TEACHING BIOMECHANICS FOR CONCEPTUAL LEARNING

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Biomechanics education is a vital component of kinesiology and physical education undergraduate coursework. However, little research exists regarding effective teaching strategies for biomechanics. Therefore, the purpose of the study was to evaluate various teaching methods utilizing the Just-in-Time Teaching (JiTT) framework over eight courses of undergraduate biomechanics and included 283 students. Students pre- and post-performance on the Biomechanics Concept Inventory (BCI) were used to evaluate student learning. The results indicated significantly higher learning gains and better conceptual understanding in the JiTT course, relative to No JiTT and a modified version of the JiTT. These results suggest JiTT may be an effective method for engaging undergraduate students and promoting learning in biomechanics courses.

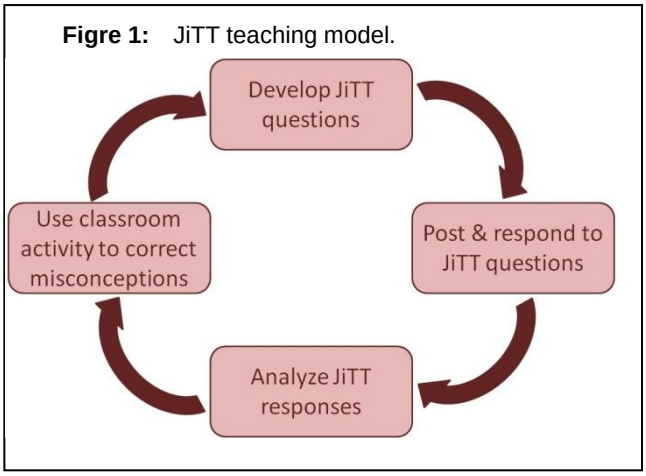
KEYWORDS: active learning; pedagogy; biomechanics principles; web-based exercises

INTRODUCTION: Biomechanics and movement science are rapidly growing fields in academia and industry. However, research suggests that many biomechanics and exercise science graduates are not prepared for subsequent employment (Ives & Knudson, 2007; Knudson, et al., 2003). One approach to improving the learning outcomes in these fields may reside in improving the classroom educational practices. Therefore, the purpose of this study was to evaluate how different teaching models affect undergraduate student learning in biomechanics.

Theoretical Framework: In educational settings, action-based research is a method for evaluating how the investigator's teaching activities affect student learning. It acknowledges that biases and partialities exist because the researcher and instructor are coupled. Thus, action-based research is a systematic, iterative method for planning, teaching, observing, evaluating and reflecting on student learning and teaching effectiveness (O'Brien, 2009).
The goals of action-based research are to test new learning approaches and implement change in a structured, dynamic manner that provides the instructor/research the opportunity to evaluate how the teaching method influences student learning (Checkland & Holwell, 1998). In short, action-based research is a means for understanding how instruction affects learning (Carr W & Kremmis, 1986).

With an action-based research paradigm, the teaching framework centered on Just-in-Time Teaching (JiTT). JiTT structures student learning as an active, iterative and synergistic process with web- and classroom-based activities (Figure 1). When teaching with JiTT, students respond electronically to conceptual web-based questions just prior to the start of the class. This allows the instructor to review, assess and address the students' understanding "just-in-time" to adapt the ensuing classroom lesson to their knowledge level.
This encourages students to come to class prepared and engaged with material, while providing an opportunity for the instructor to develop relevant, meaningful lectures to assist in correcting the students' misconceptions and misunderstanding in the material.

Figre 1: JiTT teaching model.



Other disciplines have shown improved student learning with JiTT (e.g., Marrs & Novak, 2004), and it encompasses several factors that enhance student learning (Astin, 1993; Douglas, Iverson, & Kalyandurg, 2004):

- increased student study outside of the classroom,
- low-risk, high-challenge environments that promote student conceptualization,
- frequent student assessment, *and*
- quality student-faculty interaction.

METHODS: This study was a longitudinal research assessment to determine the efficacy of on the Just-in-Time Teaching (JiTT) method. This study occurred over two years in a senior-level undergraduate biomechanics course. This biomechanics course was a required course for all kinesiology students at the university.

