimia'? *Studies in Higher Education*, 28, 321-334.
Machemer, P. L., & Crawford, P. (2007). Student perceptions of active learning in a large cross-disciplinary classroom. *Active Learning in Higher Education, 8*, 9-30.
Masden, A., McKagan, S. B., & Sayre, E. C. (2015). How physics instruction impacts students' beliefs about learning physics: A meta-analysis of 24 studies. *Physical Review Special Topics—Physics Education Research, 11*, 010115.
McConnell, D. A., Chapman, L., Czajka, C. D., Jones, J. P., Ryker, K. D., & Wiggen, J. (2017). Instructional utility and learning efficacy of common active learning strategies. *Journal of Geoscience Education, 85*, 604-625.
Miller, C. J., & Metz, M. J. (2014). A comparison of professional-level faculty and student perceptions of active learning: Its current use, effectiveness, and barriers. *Advances in Physiology Education, 38*, 246-252.
Patrick, L. E., Howell, L. A., & Wischusen, W. (2016). Perceptions of active learning between faculty and undergraduates: Differing views among departments. J*ournal of STEM Education: Innovations and Research,* 17(3), 55-63.
Riskowski, J. L. (2015). Teaching undergraduate biomechanics with Just-in-Time Teaching. *Sports Biomechanics, 14*, 168-179.
Sharma, S., Ahluwalia, P.K., & Sharma, S.K. (2013). Students' epistemological beliefs, expectations, and learning physics: An international comparison. *Physics Education Research, 9*, 010117.
Soneral, P.A.G. & Wyse, S.A. (2017). A SCALE-UP mock-up: Comparison of learning gains in high- and low-tech active-learning environments. *CBE—Life Sciences Education*, *16*, 12.
Smith, C. V., & Cardaciotto, L. (2011). Is active learning like broccoli? Student perceptions of active learning in large lecture classes. *Journal of the Scholarship of Teaching and Learning, 11*, 53-61.
Wallace, B., & Kernozek, T. (2017). Self-efficacy theory applied to undergraduate biomechanics instruction. *Journal of Hospitality, Leisure, Sport & Tourism Education, 20*, 10-15.
Walker, J. D., Cotner, S. H., Baepler, P. M., & Decker, M. D. (2008). A delicate balance: Integrating activing learning into a large lecture course. *CBE—Life Sciences Education*, 7, 361-367.
Welsh, A. J. (2012). Exploring undergraduates' perceptions of the use of active learning techniques in science lectures. *Journal of College Science Teaching, 42*, 80-87.
White, P. J., Larson, I., Styles, K., et al. (2015). Using active learning strategies to shift student attitudes and behaviours about learning and teaching in a research intensive educational context. *Pharmacy Education, 15*, 162-172.