Participants: The participating kinesiology students had either an exercise science or a physical education degree concentration. Participants signed a university-approved consent form. There were two biomechanics courses per semester (Table 1). Students who took the course in the first year were taught without using web-based questions or JiTT (No JiTT). During the study's second year, courses had web-based questions. In this second year, one course each semester used conceptual web-based questions (JiTT), while the other used simple, factual web-based questions as a modified JiTT (Mod-JiTT) method (Table 2).

Table 1: Teaching framework by semester. JiTT = Just-in-Time Teaching; Mod-JiTT = Modified JiTT.

	Year 1		Year 2	
	Fall	Spring	Fall	Spring
Morning Course	No JiTT	No JiTT	Mod-JiTT	JiTT
Evening Course	No JiTT	No JiTT	JiTT	Mod-JiTT

Table 2: Example JiTT and Mod-JiTT questions.

JiTT question:

On a kickoff, a football is kicked at 10m/s at 28°, which component will have greater velocity?

(a) The vertical component. (b) They will be the components will be the same.

(c) The horizontal component. (d) Not enough information to answer.

Mod-JiTT question:

On a kickoff, a football is kicked at 10m/s at 28°, what is the vertical velocity?

(a) 4.7 m/s. (b) 2.8 m/s.

(c) 8.8 m/s. (d) Not enough information to answer.

Data Analysis: Biomechanics understanding was assessed using the Biomechanics Concept Inventory (BCI) at the course start and conclusion (Knudson et al., 2003). BCI scores were calculated into percentage of maximum possible (POMP) scores for statistical analysis (Cohen, et al., 1999). General Linear Model statistics with a Tukey post-hoc analysis was used to assess teaching style in the student populations (e.g., Hispanic, primary English speaker). All statistical analyses were conducted using the SAS statistical analysis package, version 9.2 (SAS Institute, Cary, NC), with alpha set to $p \leq 0.05$.

Table 3: Student charateristics. Data presented as N (%), unless otherwise noted. BCI = biomechanics concept inventory; JiTT = Just-in-Time Teaching; Mod-JiTT = modified JiTT; SD = standard deviation.

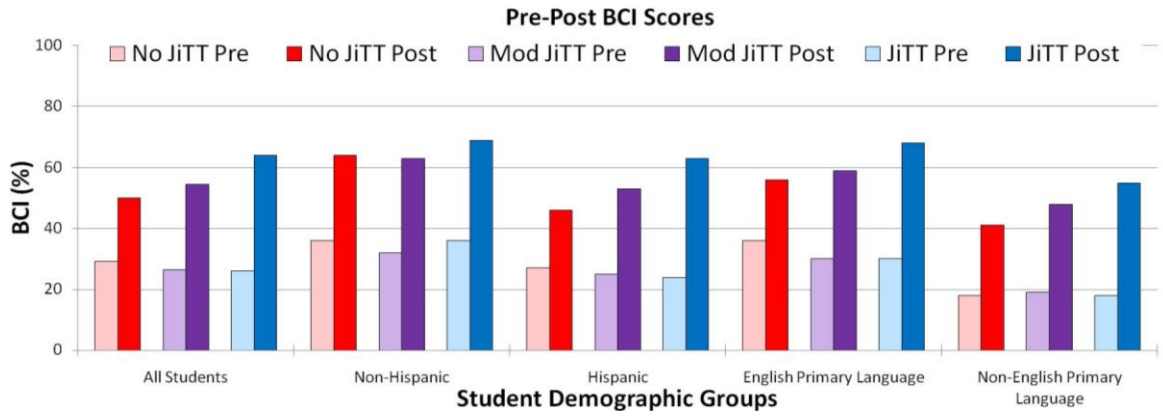
	No JiTT (N=127)	Mod JiTT (N=69)	JiTT (N=57)	p-value
Pre-BCI POMP score (SD)	29 (6.7)	27 (7.9)	27 (8.4)	0.419
Female (%)	56 (44)	34 (49)	24 (42)	0.699
Hispanic (%)	99 (78)	54 (78)	47 (82)	0.807
Non-English Primary Language (%)	50 (39)	25 (36)	17 (30)	0.892

RESULTS: There were no significant demographic or pre-biomechanics concept inventory (BCI) score differences between groups (Table 3).

Post-BCI scores were significantly higher in the Just-in-Time Teaching (JiTT) and modified JiTT (Mod-JiTT) courses (p=0.012; p=0.023) compared to the No JiTT courses (Figure 2). Students in the No JiTT courses increased their BCI scores 34%, while students in the Mod-JiTT and JiTT improved 43% and 50%, respectively

Comparing between Mod-JiTT and JiTT courses, students in the JiTT courses had significantly higher (p=0.035) post-BCI scores than students in Mod-JiTT courses. Further, non-English primary language speakers had greater learning gains in the JiTT courses (54% BCI score increase) compared to the No JiTT (36% BCI score increase) and Mod-JiTT (48% BCI score increase) courses (p=0.010; p=0.043).

Figure 2: Student pre- and post-scores on the Biomechanics Concept Inventory (BCI).



DISCUSSION: The purpose of this study was to assess how different teaching models affect student learning in an undergraduate biomechanics course.

Strong learning gains were noted in the students who were in the Just-in-Time Teaching (JiTT) and modified JiTT (Mod-JiTT) courses. Student populations that tended to see the highest gains were Hispanic students and non-English primary language learners. As biomechanics is often defined by particular constructs and models that make it abstract to

student, particularly those who have difficulty with language, using a JiTT-based curriculum may encourage students to work together and discuss the classroom material beyond what the No JiTT class structure did. Previous research suggests that when students are exposed to relevant curriculum and discussion-based course structure, student learn more and are more engaged (Smith et al., 2005), which may help student grasp the subtleties of the English language. Further, as students were regularly assessed and provided feedback, they were able to check their understanding, not only of the biomechanics material but even more broadly in terms of the language. These assessments may promote innovative problem-solving techniques that model the practices of day-to-day experiences, not just in learning the material, but also in assisting in language development.

There are a number of strengths and limitations to the present study. First, it may be that frequent testing improves testing ability, which is to say that students who were in the JiTT and mod-JiTT classroom had more opportunities to practice taking "tests." While this may explain benefits of JiTT and mod-JiTT over the No JiTT classroom, it does not explain away the benefits of conceptual-based questioning over the fact-based JiTT questioning. Further, as this was a two-year project, the classroom instructor was developing over time. Again, this may explain some of the difference between the No JiTT classrooms with the mod-JiTT and JiTT classroom, it does not explain the differences between the mod-JiTT and JiTT classroom. Thus, a strength of the study is in its cross-over study design in the second year. Moreover, the student body in the study was diverse and encompassed a range of students, including non-traditional aged, non-native English speaking, and first-generation students.

Despite these limitations and due to the positive results shown through the JiTT teaching method, there is a need for increased research into teaching biomechanics. Research is needed to understand the learning pathways from JiTT as well as to understand the long-term effects of JiTT in an undergraduate biomechanics course.

CONCLUSION: The work presented suggests that frequent conceptual-based questioning of student through the Just-in-Time Teaching (JiTT) framework can positively promote student learning in an undergraduate biomechanics course. Thus, the need moving forward in undergraduate teaching is to develop biomechanics courses that center on this type of teaching – one that utilizing frequent testing outside of the classroom as well as time-sensitive activities in the classroom that provide students opportunities to correct misconceptions they have. Part of the benefit of JiTT teaching may be related to students coming to the classroom better prepared, which allows them to be more participatory in class discussions and activities than without JiTT (Simkins & Maier, 2004). Moreover, it may also allow for the instructor to have a better understanding of students' misunderstandings and misconceptions of the biomechanics concepts prior to class, which provides for meaningful, teachable moments in the classroom.

Further, although there is a large initial time investment in developing and revising the web-based questions as well as reflecting on the results in order to develop appropriate classroom activities based on student understanding, the payoff is greater student learning. As there are a number of web-based grading systems (e.g., Blackboard), the underlying goal of engaging students to help them direct their learning through relevant classroom activities and prompt feedback is paramount for developing student self-directedness and conceptual understanding.

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